Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9648/01

Paper 1 Multiple Choice Questions

28 September 2016

1 hour 15 min

Additional Material: OTAS sheet

INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Section A MCQ [40 marks]

There are **forty** questions in 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.

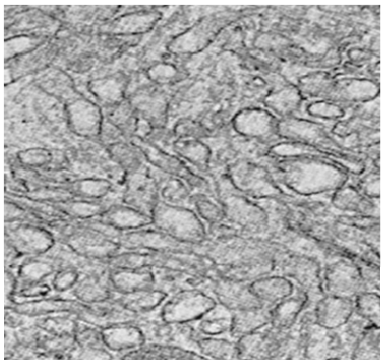
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

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

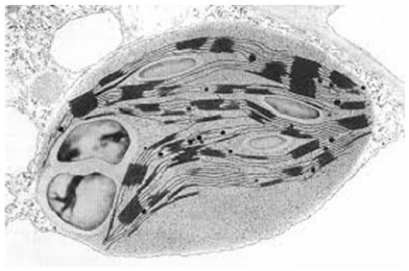
[Turn over

Answer **all** questions in this section.

1 The figure below shows electron micrographs of 4 different organelles **P**, **Q**, **R** and **S**.



P



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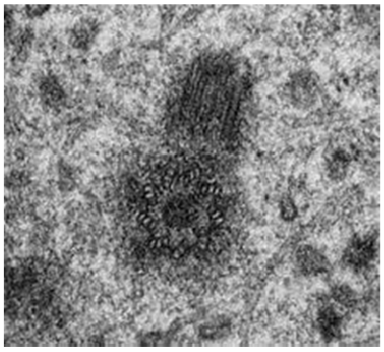
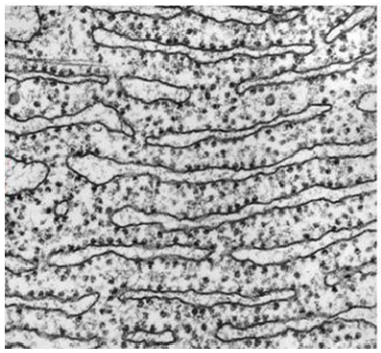


R



S

Which of the following matches the organelle to its function?

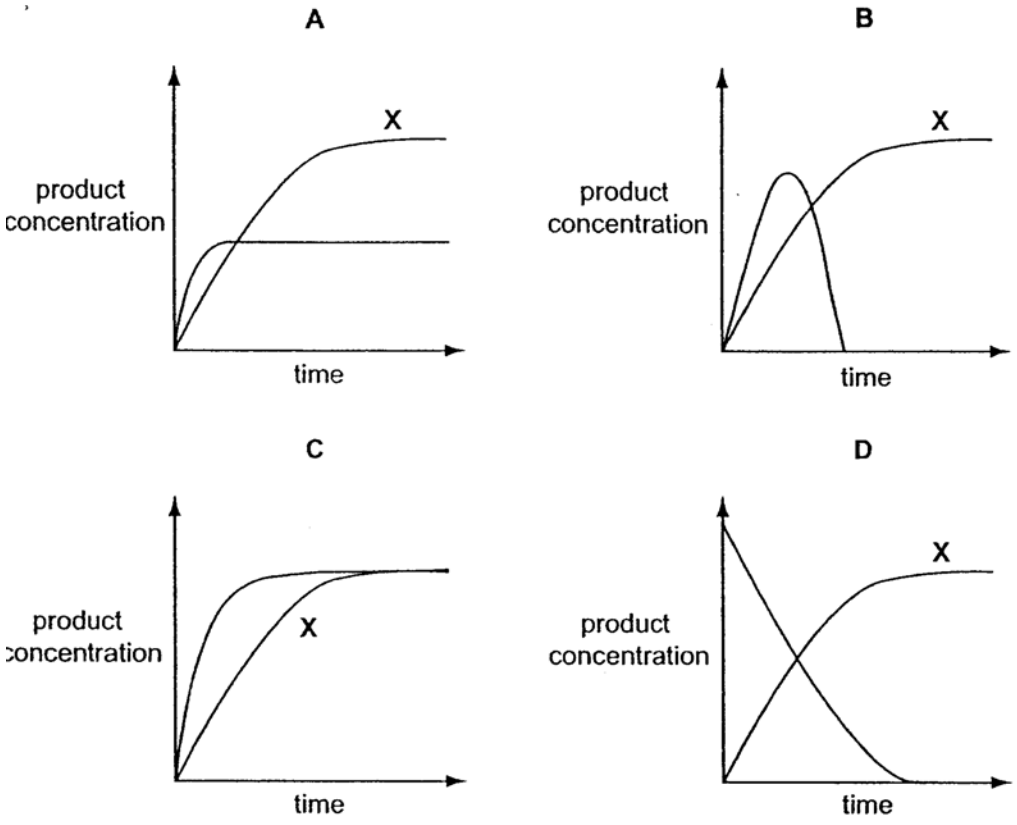
	Organelle	**Function**
A	**P**	phospholipid synthesis
B	**Q**	enzyme secretion
C	**R**	protein synthesis
D	**S**	glycosylation of proteins

2 Which pair shows the ***CORRECT*** classification?

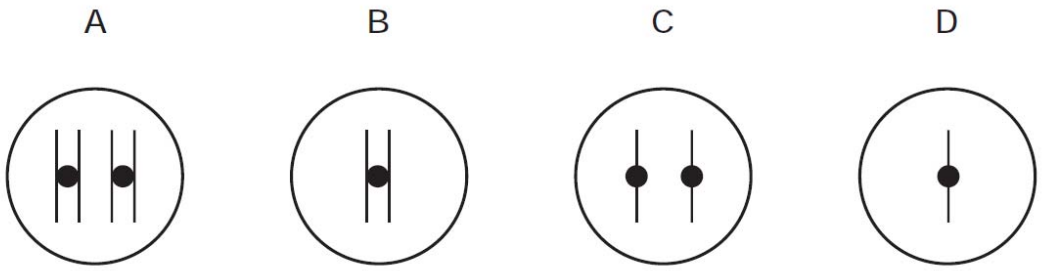
	Branched structure	**Unbranched structure**
A	amylose	glycogen
B	amylopectin	cellulose
C	cellulose	amylopectin
D	glycogen	amylopectin

3 Two enzyme experiments were carried out. The first, experiment **X**, was carried out at a constant temperature of 37°C. During the second experiment, the temperature was increased from 37°C to 80°C.

Which graph shows the results?



4 A cell with one pair of chromosomes (2n = 2) undergoes meiosis. Which nucleus is formed at the end of meiosis I?



5 In an attempt to synthesise DNA molecules *in vitro*, a student isolated and purified various molecules needed for DNA replication. She added some DNA to the mixture, and replication occurred. However, the DNA molecules formed were defective. Each molecule consists of a normal DNA strand paired with numerous segments of DNA, each about hundreds of nucleotides long.

What might she have left out in the mixture?

A DNA primer

B RNA primer

C DNA ligase

D DNA polymerase III

6 The mechanism of action of four drugs that inhibit DNA replication is stated below.

- **Aphidicholine** inhibits DNA polymerase III.
- **Cytarabine** is converted into a molecule that can substitute for a DNA nucleotide and also inhibits DNA repair mechanisms.
- **Epirubicin** inhibits an enzyme involved in the unwinding and separation of DNA strands.
- **Hydroxycarbamide** inhibits an enzyme involved in the production of deoxyribonucleotides.

Which row ***CORRECTLY*** matches the effects of these drugs on DNA replication?

	Effects of Drug on DNA Replication			
	Inhibition of chain elongation	**DNA damaged during replication**	**DNA strands not available as templates for replication**	**Exposed DNA template strands unable to be copied**
A	aphidicholine	hydroxycarbamide	epirubicin	cytarabine
B	cytarabine	epirubicin	aphidicholine	hydroxycarbamide
C	epirubicin	hydroxycarbamide	cytarabine	aphidicholine
D	hydroxycarbamide	cytarabine	epirubicin	aphidicholine

7 The diagram shows part of the normal sequence of an mRNA molecule.

CCAAGUGGUCCGCUAAGAAGGC

A mutation in the DNA resulted in a polypeptide beginning with the following sequence.

glycine - serine - proline - glycine - isoleucine - leucine

The DNA triplets for some amino acids are

Glycine	Isoleucine	Leucine	Proline	Serine
CGA	ATA	TTA	CCA	TCA
GGT	ATT	CTT	CCG	TCG
GGC		CTC		

Which mutation has occurred in the DNA molecule?

A The replacement of one nucleotide by a different nucleotide.

B A reversal in the order of nucleotides.

C An addition of an extra nucleotide.

D The loss of a nucleotide.

8 All of the following statements about viruses are true ***EXCEPT*** _____.

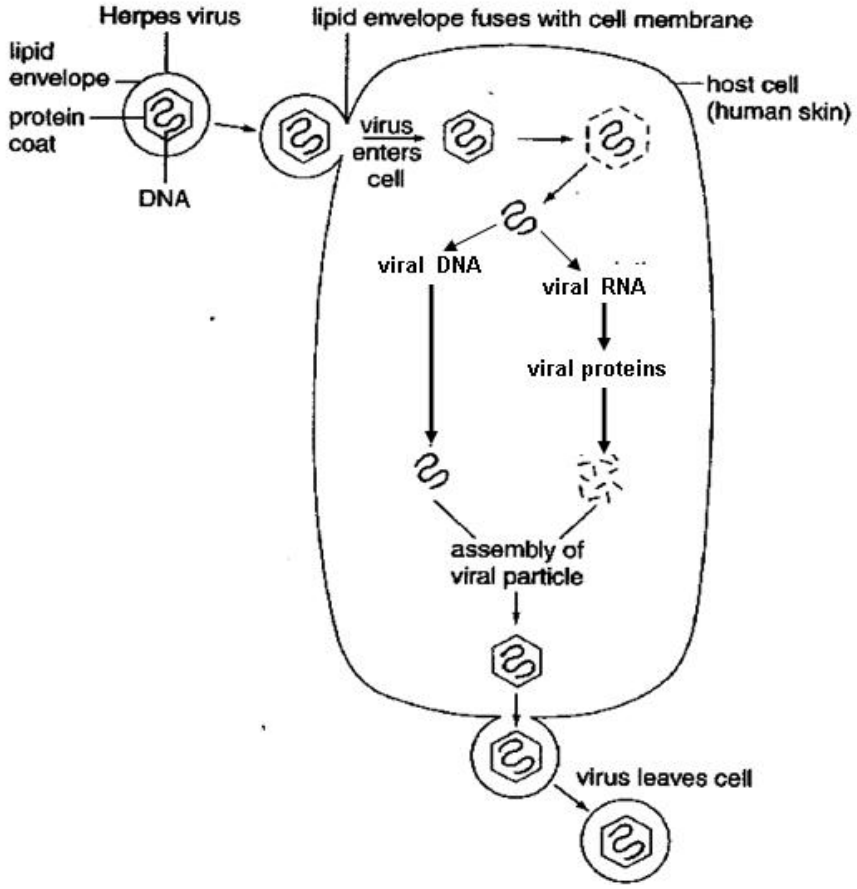
A The genome of RNA viruses are more likely to mutate than those of DNA viruses.

B All viruses produce RNA as an intermediate molecule during the production of new viruses.

C All RNA viruses produce DNA as an intermediate molecule during the production of new RNA viruses.

D Before entering a host cell, specific proteins of viruses bind to receptors on specific host cells.

9 The diagram below shows the reproductive cycle of the herpes virus which causes cold sores on the mouth.



With reference to the diagram below, which of the following statements ***BEST*** describes the herpes virus?

A It is not a retrovirus as it does not contain RNA as its genetic material.

B Its mode of replication is similar to that of influenza virus.

C Its replication cycle includes a lysogenic phase.

D Death of the host cell is necessary for the release of the viral progeny.

10 In a repressible operon under negative control, a mutation that alters the product of the operon's regulatory gene such that it is unable to bind to the co-repressor occurred.

This mutation will result in _____.

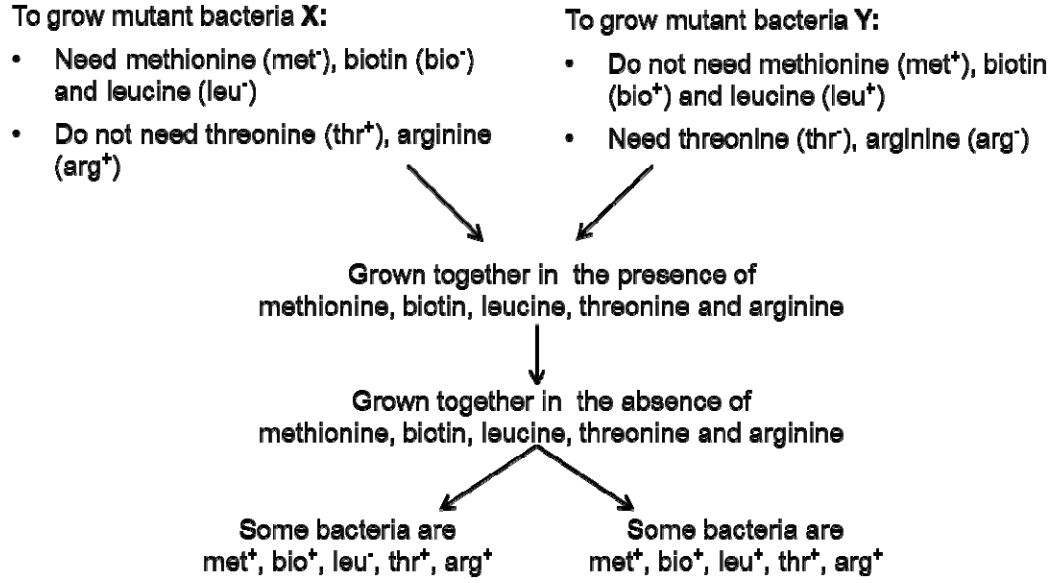
A irreversible binding of the repressor to the operon

B no transcription of genes of the operon

C continuous transcription of genes of the operon

D no difference in the transcription rate

11 The diagram shows an investigation into bacterial genetics.



Which process or processes could explain these results?

I conjugation

II transduction

III transformation

A **I** only

B **III** only

C **I** and **II**

D **I** and **III**

12 Which of the following is ***TRUE*** of cancers?

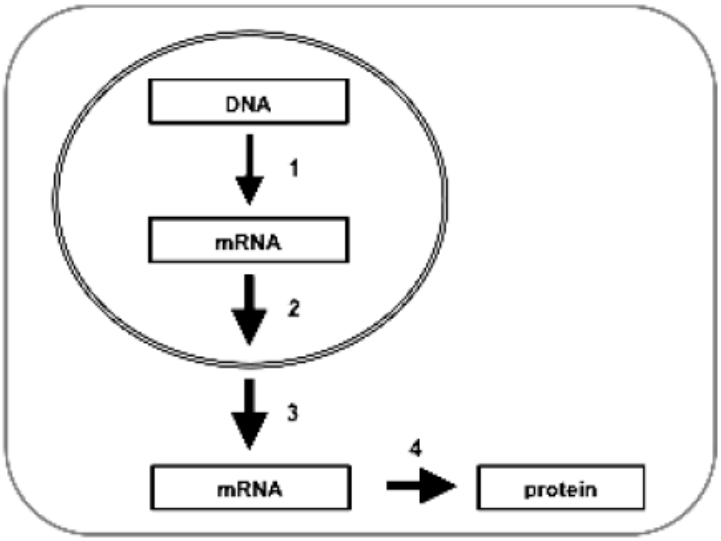
A Anchorage dependence is lost in cancer cells.

B Cancer cells are likely to have longer-than-usual telomeres despite having inactivated telomerases.

C A cell that has a copy of the p53 tumour suppressor gene inactivated can be considered to be cancerous.

D When a copy of the ras proto-oncogene is activated into an oncogene in a normal cell, cancer immediately develops.

13 The following diagram shows the expression of a particular gene to its protein product in a eukaryotic cell. Which of the following combination correctly describes steps **1** – **4**?



	1	**2**	**3**	**4**
A	DNA is demethylated	5' capping occurs	RNase does not degrade 5' capped mRNA	Initiation factors bind to ribosome
B	DNA is demethylated	Alternative splicing occurs	Activators bind to enhancers	Ribosome binds to 5' UTR
C	DNA is methylated	Poly(A) tail is added to 3' end	poly-A tail is extended	Phosphorylation of protein
D	DNA is methylated	5' capping occurs	Removal of 5' cap	Activators bind to enhancers

14 Which statement best explains how related genes involved in the same metabolic pathway are expressed together in eukaryotic cells?

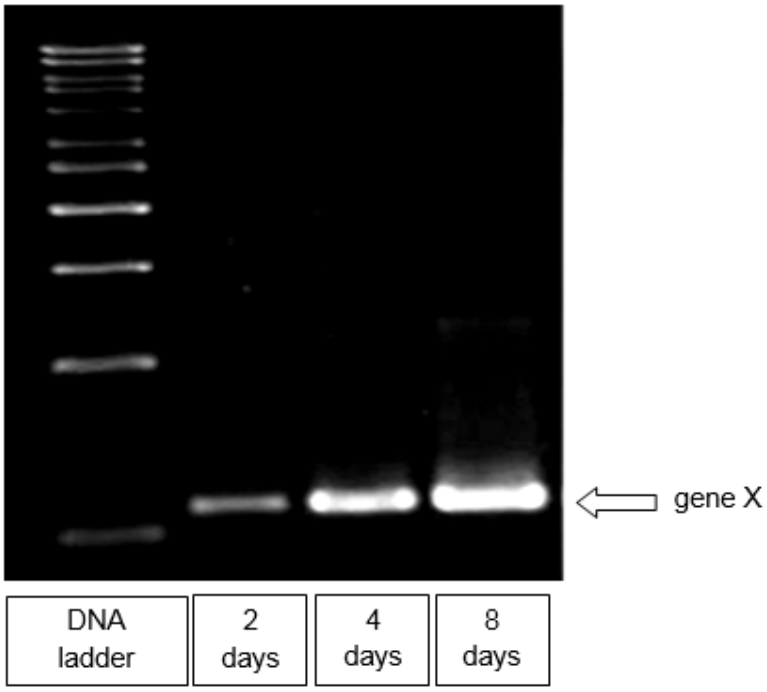
A Related genes are usually located on the same chromosome so that they can be controlled by the same set of control elements.

B The same set of general transcription factors may be capable of recognising the same promoter site of related genes.

C There are specific sets of control elements associated with related genes, recognised by specific sets of transcription factors.

D Within the control element of related genes, the specific numbers of transcription factors binding to the control element will enable related genes to be expressed.

15 Gel electrophoresis was performed using DNA samples of gene X isolated from equal number of cells from a human embryo after 2 days, 4 days and 8 days of development.



What kind of gene regulation is illustrated by the results of this gel electrophoresis?

A DNA demethylation

B Histone deacetylation

C Transcriptional activation

D Gene amplification

16 Fruit flies (*Drosophila*), homozygous for long wings, were crossed with flies homozygous for vestigial wings. The F_1 and F_2 generations were raised at three different temperatures.

At each temperature, the F_1 generation all had long wings.

The table shows the results in the F_2 generation.

Temperature / ºC	Result
21	¾ long wings, ¼ vestigial wings
26	¾ long wings, ¼ intermediate wing length
31	all long wings

Which statement explains these results?

A Heterozygous flies have vestigial wings only at 21ºC or below but have long wings at 31ºC or above.

B Long wing and vestigial wing illustrate codominance at 26ºC.

C Long wing is dominant at higher temperatures but vestigial wing is dominant at lower temperatures.

D Vestigial wing is recessive but causes a vestigial wing phenotype only at lower temperatures.

17 In mice, the gene for "dappled" coat (D) and its recessive allele for "plain" coat (d), are located on the X chromosome. The gene for "straight" whiskers (W) and its recessive allele for "bent" whiskers (w), are autosomal.

A male mouse with plain coat and bent whiskers was mated on several occasions to the same female and the large number of offspring consisted of males and females in equal numbers in all possible combinations of phenotypes,

What is the genotype of the female parent?

A X^DX^DWW

B X^DX^dWW

C X^DX^DWw

D X^DX^dWw

18 Three gene loci in mice are shown below.

Locus 1 Coat colour	**Locus 2** Tail appearance	**Locus 3** Coat appearance
agouti albino	kinky straight	non-frizzy frizzy

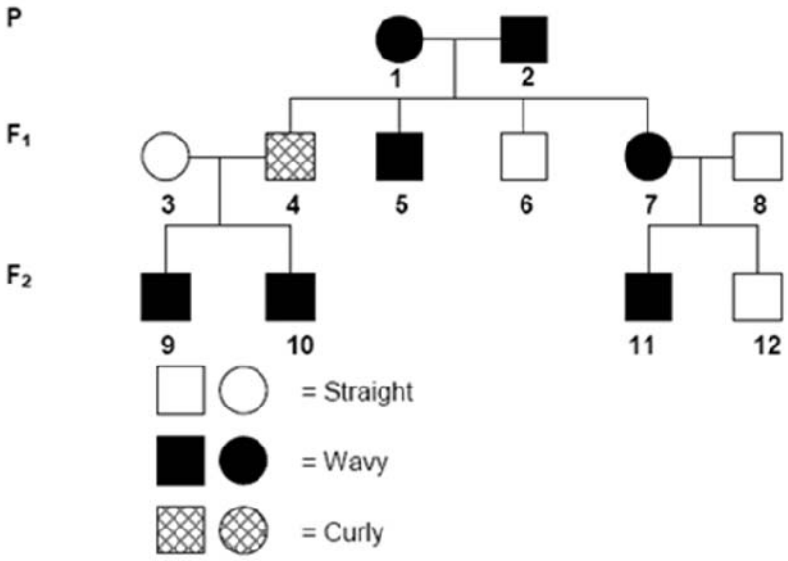
Crosses involving two loci at a time were set up and their outcomes are shown in the table below.

Parents (pure breeding)	**F1**	**Offspring of a test cross of the F1**
cross 1 agouti, non-frizzy coat x albino, frizzy coat	agouti, non-frizzy coat	agouti, non-frizzy coat 44 albino, frizzy coat 46 agouti, frizzy coat 5 albino, non-frizzy coat 5
cross 2 agouti, straight tail x albino, kinky tail	agouti, kinky tail	agouti, straight tail 23 albino, kinky tail 27 agouti, kinky tail 24 albino, straight tail 26

Which of the following statement is ***TRUE*** about **cross 1** and **cross 2**?

	Cross 1	**Cross 2**
A	The frequency of crossing over between locus 1 and locus 3 is 10%.	The agouti coat and kinky-tailed offspring of the test cross of the F1 are heterozygous at both loci.
B	Locus 1 and locus 3 undergo independent assortment.	The albino coat and straight-tailed offspring of the test cross are pure breeding.
C	Locus 1 and locus 3 are located on the same chromosome.	The F1 mice were test crossed with agouti coat and straight-tailed mice.
D	The interaction between locus 1 and locus 3 is an example of epistasis.	Locus 1 and locus 2 undergo independent assortment.

19 The pedigree below shows the inheritance of type of hair.



Which of the following statements are ***TRUE***?

I One of the parents of individual 2 may not always have the same phenotype as individual 2.

II If individual 10 married someone with wavy hair, the first child would have wavy hair.

III If individual 6 married a woman with straight hair, all of the offspring would have straight hair.

IV If individual 7 married a man with curly hair, the first child would have curly hair.

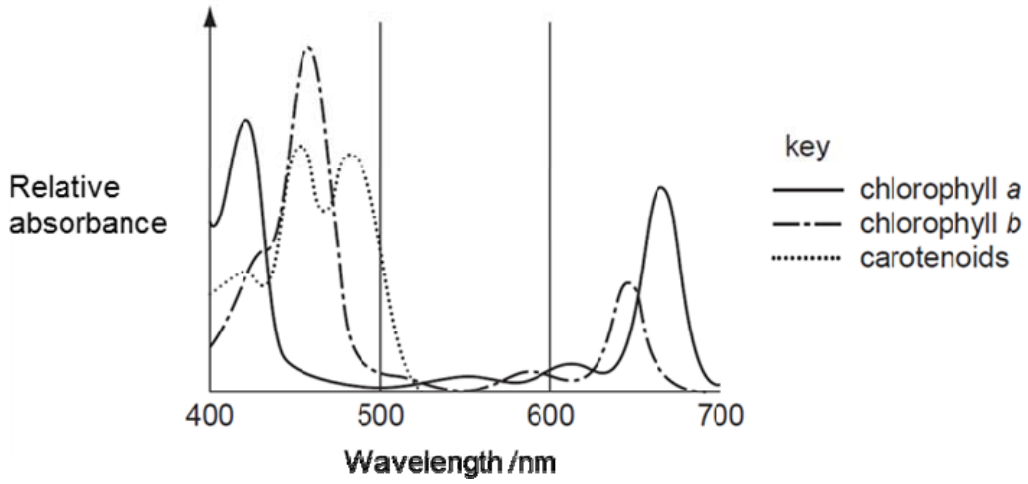
A **I** and **III** only

B **I** and **IV** only

C **II** and **III** only

D **II** and **IV** only

20 The graph shows the absorption spectra of some pigments found in chloroplasts.



Which statement is ***NOT*** correct?

A Having several pigments rather than one increases the efficiency of photosynthesis.

B Photosynthesis will be fastest when exposed to red light as red light has higher energy than blue light.

C Prior to leaf fall, chlorophyll is broken down, leaving carotenoids which makes leaves look yellow or red.

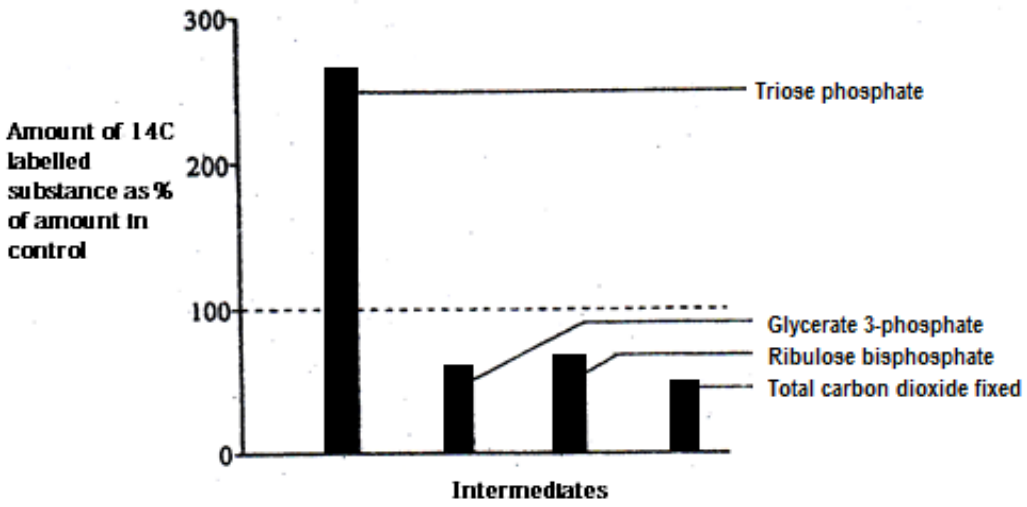
D Most leaves are green as chlorophyll absorbs light in the blue and red regions of the spectrum.

21 Removal of the source of carbon dioxide from photosynthesising chloroplasts results in rapid changes in the concentration of certain chemicals. Which one of the following represents the correct combination of concentration changes?

	ATP	***ribulose bisphosphate***	***glycerate-3-phosphate***
A	increases	increases	decreases
B	increases	decreases	increases
C	decreases	increases	decreases
D	decreases	decreases	increases

22 An experiment was conducted to test the properties of a chemical G on the photosynthetic capabilities of a unicellular agar, *Chlorella*. An illuminated suspension of the alga was treated with carbon dioxide labelled with ^{14}C in the presence of an unknown chemical G. The light was switched off and the amount of radioactivity present in some intermediates was determined after 10 minutes in the dark.

A control suspension of alga without chemical G being added was treated in exactly the same manner. The bar chart below shows the amount of radioactivity in these intermediates in the alga with chemical G added as a percentage of the intermediates in the control alga.



Which option ***CORRECTLY*** describes the action of chemical G?

A G binds to NADPH produced in light reactions and prevent its oxidation process.

B G competes with triose phosphate for the active site of the enzyme that converts triose phosphate into hexose phosphate.

C G inhibits the ribulose bisphosphate carboxylase enzyme, preventing carbon fixation from taking place efficiently.

D G prevents the regeneration of ribulose bisphosphate at the stage after triose phosphate was formed.

23 Which one of the following substances, when added, would directly result in a decline in ATP production in glycolysis?

I A chemical that would bind to NAD^+ irreversibly and induces its reduction to NADH.

II An inhibitor that has a similar structure to glucose but cannot be broken down by respiratory enzymes.

III A chemical that creates an anaerobic environment by combusting in oxygen

IV A reagent that binds to the active site of ATPase permanently

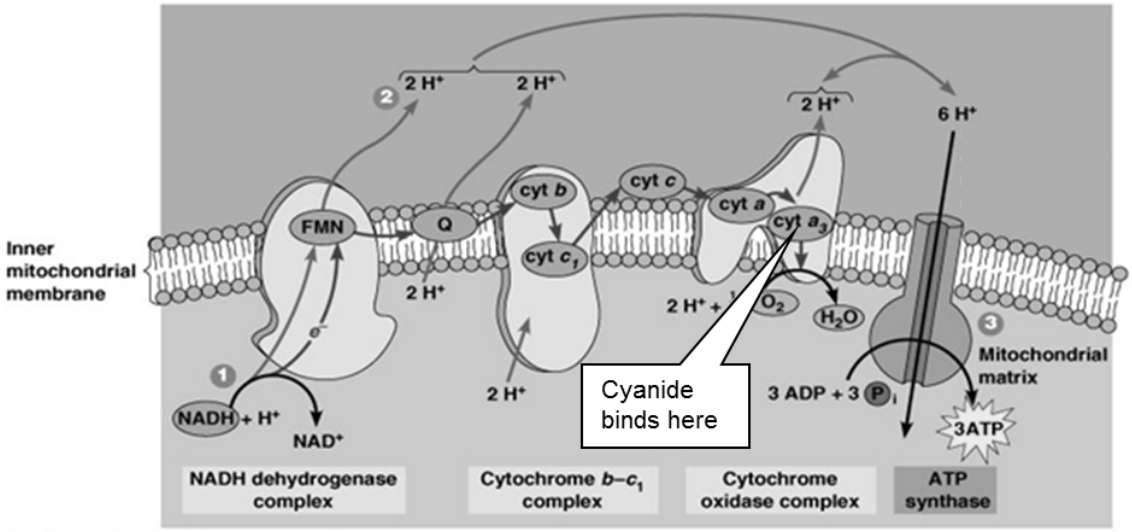
A **I** and **II** only

B **III** and **IV** only

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

D All of the above

24 Cyanide is an inhibitor that binds irreversibly with the enzyme cytochrome oxidase in the electron transport chain. The diagram below shows the position where cyanide binds.



Which statement is ***TRUE*** of its effect on cellular respiration?

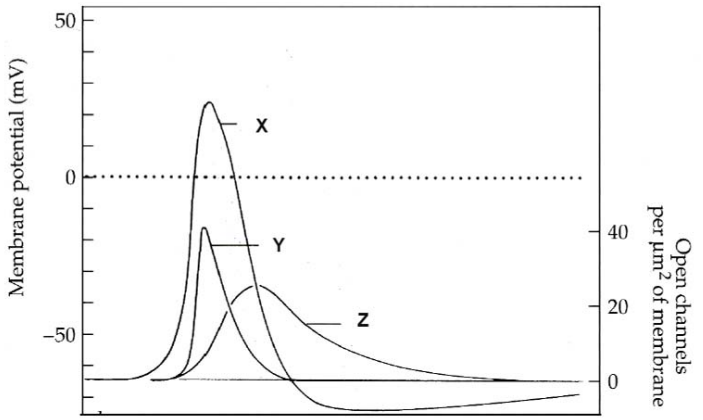
A It prevents cells from breaking down glucose.

B It prevents all synthesis of ATP in the cell.

C The cell's demand for oxygen would decrease.

D NAD+ would still be regenerated at the electron transport chain.

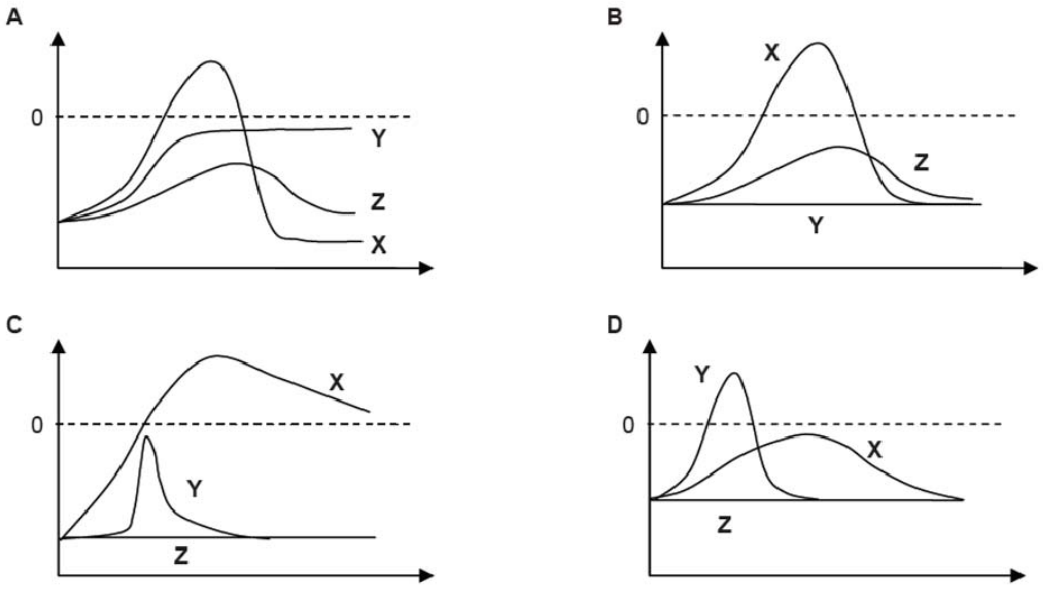
For Questions 25 and 26 refer to the figure below.



25 The values of Y and Z affect the value of X in an action potential. What do X, Y and Z in the above figure represent?

	X	Y	Z
A	Change in membrane potential	Sodium ion permeability	Calcium ion permeability
B	Sodium ion permeability	Potassium ion permeability	Calcium ion permeability
C	Change in membrane potential	Sodium ion permeability	Potassium ion permeability
D	Sodium ion permeability	Calcium ion permeability	Potassium ion permeability

26 Maurotoxin is a neurotoxin released by scorpions that blocks the pore of the voltage-gated K^+ channel in neurons. Choose from the following graphs to represent how the above diagram will change upon addition of maurotoxin to a neuron.



27 Which of the following statements about diabetes is ***FALSE***?

A In Type 1 diabetes, insulin receptors are absent.

B In Type 2 diabetes, beta cells of the islets of Langerhans are normal.

C In Type 1 diabetes, beta cells of the islets of Langerhans are not functional.

D In Type 2 diabetes, insulin receptors are defective.

28 Which of the following ***CORRECTLY*** describes the action of a trimeric G-protein?

A G-protein is phosphorylated and activated by receptor tyrosine kinase.

B G-protein has GTPase activity, hydrolysing GDP to GTP.

C Presence of an intracellular signal molecule activates the G-protein coupled receptor, leading to activation of G-protein.

D Activated subunits of the G-protein travel along the cell surface membrane to activate adenylyl cyclase.

29 A scientist is investigating the effects of Poison **T** on the cell signalling pathway of glucagon. It is found that Poison **T** is lipid soluble and diminishes the effect of glucagon. The levels of cAMP were also low in the cell.

Which of the following are possible statements that explain the effects of Poison **T**?

I Poison **T** binds directly to proteins in the cytoplasm.

II Poison **T** prevents G protein from hydrolysing GTP.

III Poison **T** inactivates the enzyme adenylyl cyclase.

IV Poison **T** prevents signal amplification by binding competitively to protein kinase A.

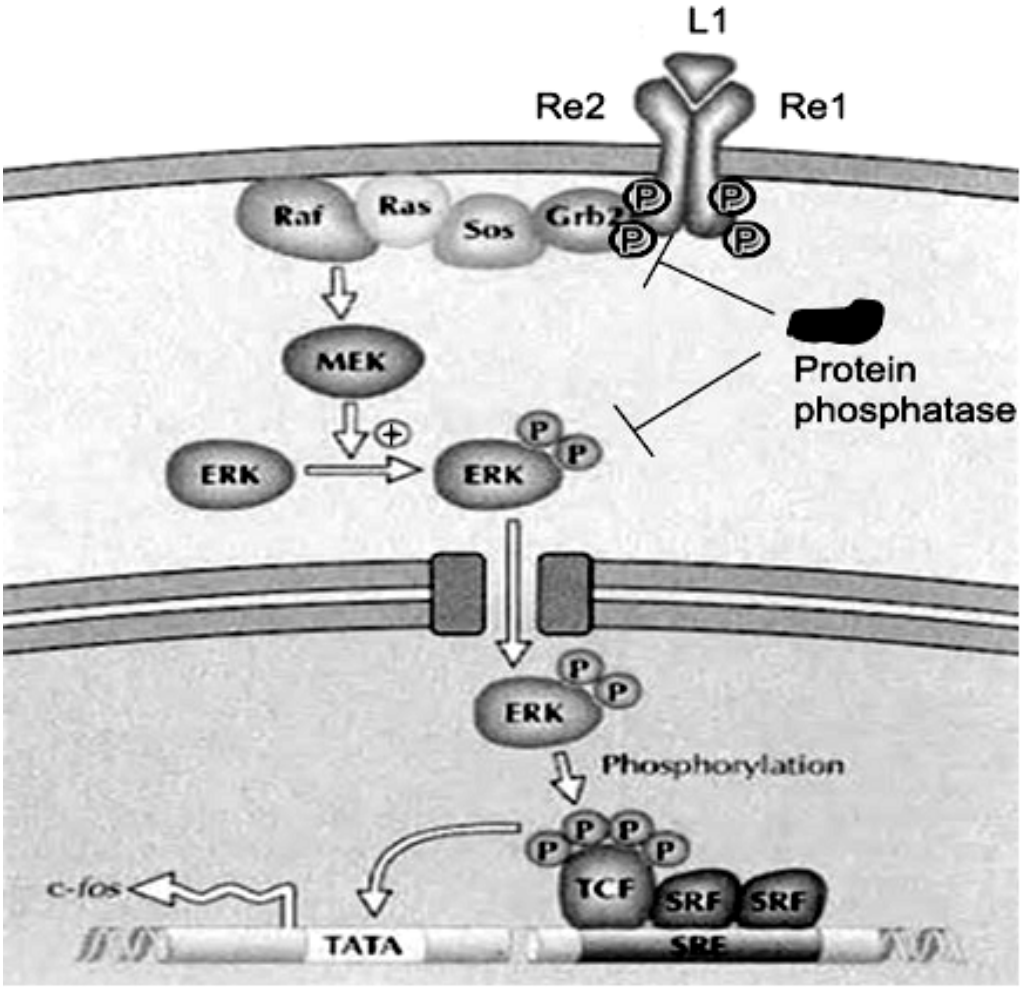
A **I** and **III** only

B **II** and **IV** only

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

D **I**, **III** and **IV**

30 The diagram below shows the cell signalling pathway involving a growth factor receptor.



From the given diagram, which step is involved in the role of signal amplification?

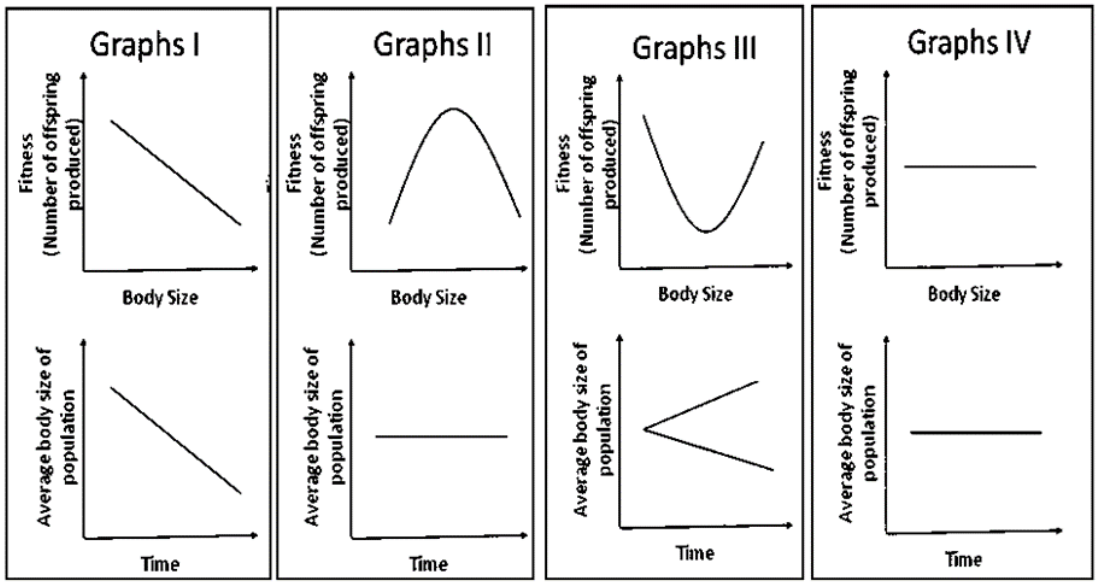
A Binding of L1 to Re1 and Re2.

B Auto-phosphorylation of Re1 and Re2.

C Phosphorylation of ERK by MEK.

D Dephosphorylation by protein phosphatase.

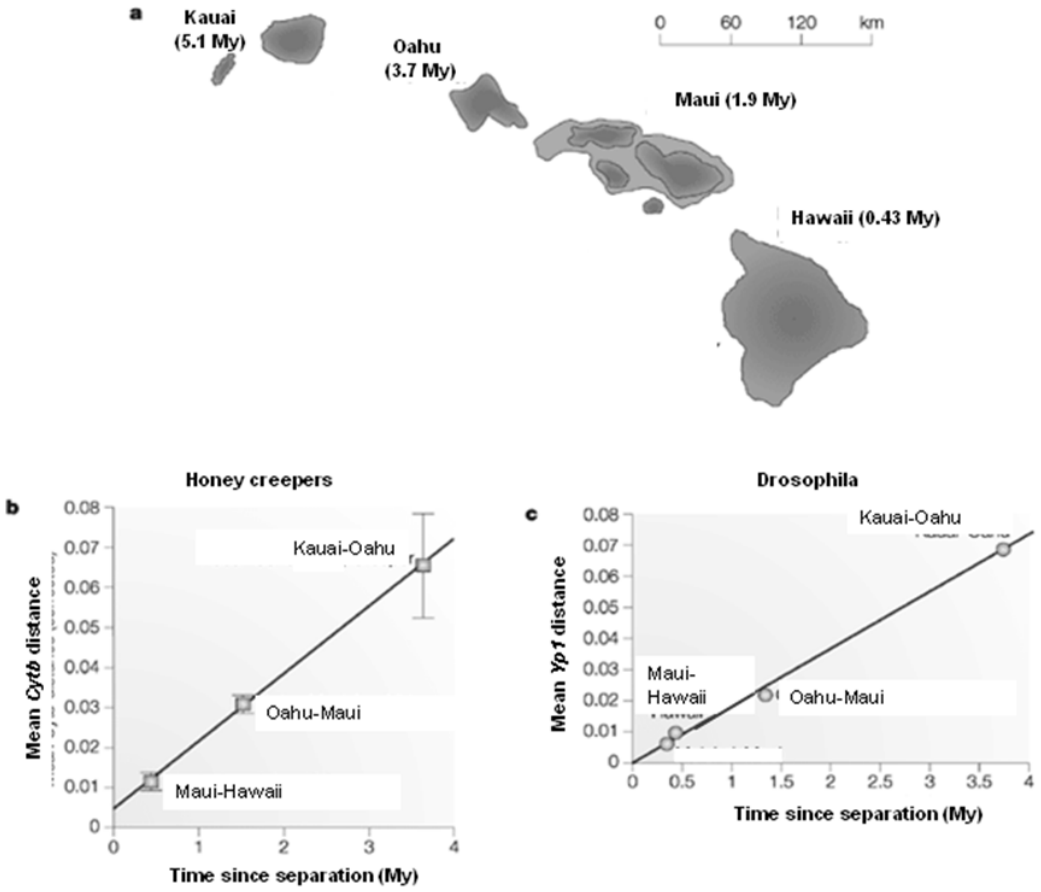
31 The different forms of natural selection can be distinguished according to their effect on the body size of the pink salmon (*Onchorhynchus gorbuscha*).



Which of the following describes the ***CORRECT*** form of natural selection for each of the following sets of graphs?

	Graphs I	**Graphs II**	**Graphs III**	**Graphs IV**
A	Disruptive selection	Directional selection	Stabilizing selection	No selection
B	No selection	Stabilizing selection	Directional selection	Disruptive selection
C	Directional selection	Stabilizing selection	Disruptive selection	No selection
D	Directional selection	Disruptive selection	No selection	Stabilizing selection

32 The volcanic islands that were formed millions of years ago, range from Kauai (the oldest) to Hawaii (the youngest). *Cytb* gene from honey creepers and *Yp1* gene from *Drosophila* were analysed for divergence.



Which of the following statement is ***INCORRECT***?

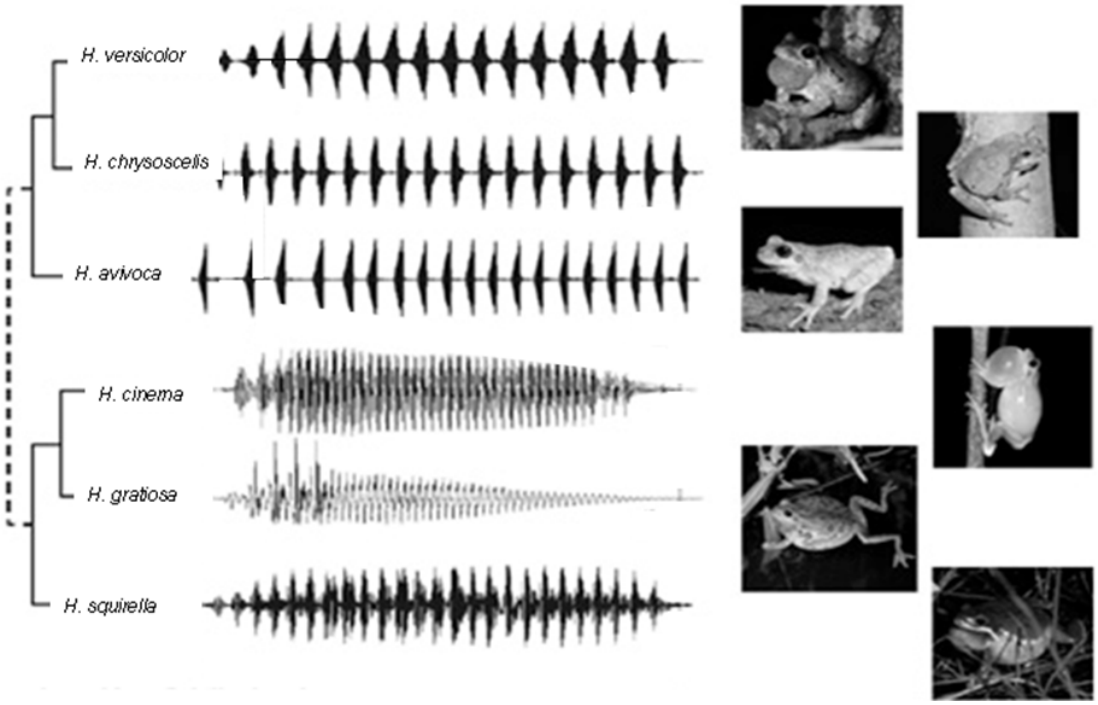
A Geographical isolation prevented colonization of newly formed islands.

B There is a positive linear correlation between genetic distance and island age.

C *Cytb* gene and *Yp1* gene are chosen because they are essential genes.

D Genetic drift is a factor that contributes to the increase in the mean genetic distance.

33 The calls of six different species of frogs belonging to the *Hyla* genus are recorded and shown.



Which of the following can be inferred from the chart?

I Frogs with more similar call patterns are more closely related.

II A frog species can be identified by looking at the duration, intensity, and frequency of the call.

III The call of each species of frog affects their survivability.

IV These calls are a form of isolation mechanism.

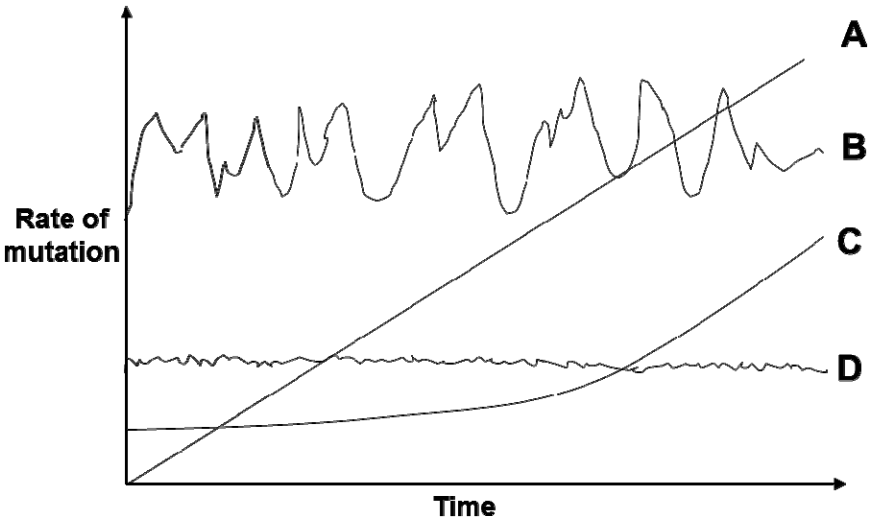
A **I** and **II** only

B **I**, **II** and **IV** only

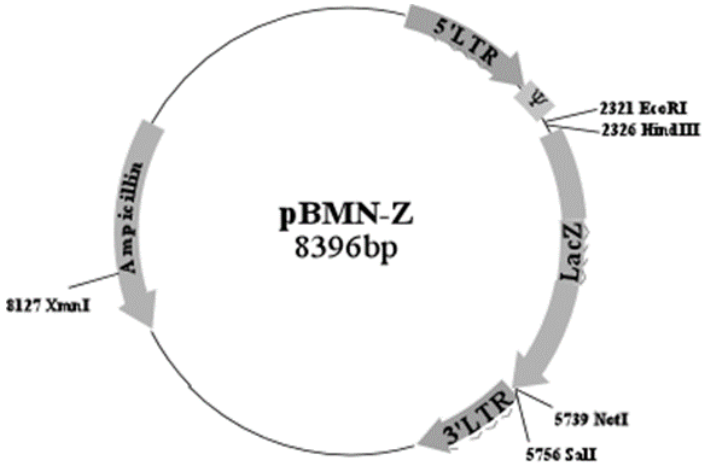
C **I** and **III** only

D All of the above

34 Which pattern of mutation rate would be most helpful if one desires to use a gene as a molecular clock to determine evolutionary relatedness of species that are closely related to each other?



35 As part of the procedure to produce recombinant proteins in *E. coli*, you are asked to insert the gene encoding for the MAL protein into the pBN-Z vector. The restriction sites and selectable markers on the vector are shown below.



If the gene for MAL protein were to be inserted into Lac Z site, what should be added to the agar plate in order to screen for recombinant clones and how would the recombinant clones appear?

	Chemicals to be added		**Colour of colonies**
A	Ampicilin	X-gal	Blue
B	β-galactosidase	X-gal	Blue
C	Ampicilin	X-gal	White
D	β-galactosidase	lactose	White

36 What is the key reason for using a greater range of probes and restriction enzymes in DNA fingerprinting?

A It permits more regions of the DNA to be analysed so as to reduce the possibility that two individuals' DNA would produce the same banding pattern.

B It is necessary for the creation of unique DNA fingerprints from two individuals' DNA that are significantly different in sequence.

C It increases the likelihood that one of the probes will bind to the polymorphic region of the DNA after the latter is cut by the restriction enzymes.

D It allows all the DNA bands produced via restriction enzymes cutting to be detected so as to give a more accurate DNA fingerprint.

37 Some of the goals of the Human Genome Project are:

- To determine the sequence of the entire human genome
- To identify all the genes in the human genome
- To find the locus of all the genes on the 46 human chromosomes

Which of the following are ethical concerns arising from the goals stated?

I Anthropologist tracing the ancestry of human populations.

II Parents choosing embryos for implantation only after tests for acceptable genes.

III Insurance company offering cheaper rates to people with genetic disposition to fewer diseases.

IV Scientists developing tests for only some disease causing genes.

V Genetic counsellors giving advice to people who are genetically pre-disposed to risks.

A **II** and **III**

B **III** and **IV**

C **I** and **V**

D **IV** and **V**

38 Totipotency is demonstrated when _____.

A cancer cells give rise to heterogeneous cell types.

B an isolated plant cell develops into a normal adult plant.

C a hematopoietic stem cell differentiates into a lymphocyte.

D an embryonic stem cell divides and differentiates.

39 Which of the following genetic modifications would ***NOT*** decrease the quantity of chemicals sprayed onto crop plants by farmers?

A Fungal resistance

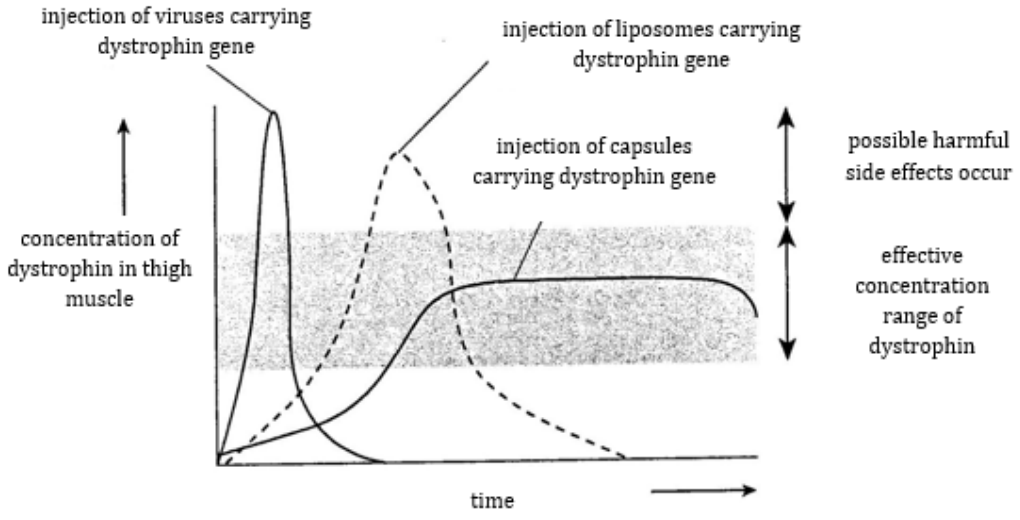
B Herbicide resistance

C Insect resistance

D Viral resistance

40 Duchenne muscular dystrophy (DMD) is a lethal X-linked human genetic disease caused by the absence of the protein dystrophin in muscle fibres.

Gene therapy experiments were conducted to compare the effectiveness of three different vectors for introducing a corrective gene coding for dystrophin. Each of the three vectors, virus, liposome and capsule, carrying normal copies of the dystrophin gene was injected into the thigh muscle tissue of DMD patients. The results are shown in the graph.



Which is a viable advantage of the capsule vector over the viral and liposome vectors?

A It produces more dystrophin.

B It takes effect in more target cells.

C It takes a shorter time to take effect.

D It requires less frequent treatments.

END OF PAPER

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2016 Y6 Preliminary Exam H2

MCQ Answer Scheme

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

Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY 9648/02

Paper 2 Structured and Free-Response Questions **19 September 2016**

2 hours

Additional Materials: Writing paper

INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Section B Structured Questions

Answer **all** questions.

Write your answers on space provided in the Question Paper.

Section C Free-Response Questions

Answer **one** question. Your answer to Section C must be in continuous prose, where appropriate. Write your answers on the writing paper provided.

Submit your answers to Sections B and Section C separately.

INFORMATION FOR CANDIDATES

Essential working must be shown.

The intended marks for questions or parts of questions are given in brackets [ ].

For Examiner's Use	
Section A [40]	
Section B [80]	
1	**/ 10**
2	**/12**
3	**/ 10**
4	**/ 12**
5	**/ 11**
6	**/ 9**
7	**/ 7**
8	**/ 9**
Section C [20]	
1 / 2	
Total [140]	

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

[Turn over

Section B: Structured Questions (80 marks)
Answer **all** questions in this section.

For Examiner's use

Question 1

Triglycerides are not transported in the blood on their own as they are insoluble in water. Instead they are transported within lipoproteins such as LDL. Lipoproteins are made up of proteins and lipids. Their function is to carry cholesterol, triglycerides and other lipids through the blood. Lipoproteins such as LDL are then taken up by target cells via receptor mediated endocytosis.

Fig. 1.1 illustrates the structure of a LDL.

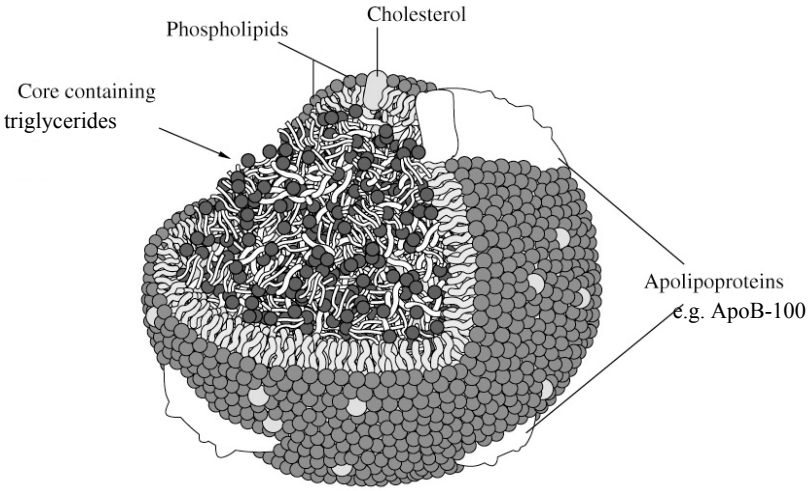


Fig. 1.1

Fig. 1.2 below shows the uptake of an LDL particle into a cell.

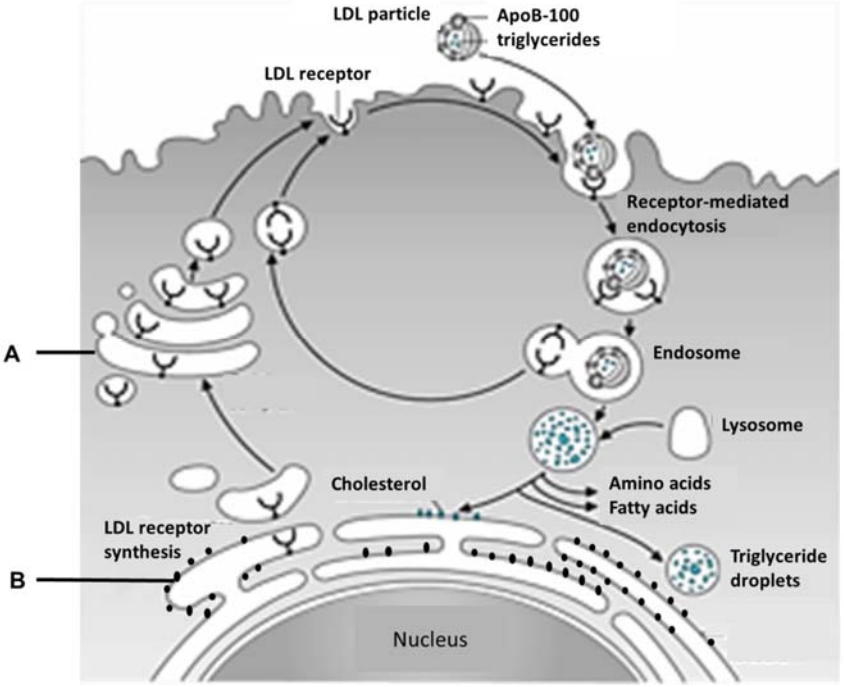


Fig. 1.2

For Examiner's use

(a) With reference to **Fig. 1.1**, explain the role of phospholipids in lipoproteins such as LDL. [2]

(b) With reference to **Fig 1.2**,

(i) Name the organelles labelled **A** and **B**. [2]

A :

B :

(ii) Explain the roles of organelles **A** and **B** in expression of the LDL receptor on the cell surface. [4]

A :

B :

(c) Using the fluid mosaic model, explain how the properties of the cell surface membrane enable the uptake of LDL by a cell. [2]

Total:[10]

Question 2

For Examiner's use

(a) **Fig. 2.1** shows the sequence of bases in a section of a single-stranded RNA virus. The bases code for the **first few amino acids** of a polypeptide chain.

5' UACAUGGAUUACCCCGUUGUACAU 3'

Fig. 2.1

Each codon codes for a specific amino acid as shown in **Table 2**.

Table 2

UUU	phe	UCU	ser	UAU	tyr	UGU	cys
UUC	phe	UCC	ser	UAC	tyr	UGC	cys
UUA	leu	UCA	ser	UAA	STOP	UGA	STOP
UUG	leu	UCG	ser	UAG	STOP	UGG	trp
CUU	leu	CCU	pro	CAU	his	CGU	arg
CUC	leu	CCC	pro	CAC	his	CGC	arg
CUA	leu	CCA	pro	CAA	gln	CGA	arg
CUG	leu	CCG	pro	CAG	gln	CGG	arg
AUU	ile	ACU	thr	AAU	asn	AGU	ser
AUC	ile	ACC	thr	AAC	asn	AGC	ser
AUA	ile	ACA	thr	AAA	lys	AGA	arg
AUG	met	ACG	thr	AAG	lys	AGG	arg
GUU	val	GCU	ala	GAU	asp	GGU	gly
GUC	val	GCC	ala	GAC	asp	GGC	gly
GUA	val	GCA	ala	GAA	glu	GGA	gly
GUG	val	GCG	ala	GAG	glu	GGG	gly

Using information from **Fig. 2.1** and **Table 2**,

(i) State the **third** amino acid coded by the section shown in **Fig. 2.1** if the virus was a **positive-sense** RNA virus. [1]

(ii) State the **fourth** amino acid coded by the section shown in **Fig. 2.1** if the virus was a **negative-sense** RNA virus. [1]

For Examiner's use

(b) **(i)** Termination of protein synthesis is not 100% efficient. A number of natural mechanisms that suppress translation termination exist. One of them is the 'STOP codon readthrough'. This process enables the ribosome to pass through the STOP codon in mRNA and continue translation to the next STOP codon. STOP codon readthrough is commonly observed in viruses.

Suggest an advantage of STOP codon readthrough for viruses. [1]

(ii) 'Nonstop' mutations are single base-pair substitutions that occur within translational termination (stop) codons.

State the immediate events that would occur when the ribosome reaches one such 'nonstop' mutation during translation of an mRNA in yeast. [2]

(iii) Contrast 'nonstop' mutation with 'nonsense' mutation. [1]

For Examiner's use

(c) Cystic fibrosis is a genetic disorder that affects the respiratory and digestive systems. People with cystic fibrosis inherit a defective gene on chromosome 7 called CFTR (cystic fibrosis transmembrane conductance regulator) gene.

Well over one thousand mutations have been described that can affect the CFTR gene. Two of such mutations are shown in **Fig. 2.2**.

Amino acid position	*506*	*507*	*508*	*509*	*510*		*522*	*523*	*524*
Normal CFTR gene	ATC	ATC	TTT	GGT	GTT	.....	GCA	TGC	CAA
Mutation 1	ATC	ATT	GGT	GTT	GCC	.....	GCA	TGC	CAA
Mutation 2	ATC	ATC	TTT	GGT	GTT	.....	GCA	TGA	CAA

Fig. 2.2 (showing part of the base sequence on the non-template DNA strand)

Table 2

UUU	phe	UCU	ser	UAU	tyr	UGU	cys
UUC	phe	UCC	ser	UAC	tyr	UGC	cys
UUA	leu	UCA	ser	UAA	STOP	UGA	STOP
UUG	leu	UCG	ser	UAG	STOP	UGG	trp
CUU	leu	CCU	pro	CAU	his	CGU	arg
CUC	leu	CCC	pro	CAC	his	CGC	arg
CUA	leu	CCA	pro	CAA	gln	CGA	arg
CUG	leu	CCG	pro	CAG	gln	CGG	arg
AUU	ile	ACU	thr	AAU	asn	AGU	ser
AUC	ile	ACC	thr	AAC	asn	AGC	ser
AUA	ile	ACA	thr	AAA	lys	AGA	arg
AUG	met	ACG	thr	AAG	lys	AGG	arg
GUU	val	GCU	ala	GAU	asp	GGU	gly
GUC	val	GCC	ala	GAC	asp	GGC	gly
GUA	val	GCA	ala	GAA	glu	GGA	gly
GUG	val	GCG	ala	GAG	glu	GGG	gly

Using information from **Fig. 2.2** and **Table 2**,

(i) Explain the effect of mutation 1 on the structure of the protein formed. [4]

(ii) Explain the effect of mutation 2 on the amino acid sequence in the protein. [2]

For Examiner's use

Total: [12]

Question 3

For Examiner's use

Fig. 3.1 shows the first step in T4 infection of its host.

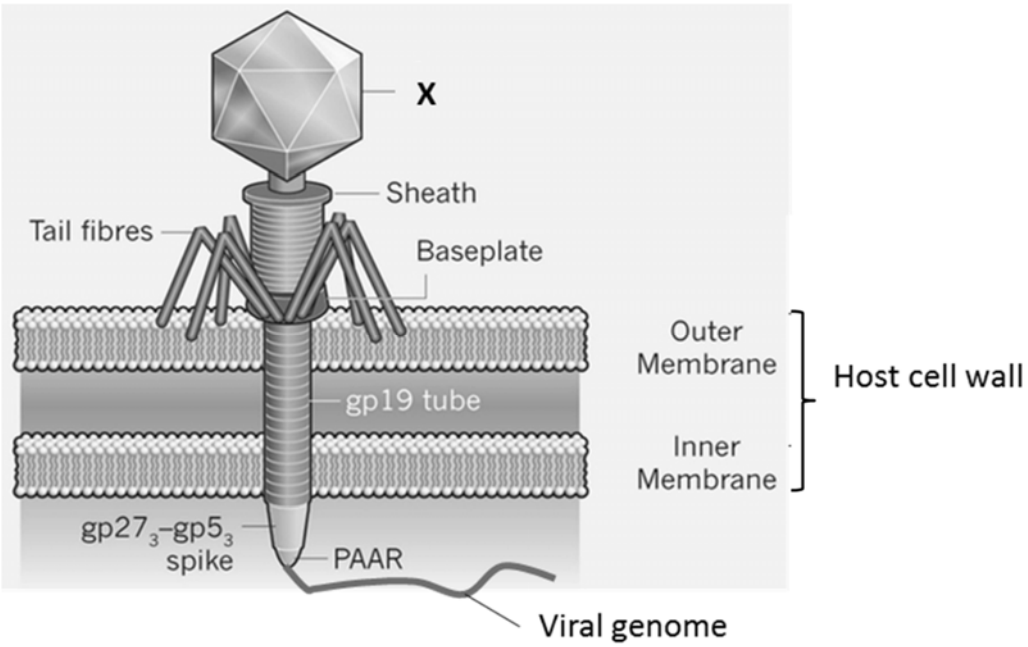


Fig. 3.1

(a) Name structure **X** and explain its function. [2]

(b) Explain the role of the contractile sheath and as shown in **Fig. 3.1**. [2]

(c) Describe what occurs after the stage shown in **Fig. 3.1** to complete the virus life cycle. [4]

For Examiner's use

(d) Explain how the T4 phage can result in horizontal gene transfer between bacteria. [2]

Total: [10]

Question 4

For Examiner's use

(a) **Fig. 4.1** shows the different phases of the cell cycle. The arrows indicate the checkpoints of the cell cycle.

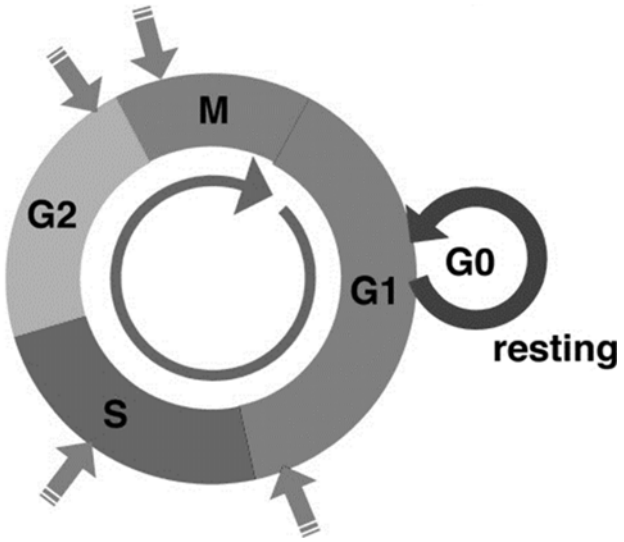


Fig. 4.1

(i) Outline how the normal mitotic cell cycle is regulated at the G_1 and M checkpoints. [4]

(ii) G_2 is part of a stage that takes place during the cell cycle. Describe what happens during this stage. [2]

For Examiner's use

(iii) Upon maturity, nerve and heart muscle cells enter into a G_0 phase that can last indefinitely. Such cells are said to be quiescent. On the other hand, cells such as fibroblasts can reach a maximum of 50 cell divisions before becoming senescent.

State two differences between cellular quiescence and senescence. [2]

(b) **Fig. 4.2** below shows a cell at a certain stage of nuclear division in *Drosophila*.

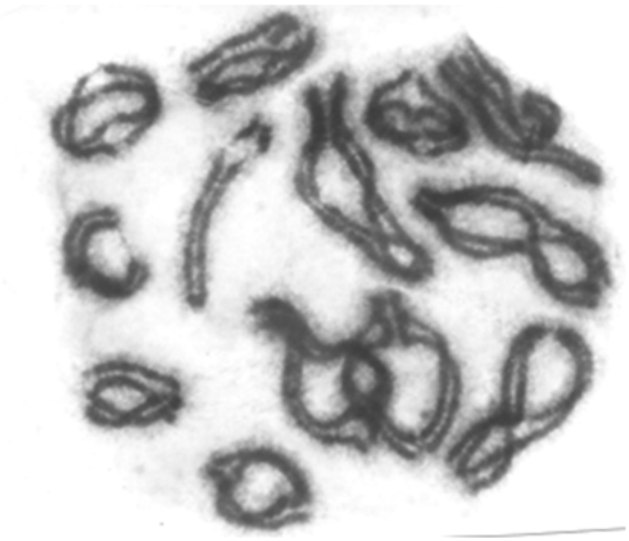


Fig. 4.2

(i) State the number of telomeres present in the cell. Explain your answer. [2]

(ii) Explain the role centromeres play in mitosis. [2]

Total: [12]

Question 5

For Examiner's use

(a) Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries which may have anticancer properties. The dominant allele, K, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, D, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, d, does not affect malvidin production.

(i) Draw a genetic diagram to show the gametes and the genotypes and phenotypes of the F1 and F2 generations of a cross between a pure-breeding malvidin-producing plant and a non-producing plant of genotype k'k'DD. Give the ratio of the phenotypes in the resulting F2 generation. [4]

For Examiner's use

(ii) Explain how the two genes interact. [2]

.....

.....

.....

.....

(b) The dominant allele, S, of another gene results in the fruits having smooth skin, whilst the recessive allele, s', results in the fruits having wrinkled skin. A cross was made between a malvidin-producing plant with smooth-skinned fruits (KKSS) and a non-producing plant with wrinkled-skinned fruits (k'k's's'). The F_1 generation were all malvidin-producing plants with smooth-skinned fruits. The F_1 plants were test crossed and gave offspring with the following numbers of plants in each of the four phenotypes:

Malvidin-producing plants with smooth-skinned fruits	40
Non-producing plants with wrinkled-skinned fruits	42
Malvidin-producing plants with wrinkled-skinned fruits	20
Non-producing plants with smooth-skinned fruits	18

Distribution of χ^2

Degrees of freedom	Probability, p				
	0.10	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

χ^2 test: $\chi^2 = \Sigma \frac{(O - E)^2}{E}$ $\nu = c - 1$

Key to symbols: Σ = sum of …
ν = degrees of freedom
c = number of classes
O = observed value
E = expected value

For Examiner's use

(i) Calculate the χ^2 value for the given data. Show your working below. [2]

(ii) Using the information from the table provided, explain the conclusion drawn from the calculated χ^2 value above. [3]

Total:[11]

Question 6

For Examiner's use

(a) The Korean rice beer *takju* is prepared by mixing a yeast fermentation starter powder (*nuruk*) with cooked rice and incubating at approximately 20°C for 2-3 days, following which it is filtered through a fine mesh. **Fig. 6.1** shows the summary of this process.

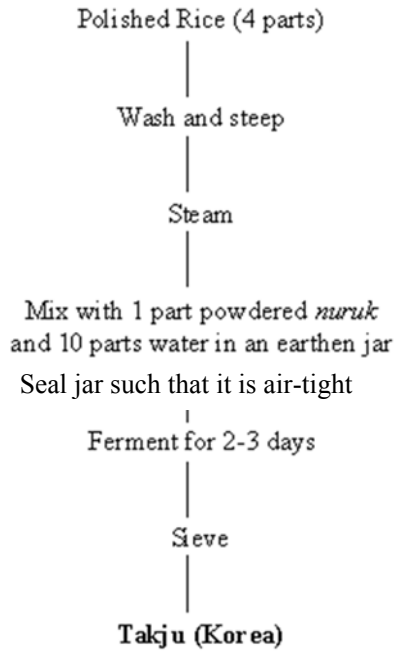


Fig. 6.1

Biochemical changes occurring during the fermentation of *takju* are summarised in **Fig. 6.2**.

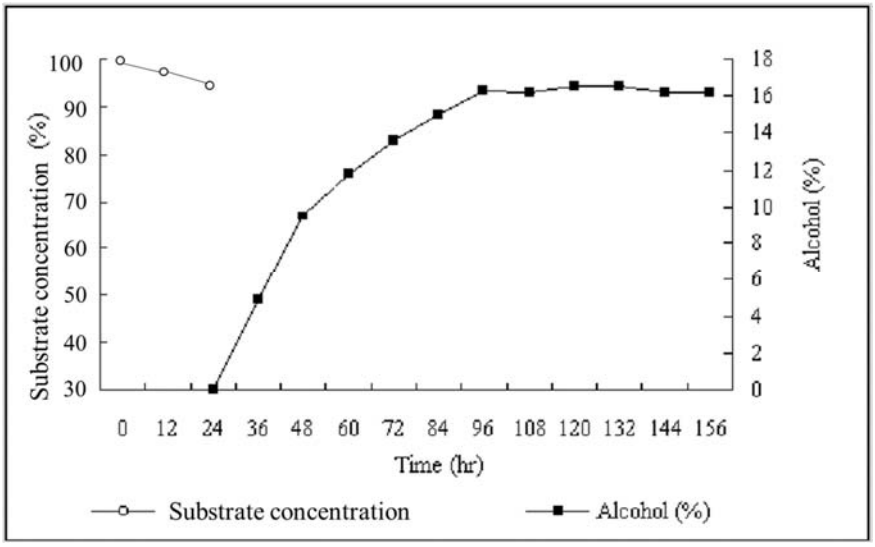


Fig. 6.2

For Examiner's use

(a) With reference to **Fig. 6.1** and **Fig. 6.2**,

(i) Explain why there was a lag time of 24h before any alcohol was produced. [1]

(ii) Explain the mode of respiration of the yeast between 24-96h and relate it to the production of alcohol in the brewing of *takju*. [5]

(iii) Explain why there is no further increase of alcohol concentration after 96h. [2]

(b) **Fig. 6.2** shows the changes in substrate concentration in the brewing of *takju* from 0-24h.

Complete the graph on **Fig. 6.2** to show the predicted changes in substrate concentration from 24-96h. [1]

Total: [9]

Question 7

For Examiner's use

(a) GABA is a neurotransmitter present in some parts of the nervous system. **Fig. 7.1** shows how the release of GABA from a presynaptic membrane affects the ion channels of a postsynaptic membrane.

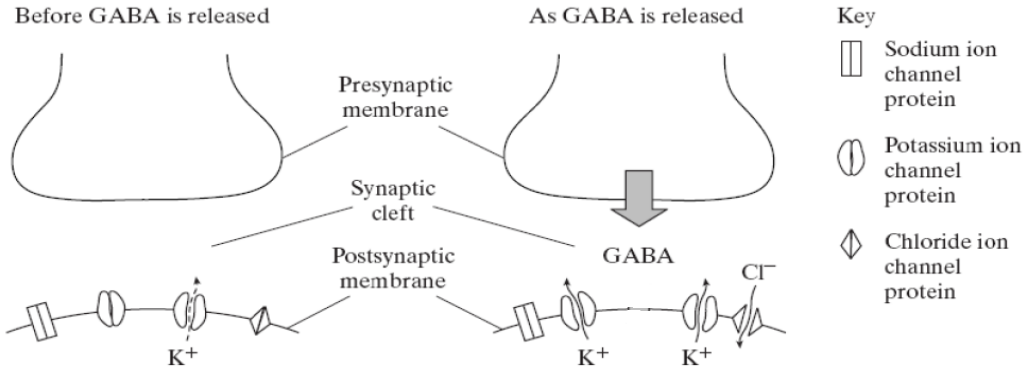


Fig. 7.1

(i) With reference to **Fig. 7.1**, explain what would happen to the membrane potential on the postsynaptic membrane when GABA is released. [2]

Fig. 7.2 shows the synapses of neurone **B** with two other neurones, **P** and **Q**.

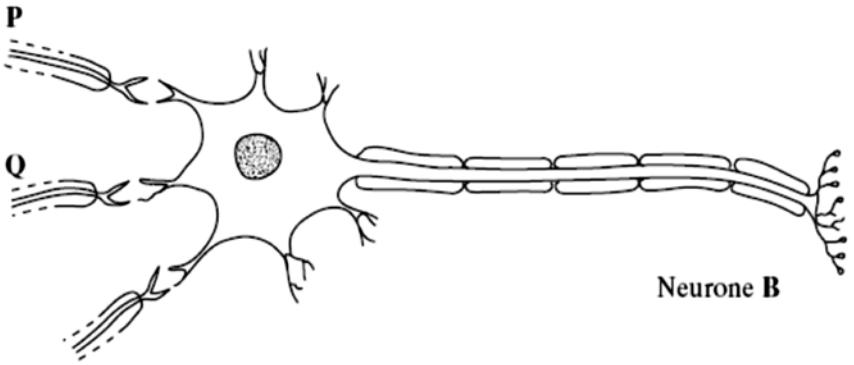


Fig. 7.2

Neurone **P** releases acetylcholine whereas neurone **Q** releases GABA.

For Examiner's use

(ii) Explain why neurone **B** is less likely to respond if both neurones **P** and **Q** are stimulated at the same time. [2]

(iii) Barbiturates act as depressants with effects similar to anesthetics. They act mainly by enhancing the activity of the GABA neurotransmitter. Suggest how barbiturates enhance the activity of the GABA neurotransmitter. [1]

(b) Explain how the temporal summation of various stimuli can result in a coordinated response at the postsynaptic neurone through post synaptic potentials. [2]

Total:[7]

Question 8

For Examiner's use

(a) Fishes in the genus *Anisotremus* comprise of ten described species which occur predominantly on coral reefs and subtropical rocky reefs in the Neotropics.

Bernardi *et.al.* did a molecular phylogenetic study on such fishes in that area. Results are shown in **Fig. 8.1**.

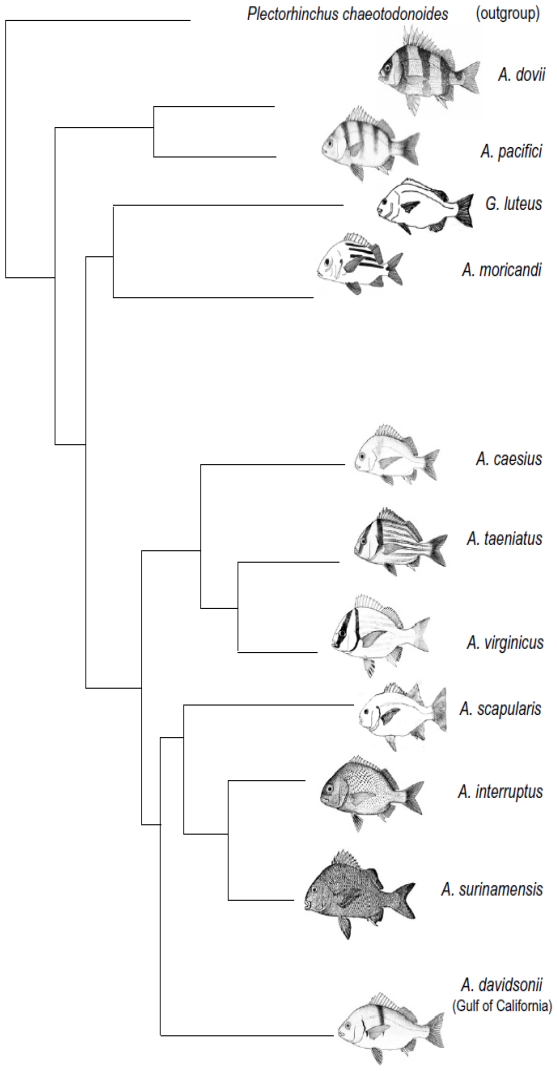


Fig. 8.1

(i) Explain how molecular methods can be used to elucidate the evolutionary relationships of the different species of *Anisotremus* fishes. [2]

(ii) Explain why it may be more reliable to construct a phylogenetic tree of the ten species of *Anisotremus* using molecular data instead of morphological comparisons. [2]

For Examiner's use

(iii) With reference to **Fig. 8.1** and molecular homology, comment on the evolutionary relationship between *A. taeniatus* and *A. virginicus*. [1]

For Examiner's use

(b) *A. taeniatus* is found in the Pacific Ocean, whereas *A. virginicus* is found in the Caribbean Sea. These two species were derived due to the formation of the Isthmus of Panama about 3.5 million years ago. Before that event, the waters of the Pacific Ocean and Caribbean Sea mixed freely.

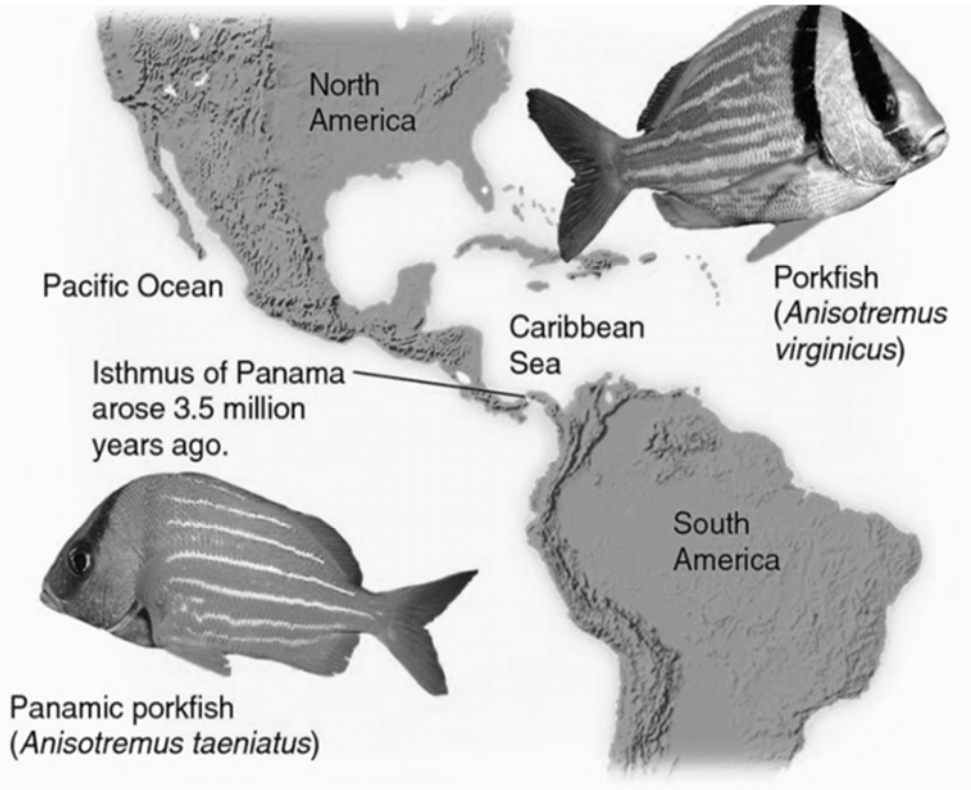


Fig. 8.2

Explain how the formation of the Isthmus of Panama results in the emergence of *A. taeniatus* and *A. virginicus*. [4]

Total:[9]

Section C: Free-Response Question (20 marks)

Answer only **one** question.
Write your answers on the writing paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.
A **NIL RETURN** is required.

Question 1

(a) Describe the protein folding of an enzyme and relate its structure to its function. [10]

(b) Describe the effect of pH on enzymes and their activity. [4]

(c) Compare and contrast competitive and non-competitive inhibitors and their effects on the rate of enzyme activity. [6]

OR

Question 2

(a) Distinguish between the processes of Krebs Cycle and Calvin Cycle. [8]

(b) State the similarities between ATP production in mitochondria and chloroplasts and suggest why these similarities exist. [6]

(c) Discuss the effects of varying carbon dioxide and oxygen levels on photosynthesis. [6]

Total: [20]

END OF PAPER

DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2016
YEAR SIX
H2 BIOLOGY (9648)
PAPER 2

Structured Questions Answers

Question 1

(a)
Phospholipids arranged in a **monolayer** with **hydrophobic hydrocarbon tails face inward** to interact with triglycerides in interior and **hydrophilic phosphate heads face outwards** to interact with the aqueous medium;

Makes hydrophobic lipids soluble for transport in the blood;

(b)(i)
A: Golgi apparatus;
B: Rough endoplasmic reticulum; (A: ribosome, R: ribosomes)

(b)(ii)
A:
chemically modifies the LDL receptors (e.g. glycosylates);
packages LDL receptors the into transport vesicles to be **targeted** to the plasma membrane for insertion into membrane;

B: RER
Ref to **translation** of LDL receptor mRNA at bound **ribosome**s to from LDL receptor polypeptide;
folding of polypeptide into native configuration inside cisternal space;
transport of newly synthesized LDL receptor to the cis face of the golgi apparatus within transport vesicles;
2 max

OR
B: ribosome
Ref to **translation** of LDL receptor **mRNA** to from LDL receptor **polypeptide**;
Ref to **peptidyl transferase** in large ribosomal subunit catalyzing the formation of **peptide bonds** between amino acids;

(c)
Fluid nature of phospholipids moving in the membrane allows invagination of plasma membrane/ fusion of two ends of plasma membrane to form endocytic vesicle;
Mosiac – membrane has proteins embedded such as the LDL receptor. Binding of LDL to receptor triggers invagination of the membrane;

Question 2

(a)(i) **Tyrosine (tyr);**

(a)(ii) **Glycine (gly);**

(b)(i) Increase coding capacity; AVP

(b)(ii)

Ribosomes will continue translation as **STOP codon now codes for an amino acid**;

Translation of the mRNA continues into the **3'-untranslated region**;

Translation continues until the **next in-frame stop codon downstream**;

2 max

(b)(iii)

Nonstop mutations differ from nonsense mutations in that they **do not create a stop codon but, instead, delete one**;

(c)(i)

Deletion of CTT (or TCT), at corresponding amino acid positions 507 and 508;

Change of codon from ATC to ATT results in **same amino acid encoded at position 507, isoleucine**;

Change of codon from TTT to GGT results in a **different amino acid at position 508 - glycine instead of phenylalanine** (OR **deletion of phenylalanine at position 508**);

Overall **primary structure of the polypeptide / amino acid sequence is changed;**

Ref. to change **affecting folding of the polypeptide / incorrect folding** of the polypeptide;

4 max

(c)(ii)

Single base substitution, at corresponding **amino acid position 523**, where the third base, **C is replaced by A**, changing the codon UGC to a **stop codon** UGA;

Results in **premature termination of translation**, producing a **truncated / shortened polypeptide chain**;

Question 3

(a)
Icosahedral capsid head;
protects the viral ds DNA when virus is outside its host;

(b)
Contractile sheath punctures a hole through bacterial host cell wall to allow entry of viral DNA into the host cell;
Ref to gp19 tube / gp27 – gp5 spike;
As viral DNA too large and charged to cross bacterial cell wall and cell membrane on its own;
2 max

(c)
Phage uses host cell DNA polymerase to synthesize new copies of phage DNA;
And host RNA polymerase and ribosomes to synthesize new phage proteins;
new phage particles then assemble from newly synthesized components;
Phage coded lysozyme breaks down peptidoglycan cell wall resulting in osmotic lysis of host and release of phage particles;
4 max

(d)
During T4 phage replication, a phage enzyme degrades bacterium host cell's DNA;
During assembly of the virus, a fragment of the host's genome may be packaged inside the virus capsid by mistake;
The resultant defective phage then injects this bacterial gene into another bacterium, thus resulting in horizontal gene transfer between bacteria;
2 max

Question 4

(a)(i)

G_1 checkpoint (**2 max**): checks that

- sufficient nutrients present;
- environment is favourable / need for new cells for replacement;
- sufficient growth of the cell / cell reach a minimum size;
- sufficient organelles;
- DNA not damaged and can be replicated;
- growth factors are present;

M checkpoint (**2 max**):

- Checks for attachment of spindle fibers to the kinetochores (centromeres) of the chromosomes;
- Ensures correct alignment of chromosomes at metaphase plate;
- Allows separation of sister chromatids equally at anaphase;

(a)(ii)

Synthesis of proteins/RNA/enzymes;

Formation of new organelles;

ATP production;

(a)(iii)

Quiescence is **reversible** while senescence is **irreversible**;

Quiescence occurs when cells are **neither dividing nor preparing to divide** (e.g. when they ‘exit’ from the cell cycle) while senescence occurs **in response to DNA damage or degradation** that would make a cell's progeny nonviable / when cells reach the **Hayflick limit** (i.e. reproductive limit);

(b)(i)

96 telomeres;

There are 11 tetrads/ bivalents and 1 pair of unpaired chromosomes (**A!** any suitable number based on clarity of diagram). Each chromosome consists of two sister chromatids, hence total number of sister chromatids is 48. Both ends of each sister chromatid is flanked by telomeres, hence the total number of telomeres is 96;

(b)(ii)

- Centromeres **hold genetically identical sister chromatids together** as the chromosomes align themselves at the metaphase plate;
- **Kinetochore proteins** bind to the centromeres;
- During metaphase spindle fibres from both poles attach to the kinetochore proteins;
- During anaphase, shortening of the spindle fibres and the duplication of the centromeres results in sister chromatids being separated to opposite poles;
- Such that at the end of mitosis, each daughter nuclei contains the identical genetic material.

2 max

Question 5

(a)(i)

Parental phenotypes malvidin producing plant X non-producing
Parental genotypes KKdd X k'k'DD

Gametes (Kd) X (k'D) [1]

F_1 phenotype Non-producing plant X Non-producing plant
F_1 genotype Kk'Dd X Kk'Dd

F_1 gametes (KD) (k'D) (Kd) (k'd) X (KD) (k'D) (Kd) (k'd)
[1]

F2 genotype

	(KD)	(k'D)	(Kd)	(k'd)
(KD)	KKDD Non-producing	Kk'DD Non-producing	KKDd Non-producing	Kk'Dd Non-producing
(k'D)	Kk'DD Non-producing	k'k'DD Non-producing	Kk'Dd Non-producing	k'k'Dd Non-producing
(Kd)	KKDd Non-producing	Kk'Dd Non-producing	KKdd Malvidin producing	Kk'dd Malvidin producing
(k'd)	Kk'Dd Non-producing	k'k'Dd Non-producing	Kk'dd Malvidin producing	k'k'dd Non-producing

[1]

F2 genotype:	**KKDD, Kk'DD, KKDd, Kk'Dd, k'k'Dd, k'k'DD, k'k'dd**	**KKdd, Kk'dd**
F2 phenotype:	**non-producing**	**malvidin producing plant**
F2 phenotypic ratio:	**13**	**: 3**

[1]

(a)(ii)
Allele D is epistatic over the K and k' locus where it prevents the formation of malvidin;
By synthesizing a gene product which suppresses the action of the enzyme encoded by K / D codes for an inhibitor which binds to and prevents the action of the enzyme encoded by K;

(b)(i)

$$\chi^2 = \frac{(40 - 30)^2}{30} + \frac{(42 - 30)^2}{30} + \frac{(20 - 30)^2}{30} + \frac{(18 - 30)^2}{30}$$

$$= 16.27; \text{ (2dp);}$$

(b)(ii)

At n=3 where the calculated value of χ^2 (16.27), the corresponding probability is 0.001;

Critical χ^2 value (7.82) < calculated χ^2 value (16.27), therefore there is a significant difference between observed and expected values;

The cross does not follow ratio of 1:1:1:1. Any difference is not due to chance alone but other factors must be at operation (eg. linked genes);

Question 6

(a)(i)

Yeast are still respiring aerobically, using up oxygen in jar after it was sealed;

(a)(ii)

Anaerobic respiration - Ref. to incomplete/partial oxidation of glucose during glycolysis in the absence of oxygen;

1 molecule of glucose is broken down to 2 molecules of pyruvate with the net yield of 2 ATP by substrate level phosphorylation and 2 reduced NAD/ 2NADH;

Alcoholic fermentation occurs to regenerate NAD^+ for glycolysis to continue;

Pyruvate is decarboxylated to form acetaldehyde with the removal of carbon dioxide;

Acetaldehyde is then reduced to ethanol by accepting H atoms from NADH to regenerate NAD^+;

Resulting in an increase in concentration of alcohol from 0 to 16% from 24 to 96 hr;

(a)(iii)

Yeast is killed at 16% ethanol;

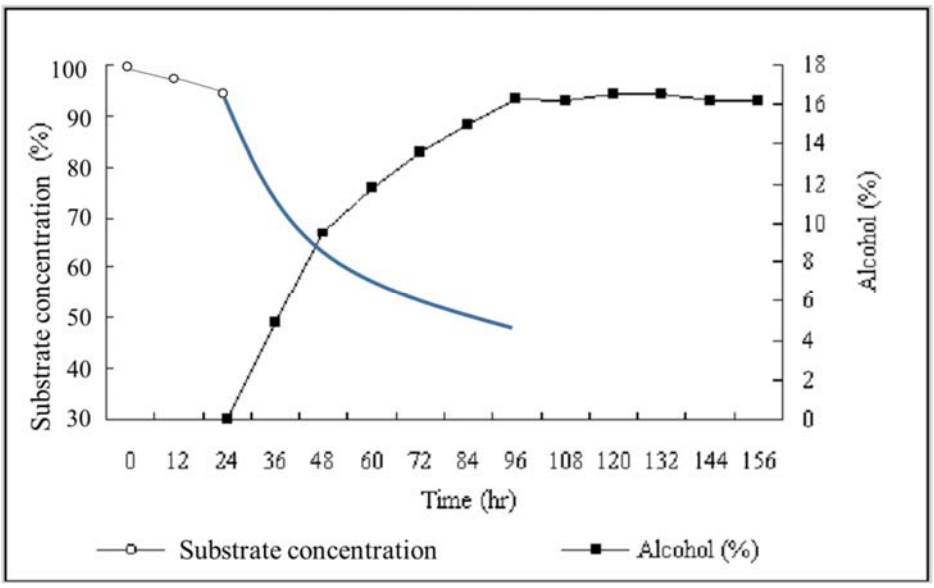
ethanol is organic and thus dissolves and disrupts phospholipid bilayer of the cell membranes in yeast;

enzymes in yeast are also denatured by the high ethanol concentration;

2 max

(b)

Curve with sharper initial decrease in substrate concentration than original gradient from 0-24h;



Question 7

(a)(i)
GABA binds to receptors and thus leads to the opening of K+ / Cl- gated channels;
This results in more Cl- diffusing into / more K+ diffusing out of postsynaptic membrane, thus membrane potential becomes more negative / hyperpolarized;

(ii)
Acetylchloline from P will cause depolarisation while GABA from Q will cause hyperpolarisation / ref. to acetylcholine causing influx of Na+ & GABA causing influx of Cl- and efflux of K+;
Ref. to spatial summation of these potentials counteracts each other resulting in a weak stimulus in neurone B;

(iii)
Barbiturates bind to GABA receptor and cause more influx of Cl- ions and efflux of K+ ions;
Prevents enzyme from degrading GABA;
Prevents GABA from unbinding from GABA receptor;
Ref. to binds to GABA and helps GABA bind to the GABA receptor;
Ref. to barbiturates causes increased secretion of GABA;

1 Max.

(b)
Ref. to the summation of EPSPs produced by repeated stimulation of only ONE presynaptic neurone (at high frequency);
If more neurotransmitters are released into the cleft before the first EPSP is destroyed;
Additive effects of several EPSPs may exceed threshold potential to result in an action potential in the post synaptic neurone;

2 Max.

Question 8

(a)(i)
Compare DNA sequence of a particular common gene between different species of fish / comparison/alignment of homologous genetic sequences;
% sequence homology indicates degree of evolutionary closeness / number of mutation in genetic sequence is used to calculate the length of time since divergence;
Neutral mutations are accumulated at a relatively constant rate and use as a molecular clock;

2 Max.

(a)(ii)
Quantifiable where protein, nucleic acid sequence data are precise and accurate and easy to quantify / convertible to numerical form for mathematical and statistical analysis**;**
Based on the idea of molecular clock, that the rate of mutation is constant, species can be arranged in order of time of evolution;
Objective where data is based strictly on heritable material / can be easily described in an unambiguous manner / some morphological similiarities may be analogous / ref. convergent evolution**;**
Use of phenotypically non-visible characteristics / considers changes caused by silent mutation which is not shown on the phenotype;

2 Max.

(a)(iii)
A. taeniatus and *A. virginicus* are closely related where they share a (recent) common ancestor. They have a high percentage homology in DNA sequence alignment;

(b)
Geographical isolation /Isthmus of Panama is a physical barrier / ref. allopatric speciation;
Disruption to gene flow in the ancestral population where there is no interbreeding between the organisms in the Pacific Ocean and Caribbean Sea;
Genetic variations exist within each sub-population due to mutation or genetic recombination;
Different selection pressures in Pacific Ocean and Caribbean Sea. List 1 eg. food availability/ salinity /temperature/ different predators;
Individuals with traits that are selectively advantageous in the particular environment survive, reproduce and pass on their alleles to offspring;
There will be changes in allele frequency of gene pool and accumulation of genetic changes takes place over many generations;
Speciation into *A. taeniatus* and *A. virginicus* takes place when the two populations ultimately cannot interbreed to produce viable, fertile offspring;

4 Max.

Essay Answers

Essay Question 1

(a) Describe the protein folding of an enzyme and relate its structure to its function. [10]

1. Enzymes are globular proteins with unique three-dimensional conformation / tertiary / quaternary structure;
2. Ref to primary structure being the unique sequence and number of amino acids in a polypeptide linked by peptide bonds;
3. Ref to secondary structure being the regular coiling and folding/pleating of the polypeptide held by *hydrogen bonds** between CO and NH groups of the peptide bonds / polypeptide backbone;
4. In *alpha helix**, *hydrogen bonds** form between CO and NH groups 4 a.a. apart, forming a 3D helical structure
5. In *beta pleated sheet**, *hydrogen bonds** form between CO (or NH) group of one region/segment and NH (or CO) group of an adjacent region/segment of a single polypeptide chain, forming a flat/pleated sheet;
6. Tertiary structure refers to the folding of polypeptide into a specific conformation, held by bonds between *R-groups** of structural amino acids within same polypeptide, maintained by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges;*
7. Ref to quaternary structure: more than 1 polypeptide chain to form functional protein held by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges* between R groups between polypeptide chains;
8. Folding gives rise to a specific cleft / groove - *active site* that is *complementary in shape and charge* to its *substrate*.
9. Folding brings catalytic amino acids and binding amino acids far apart in the primary structure / polypeptide close together in the active site
10. R groups of binding residues bind reversibly with substrate to position it in the correct orientation for catalysis to occur.
11. R groups of catalytic residues present within active site catalyze conversion of substrate to product.
12. The rest of the amino acids in the protein molecule are structural residues - provides a framework to maintain active site configuration
13. Active site may not be a rigid receptacle → ref to induced fit model – entrance of substrate induces enzyme to change its shape slightly to 'wrap around' substrate, bringing R group of active site into positions that enhance their ability to catalyze the chemical reaction;
14. Some enzymes contain another site (apart from active site) for another molecule to bind to (cofactors/allosteric molecules) allowing for regulation of enzyme activity;
15. Enzymes are soluble due to arrangement of hydrophilic residues on the surface and hydrophobic residues in the interior, allowing them to catalyse reactions in the aqueous environment of the cell;

(b) Describe the effect of pH on enzymes and their activity. [4]

1. Reference of influence of pH to the effect on ionic bonds, hydrogen bonds;
2. Change in charges of catalytic residues in active site affects catalytic function of enzyme;
3. Changes in shape / conformation and configuration of the tertiary structure affecting the fit and binding of the substrate to the active site;
4. Optimum pH / show graph of narrow pH range / named example;
5. Denaturation results in loss of structure and activity;
6. Denaturation is often reversible, restoring pH to optimum restores enzyme activity;

(c) Compare and contrast competitive and non-competitive inhibitors and their effects on the rate of enzyme activity. [6]

1 Both serve to lower rate of enzyme activity by preventing substrate from binding to active site
2 Both involve reversible binding of inhibitor to enzyme

	Competitive	Non-competitive
3 Structure	Structural similarity to substrate	No structural similarity to substrate
4 Binding site	Binds to active site	Binds to site other than active site – allosteric site
5 Competing for active site	Competes with substrate for active site	Does not compete with substrate for active site
6 Conformation of Enzyme	Does not change conformation of enzyme upon binding	Changes conformation of enzyme upon binding such that substrate can no longer bind to active site
7 Effect of increasing [S]	Increasing [S] concentration alleviates effect of inhibitor	Increasing [S] concentration does not alleviate effect of inhibitor
8 V_{max}	Max rate of reaction can be reached (with increased S concentration) / V_{max} unchanged	Max rate of reaction cannot be reached (with increased S concentration) / V_{max} reduced
If points 5 and 6 not awarded, can award point 9		
9 Mode of action	Competes with substrate for active site	Changes conformation of enzyme upon binding such that substrate can no longer bind to active site

Essay Question 2

(a)

Marking Point		Krebs cycle	Calvin cycle
1	**Location**	Mitochondrial matrix	Chloroplast stroma
2	**Substrate**	Acetyl-CoA and oxaloacetate combines to form citrate	CO_2 and Ribulose bisphosphate (RuBP)
3	**Products**	Each glucose molecule gives rise to: 6 NADH 2 $FADH_2$ 2 ATP 4 CO_2	For every 3 molecules of CO_2 that enter the cycle, one triose phosphate / Glyceraldehyde 3 phosphate is made
4	**Regenerated / Starting material**	Oxaloacetate is the starting material that is eventually regenerated	Ribulose bisphosphate (RuBP) is the starting material that is eventually regenerated
5	**ATP**	Produced via substrate level phosphorylation	Used in reduction of glycerate-3-phosphate where energy Is required through hydrolysis of ATP
6	**Electron carriers / donors**	Use NAD^+ and FAD for the oxidation of the intermediates of the cycle by serving as electron acceptors	Uses NADPH / reduced $NADP^+$ to reduce glycerate-3-phosphate to triose phosphate by serving as electron donors
7	**Overall**	Catabolic	Anabolic
8	**Role of CO_2**	CO_2 is released as a result of decarboxylation reactions	Required for carbon fixation. CO_2 is used to convert Ribulose bisphosphate (RuBP) to form an unstable 6C compound that breaks down to form glycerate-3-phosphate
9	**Role of O_2**	Occurs only when O_2 is present	Does not require O_2

8 Max.

(b)

Similarities

1. Both have electron carriers embedded in membranes - inner membrane of mitochondrion and thylakoid membrane of chloroplast;
2. Both involve electrons being passed down a series of electron carriers with increasing electronegativity and in order of decreasing energy levels;
3. Energy released from electron transport chain is used to generate a proton gradient / proton motive force;
4. Both involves diffusion of protons down a concentration gradient through ATP synthase / ref. chemiosmosis;
5. Potential energy of the proton gradient is used for the synthesis of ATP from ADP and Pi;

Why these similarities exist

6. Both processes of ATP production are similar in the organelles because of the endosymbiont theory / endosymbiosis;
7. Mitochondria and chloroplasts originated as prokaryotic organisms which were taken inside a eukaryotic cell;

6 Max.

(c)

1. Under normal field conditions, carbon dioxide is the major limiting factor in photosynthesis, since its concentration in the atmosphere is about 0.03%.
2. Increasing carbon dioxide concentration leads to a linear increase until limited by other factors.
3. Ribulose bisphosphate carboxylase oxygenase (Rubisco), the enzyme that captures carbon dioxide in the light-independent reactions, has a binding affinity for both carbon dioxide and oxygen.
4. When the concentration of carbon dioxide is high, Rubisco will fix carbon dioxide in Calvin Cycle which increases the rate of photosynthesis.
5. If the carbon dioxide concentration is low and oxygen concentration is high, oxygen will out-compete carbon dioxide for the active site of the enzyme Rubisco during the dark stage of the reaction.
6. Therefore, a high concentration of oxygen lowers the rate of photosynthesis.

Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY 9648/03

Paper 3 Applications Paper and SPA Planning Task **23 September 2016**

2 hours

Additional Materials: Writing paper

INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Section A:
Consists of 3 Structured Questions
Answer **all** questions.
Write your answers in the **space provided** on the question paper.

Section B:
Consists of 1 SPA Planning Task
Write your answers on the separate **writing papers** provided. At the end of the examination, fasten all your work securely together.

Section C:
Consists of 1 Free-Response Question.
Write your answers on the separate **writing papers** provided. At the end of the examination, fasten all your work securely together.

Sections A, B and C are to be submitted **separately**.

INFORMATION FOR CANDIDATES

Essential working must be shown.

The intended marks for questions or parts of questions are given in brackets [ ].

For Examiner's Use	
Section A [40]	
1	**/ 13**
2	**/ 12**
3	**/ 15**
Section B[12]	
Section C [20]	
Total [72]	

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

[Turn over

Section A: Structured Questions (40 marks)
Answer **all** questions in this section.

For Examiner's use

Question 1

(a) **Fig. 1.1** shows two types of plasmids, pAMP and pKAN. pAMP carries an ampicillin-resistant (amp^r) gene and pKAN carries a kanamycin-resistant (kan^r) gene. Restriction sites for BamHI and HindIII are found in both plasmids.

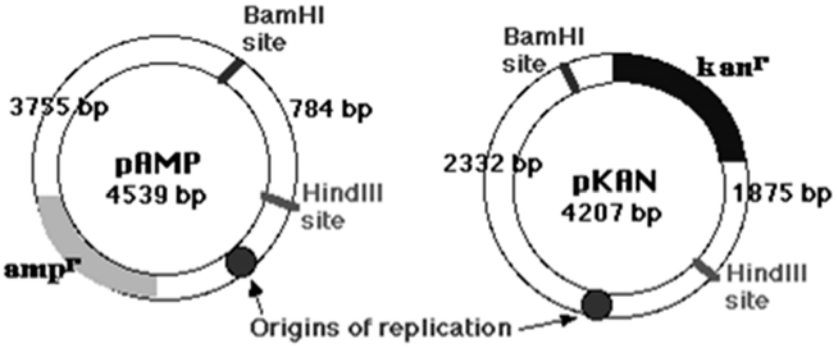


Fig. 1.1

A ligation solution of these two plasmids is mixed together with the enzymes BamHI and HindIII. The pAMP and pKAN fragments were then allowed to anneal, resulting in the plasmid shown in **Fig. 1.2**.

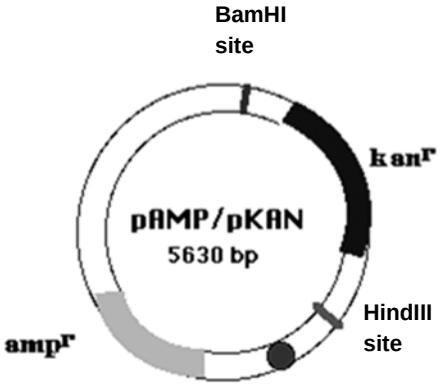


Fig. 1.2

For Examiner's use

(i) In addition to the recombinant plasmid shown in **Fig. 1.2**, three other recombinant plasmids are also formed. Draw and label clearly these three recombinant plasmids in the space provided below. [3]

(ii) *E. coli* is mixed with the ligation solution in (a). Describe and explain how *E. coli* carrying plasmid shown in **Fig. 1.2** can be selected. [2]

For Examiner's use

(iii) With reference to **Fig. 1.2**, in addition to the restriction sites for BamHI and HindIII, a single restriction site for EcoR1 was found within the sequence of the kan^r gene. To clone a human gene with a molecular size of 600 bp into bacterial cells, EcoR1 was used to cut the human gene and the plasmid in **Fig. 1.2**. The cut human gene and plasmid are then mixed together with DNA ligase. The ligated DNA mixture is then used for the transformation of *E. coli*. The bacteria is then grown on a nutrient agar plate.

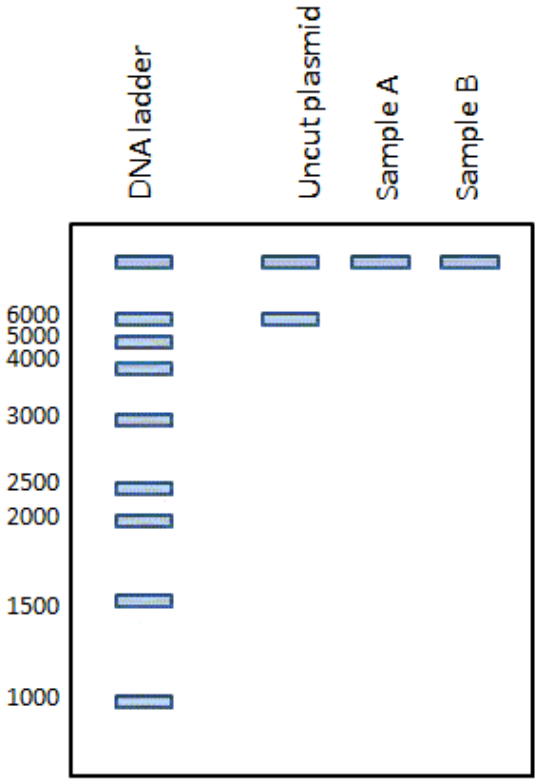
To identify *E. coli* cells that have taken up the recombinant plasmid with the human DNA, a scientist isolates two types of plasmids from 2 bacteria colonies repectively. He then subjects the two DNA samples to restriction digestion using enzymes BamHI and HindIII, producing DNA fragments of the following sizes.

Sample	Fragments (kb)
A	3755, 1875
B	3755, 2475

Suggest which sample of transformed bacterial cells is able to survive on an agar plate containing ampicillin but ***NOT*** on an agar plate containing kanamycin. Explain your answer. [3]

For Examiner's use

(iv) On the diagram below, complete the banding patterns in lanes Sample A and Sample B that the scientist will observe when he conducts gel electrophoresis using uncut plasmid, sample A and sample B. [1]



For Examiner's use

(b) DNA of organisms may be stored in genomic DNA libraries or cDNA libraries.

(i) Outline the roles of one enzyme used in the formation of the cDNA in a cDNA library. [1]

(ii) Explain why cDNA libraries made from the same type of cell at different times in the life of the cell may vary, whilst a genomic library for that organism will always be the same. [3]

Total: [13]

For Examiner's use

Question 2

(a) Although the DNA from different individuals is more alike than different, there are many chromosomal regions that exhibit a great deal of diversity. Such variable sequences are termed polymorphic and provide the basis for disease diagnosis, forensic identification and paternity testing.

One class of polymorphism results from repeated copies of a DNA sequence that lie next to each other on the chromosome. Two common types of repeat polymorphisms are short tandem repeats (STRs) and variable number of tandem repeats (VNTRs). In each type, different numbers of repeats create alleles that differ in size.

(i) Many repeat polymorphisms are highly polymorphic, having tens of different alleles. Repeat polymorphisms also exhibit high level of heterozygosity. Explain what you understand by the term "heterozygosity". [1]

(ii) Repeat polymorphisms used in forensic biology are neutral mutations, which do not affect protein functions. Suggest one location where such mutations are primarily found. [1]

For Examiner's use

(b) An experiment examines a VNTR on human chromosome 1 known as D1S80. Each repeat unit in this VNTR is 16 base-pairs (bp) long. Most individuals have between 14 and 40 copies of the repeat at the D1S80 locus.

In this experiment, polymerase chain reaction (PCR) is used to determine the number of repeated DNA sequences at the D1S80 locus. Each DNA sample is obtained from a single swab of cheek cells from a volunteer. Primers (see arrows) were used for the PCR as shown in **Fig. 2.1**.

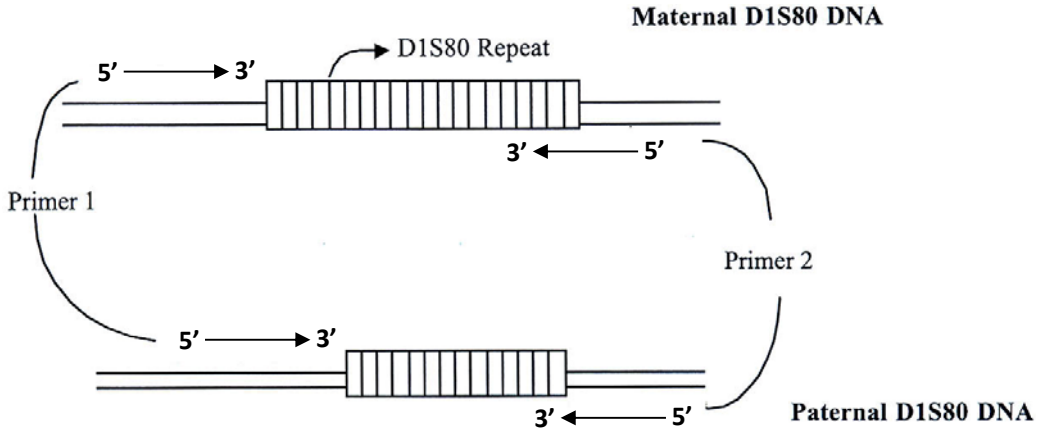


Fig. 2.1

Note:
Primer 1 : 5'-GAA ACT GGC CTC CAA-3' (15-mer)
Primer 2: 5'-GTC TTG TTG GAG ATG-3' (15-mer)

To compare the genotypes from a number of volunteers, aliquots of the respective PCR products and a DNA molecular marker are loaded onto the wells of a DNA chip. Microfluidic electrophoresis is carried out. Following computer analysis, the PCR products of one of the volunteers appear as distinct peaks with assigned base-pair sizes on an electropherogram, as shown in **Fig. 2.2**. The sizes of the PCR products can then be used to determine the specific number of repeats within each VNTR allele.

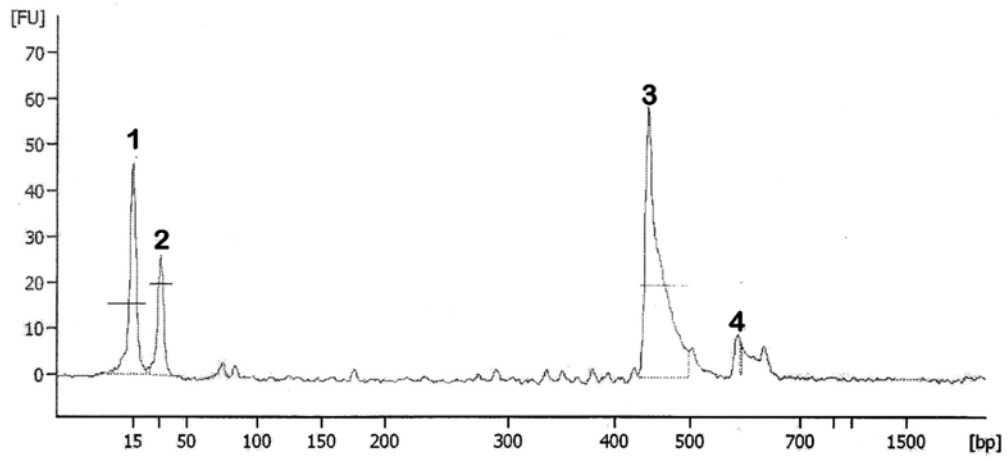


Fig. 2.2

For Examiner's use

The size of DNA corresponding to each of the peak is shown in **Table 2.1**.

Table 2.1

Peak	**Size / bp**
1	15
2	30
3	443
4	590

(i) Explain why peaks **1** and **2** appear in the electropherogram. [2]

(ii) Based on the DNA sizes corresponding to peaks **3** and **4**, calculate the number of repeats present in each VNTR allele of the volunteer. [3]

(iii) Suggest why there is an anomaly in the number of repeats found in one of the VNTRs, besides instrumental error. [2]

(iv) Discuss the benefits of using PCR analysis in place of RFLP analysis for this experiment. [3]

For Examiner's use

Total: [12]

Question 3

For Examiner's use

(a) The first gene therapy trial for an inherited disorder was initiated on 14 September 1990. The patient, Ashanti DeSilva, suffered from a very rare recessively inherited disorder, adenosine deaminase (ADA) deficiency.

An inherited deficiency of ADA has particularly severe consequences in the case of T lymphocytes. As a result, ADA-deficient patients suffer from severe combined immunodeficiency (SCID).

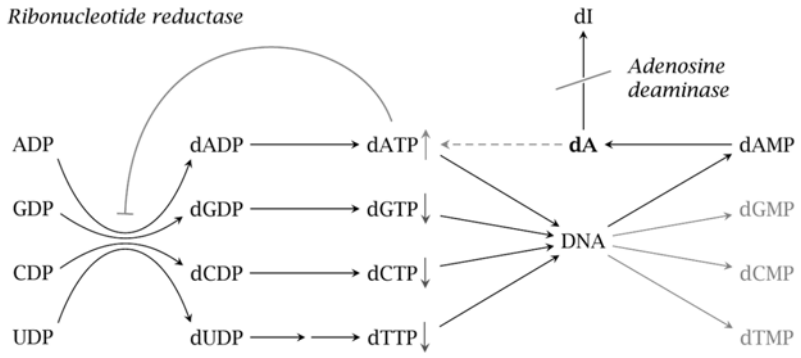


Fig. 3.1

(i) Using the information provided, explain how ADA deficiency can lead to SCID. [3]

The novel ADA gene therapy approach conducted on Ashanti DeSilva involved the following steps:

For Examiner's use

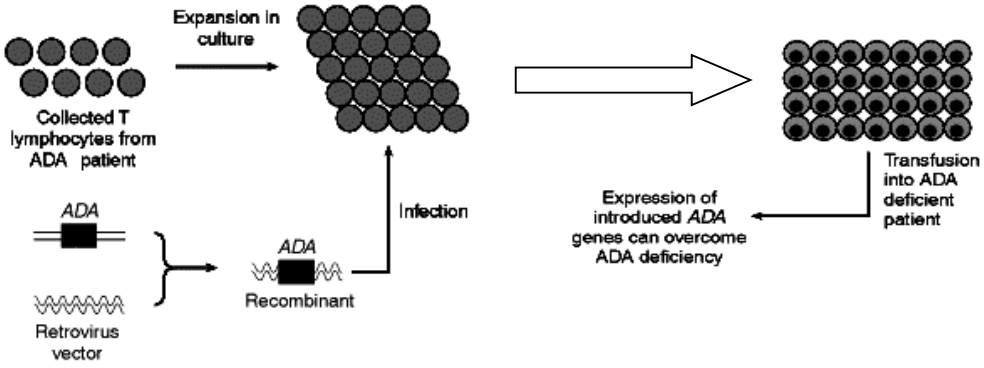


Fig. 3.2

The protocol was reviewed a dozen times by seven regulatory committees before it was finally approved by the RAC in July 1990, and by the FDA two months later. The gene therapy was considered to be a success for Ashanti but the response was far more limited in the second patient.

(ii) Suggest an improvement to the procedure shown in **Fig. 3.2** that will increase the success rate of the treatment. Explain your answer. [2]

(b) **(i)** ADA-SCID, cystic fibrosis and sickle cell anaemia are examples of autosomal recessive disorders. Such disorders are often prime candidates to be treated by gene therapy.

Explain why it is easier to perform gene therapy when a mutant allele is recessive instead of dominant. [2]

For Examiner's use

(ii) Although the use of gene therapy for treatment of genetic disorders in humans seems promising, there are still many concerns to be addressed.

Explain the factors that may keep gene therapy from becoming an effective treatment for genetic disorders. [3]

(c) Scientists have come up with an alternative method of generating pluripotent cells, which is to genetically reprogramme adult cells to an embryonic stem cell-like state. Genetic reprogramming is carried out by using deactivated retroviruses to introduce the genes of four transcription factors into adult cells from a patient (**Fig. 3.3**).The reprogrammed cells, called induced pluripotent stem (iPS) cells, are specific to the patient from which the adult cells were taken

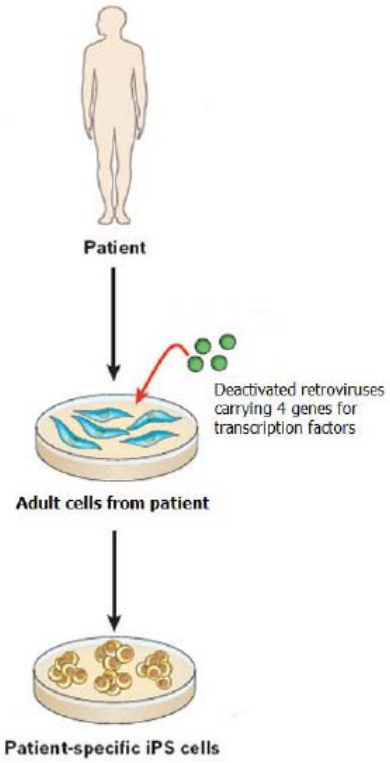


Fig. 3.3

For Examiner's use

(i) State two advantages of using iPS cells instead of embryonic stem cells for research and clinical trials. [2]

(ii) Suggest how the expression of such a small number of transcription factors in adult cells could genetically reprogramme these adult cells to an embryonic stem cell-like state. [3]

Total: [15]

Section B: SPA Planning Task (12 marks)
Write your answers on the writing paper provided.
A **NIL RETURN** is required.

Question 4

Beetroots are plants that have storage roots that are 5 to 10cm in diameter. The storage tissues of these plants have cells that contain betacyanin (red pigment) in the cell vacuole. The betacyanin pigment cannot pass through membranes, but can pass through the cellulose cell walls if the membrane integrity is disrupted.

Physical damage to the storage roots of beetroot, for example by cutting, causes large loss of pigment.

Using this information and your own knowledge, design an experiment to determine the effect of temperature on beetroot membrane integrity.

You must use:

- Beetroot
- Distilled water

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

- Normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, syringes, glass rods etc.
- White card
- White tile
- Knife, scapel, cork borers
- Ruler
- Blunt forceps
- Stopwatch
- Thermometer
- Access to a kettle to boil water and ice
- Marker pen
- 5% betacyanin
- colorimeter

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 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 minimize any risks associated with the proposed experiment.

Total: [12]

Section C: Free-Response Question (20 marks)

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

Question 5

(a) Biofuels can be obtained from the conversion of cellulosic biomass, which is both abundant and renewable. However, the enzymes and pretreatment processes involved are very expensive. One approach is to genetically engineer plants to produce cellulase so as to enhance the conversion of cellulose into fermentable sugars and reduce the need for pretreatment processes.

Describe how one can mass produce more plants that has already been genetically modified to synthesize cellulase. [7]

(b) Explain the significance of genetic engineering in GM salmon and Bt corn in solving the demand for food in the world. [7]

(c) Discuss the social and ethical implications of Bt corn. [6]

Total: [20]

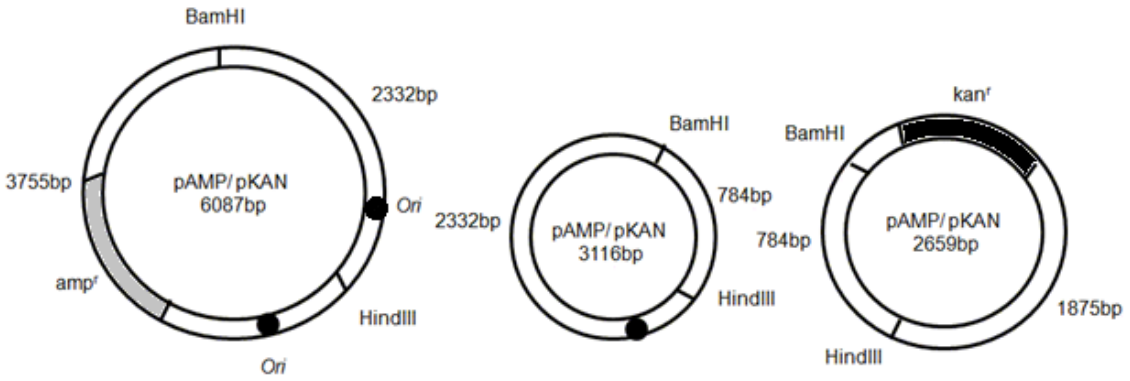
END OF PAPER

DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2016
YEAR SIX
H2 BIOLOGY (9648)
PAPER 3

Structured Questions Answers

Question 1

(a)(i)

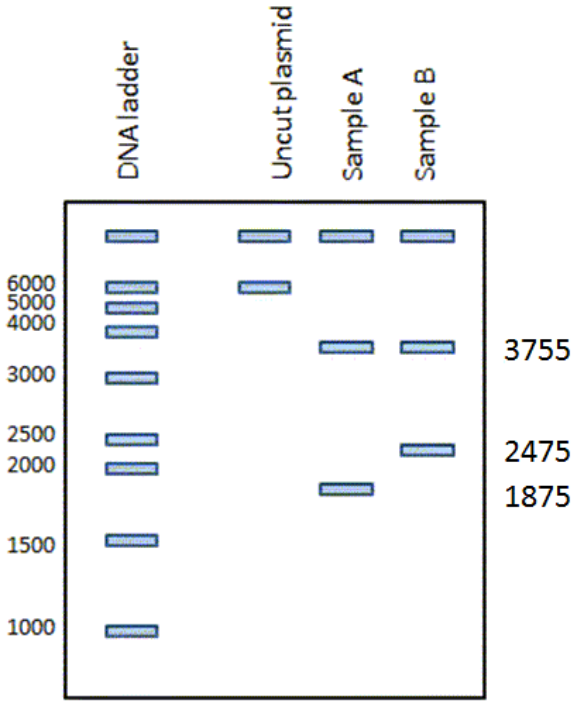


1M for each drawing of recombinant plasmid showing size of plasmid, correct labels, position of antibiotic resistance gene and *ori*
Comment: many students draw without showing complete labeling. The relative size of plasmids and segments should also be accurately represented.

(ii)
Culture *E.coli* on a nutrient plate containing ampicillin and kanamycin;
Plasmid shown in **Fig 1.2** contains ampicillin and kanamycin resistant genes and hence *E.coli* carrying this type of plasmid will survive and grow into colonies;
Or
E.coli carrying the other three types of plasmid does not contain both ampicillin and kanamycin resistant genes) and thus will not survive and grow into colonies;
Note: Plasmids DO NOT survive and grow on nutrient plates.

(iii)
Sample B is able to survive in an agar plate containing ampicillin but not kanamycin;
Sample B bacteria carry plasmid with human gene. 3755 kb and 2475 kb fragments. This 2475 kb fragment is the 1875 kb with an addition of the 600kb human gene;
Thus kan^r gene is disrupted by the insertion of the human gene and that the bacteria cannot product protein that confer resistance to kanamycin and thus not able to grow on the plate with kanamycin;

(iv)



(b)(i)
Reverse transcriptase – synthesizes single stranded cDNA from mRNA template;

RNAse- partially degrades mRNA template after single stranded cDNA is synthesized, remaining short RNA segments serve as primers for synthesis of second strand;

DNA polymerase – synthesizes second strand of cDNA using first strand of cDNA as a template through the formation of phosphodiester bond;

DNA ligase – joins cDNA fragments of second strand to get a complete double-stranded cDNA molecule through the formation of phosphodiester bond;

1 Max.

(ii)
The starting material / template for the synthesis of cDNA is mature mRNA expressed from certain genes at that particular time;
The expression of genes varies at different times in the life of the cell / can also change in response to different stimuli;
For genomic library, the set of DNA remains the same throughout the life of the cell;

Question 2

(a)(i)
Human beings are diploid organisms where 2 different alleles are inherited, one from each parent;
(ii)
Centromere, telomere, introns;

1 Max.

(b)(i)
Excess primers are used where peak 1 corresponds to the primers;
And peak 2 corresponds to the primer dimers;

(ii)
For PCR products corresponding to each peak, there is a need to consider the length of the 2 flanking primers, i.e.
15 bp x 2 = 30 bp;

Since primers are not repeats, there is a need to subtract the length of the flanking primers from the total length of the PCR products, i.e.
For peak 3: 443 bp – 30 bp = 413 bp
For peak 4: 590 bp – 30 bp = 560 bp;

Since each repeat is 16 bp in length, divide length of PCR products in step 2 by 16 to obtain number of repeats present in each VNTR allele:
Number of repeats present in VNTR allele in peak 3 = 413/16 =25.8 (correct to 3 s.f.) = 26
Number of repeats present in VNTR allele in peak 4 = 560/16 =35;

(iii)
Identify as the 443 bp fragment where it has 25.8 repeats, i.e. not whole repeats;
This could be due to deletion mutation;

(iv)
Small amounts of DNA collected from volunteers, therefore need amplification for differences to be detected;
No restriction sites flanking the locus, thus restriction enzymes cannot cut out the marker / locus for RFLP analysis;
Specific primers used, thus can home in on a single marker / locus;
No need for Southern blot, thus it is less tedious / safer because radioactive probes are not used;

3 Max.

Question 3

(a)(i)

- Deficiency of ADA results in accumulation of the substrate deoxyadenosine (dA) in cells. This leads to the buildup of dATP in cells;
- dATP inhibits ribonucleotide reductase and prevents DNA synthesis / formation of deoxyribonucleoside diphosphates (dNDP);
- As a result, T lymphocytes are unable to divide. Consequently, the immune system is severely compromised and this leads to SCID;

(a)(ii)

- Use hematopoietic stem cells from the bone marrow of the patient instead of T-lymphocytes;
  R! Bone marrow cells / bone marrow stem cells
- since hematopoietic stem cells are able to self renew and differentiate into B- and T-lymphocytes. This will provide a more long term / permanent cure;

(b)(i)

When mutant allele is recessive, addition of functional / normal dominant allele by gene therapy will produce sufficient amounts of gene product to mask the effect of recessive allele;

If mutant allele is dominant, both alleles must be removed / repaired / inactivated to block production of defective gene product;

(b)(ii)

- Transient expression of therapeutic gene / difficult to ensure that therapeutic gene is integrated into genome of host cells;
- Incorrect insertion of therapeutic gene into genome of host cell results in cancer / insertional mutagenesis, as the insertion is random;
- Immune response may be triggered resulting in rejection because a foreign vector is introduced;
- Difficult to control expression of normal functional gene to give a fully functional protein;
- Unable to treat multigene disorders;

3 Max.

(c)(i)

- iPS cells can be generated from skin cells/adult cells, so there are **fewer <u>ethical issues</u>** involved as compared to using embryonic stem cells obtained from an embryo;

- iPS cells can be generated from skin cells/adult cells of the patient/sufferer, so there might be **less risk of tissue rejection** after gene therapy and transplantation;

- iPS cells are more **readily available** than embryonic stem cells; OWTTE

(c)(ii)

1. Each transcription factor can **activate the transcription of multiple genes**. Each gene in turn could code for a transcription factor which **activates/inactivate other genes**;

2. Transcription factors **switch on genes that are expressed in ES cells,** resulting in the synthesis of proteins which are found in ES cell;

3. **Give example of activated genes:** e.g. telomerase gene/ genes which promote cell division/ genes which cause the cell to revert to undifferentiated state;

4. Transcription factors could also **inhibit gene expression / repress genes not expressed in ES cells;**

5. **Give example of inactivated genes:** e.g. genes that result in differentiation / specialisation;

<u>3 Max.</u>

Planning Answer

<table>
<tr>
<td>Theory</td>
<td>The hydrophobic core of the phospholipid bilayer of the cell membrane prevents any large, polar, hydrophilic molecules like betacyanin to freely exit the plant cell.

Cell membrane follows fluid mosaic model - composed of membrane proteins embedded in a phospholipid bilayer. Increase in temperature increases kinetic energy, resulting in increased movement of phospholipids, increasing fluidity of membrane, making membrane slightly leaky. Too high a temperature can cause movement of phospholipids to be too great, disrupting membrane integrity, causing betacyanin to leak out of the cell.

Too high a temperature can also cause denaturation of membrane proteins by disrupting hydrophobic interactions, hydrogen bonds and ionic bonds, also disrupting membrane integrity, causing betacyanin to leak out of the cell.

As temperature increases, the cell surface membrane will become more fluid and leak a small amount of pigment, beyond a certain temperature the membrane integrity would become significantly disrupted and a large amount of pigment would leak out of the cell into the bathing solution. Beyond a certain temperature, membrane integrity is completely disrupted and further increase in temperature will not result in significant increase in amount of betacyanin released.</td>
<td>1. Theory on why betacyanin cannot pass through membrane

2. theory of how temperature affects membrane phospholipids OR theory of how temperature denatures membrane proteins

3. hypothesis:</td>
</tr>
<tr>
<td>Variables</td>
<td>Independent variables: 5 temperature water baths, evenly distributed (10, 30, 50, 70, 90^{o}C).

Dependent variables: intensity of red colouration of bathing solution after a fixed time interval in waterbath (as measured using colorimeter / as compared against colour standard)

Controlled variables: Fixed amount of time given for soaking in bathing solution,

Number/size of discs of beetroot used,</td>
<td>4. independent and dependent variables</td>
</tr>
<tr>
<td>Procedure</td>
<td>1. Use the cork borer to obtain a uniform cylinder of beetroot.
2. Use a ruler to measure 1cm to ensure uniform thickness and a scapel to cut the beetroot into discs. Obtain 3x 5 discs.

3. Wash the discs and ensure that any red pigment leakage caused by cutting is washed away before start of experiment.

4. Carryout dilution of the 5% betacyanin to have a colour standard for comparison according to the table below.

<table>
<tr><th>Percentage of betacyanin / %</th><th>Volume of 5% betacyanin stock / cm^3</th><th>Volume of distilled water / cm^3</th><th>Final volume / cm^3</th></tr>
<tr><td>5</td><td>10</td><td>0</td><td>10</td></tr>
<tr><td>4</td><td>8</td><td>2</td><td>10</td></tr>
<tr><td>3</td><td>6</td><td>4</td><td>10</td></tr>
<tr><td>2</td><td>4</td><td>6</td><td>10</td></tr>
<tr><td>1</td><td>2</td><td>8</td><td>10</td></tr>
<tr><td>0</td><td>0</td><td>10</td><td>10</td></tr>
</table>
</td>
<td>5. how to ensure uniform size of discs

6. wash

7. dilution of betacyanin for color standard</td>
</tr>
</table>

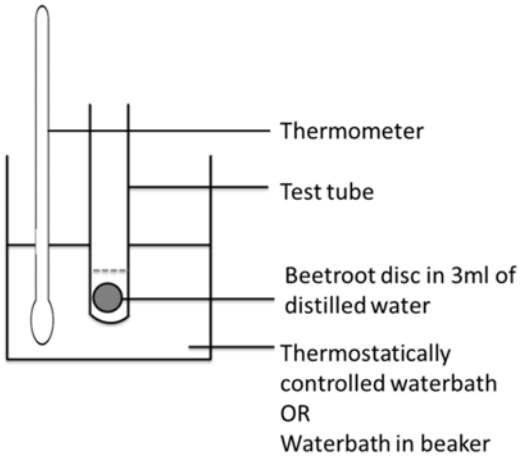
	5. Label 5 large beakers (10, 30, 50, 70, 90^{o}C) and prepare the 5 different water bath temperatures by mixing hot water and tap water or ice provided. Use a thermometer to check and monitor water bath temperatures. Add ice or hot water as necessary to maintain these temperatures. OR Prepare the 5 different thermostatically controlled water baths at 10, 30, 50, 70, 90^{o}C. Use a thermometer to check and adjust settings to achieve and maintain water bath temperatures.	8.how to prepare & maintain water baths
	6. Label 3x 5 test tubes (10, 30, 50, 70, 90^{o}C) and add 3cm^{3} of distilled water into each tube using a clean syringe. 7. Place the test tubes in each of their respective water baths and incubate for 5 minutes to allow distilled water in each test tube to reach water bath temperature. Use thermometer to check that test tube distilled water has reached desired temperature.	9. equilibrate temperate
		10. relevant figure
	8. Use the forceps to transfer a beetroot disc into first test tube at 10^{o}C. Immediately start the stop watch and allow the discs to incubate for 5 minutes. 9. After 5 minutes of incubation time, remove beetroot disc from test tube using forceps / decant bathing solution from test tube into clean test tube.	11. how to ensure uniform incubation time
	10. Observing the test tube against a white card as background, compare with prepared colour standard to determine concentration of betacyanin present. OR fill a cuvette with 1ml (A:1ml-1.5ml) distilled water and place in colorimeter. Press tare button. Fill a second cuvette with 1ml (A:1ml-1.5ml) of beetroot bathing solution. Place the cuvette in the colorimeter, press the test button and take the absorbance reading.	12a. comparison with colour standard OR 12b1. tare colorimeter with water 12b2. 1ml in cuvette to take absorbance reading w/o beetroot.
	11. Record results in the table below.	
	12. Repeat steps 8-9 to obtain 3 replicates for each temperature to ensure reliability of results. Repeat experiment 2 more times to ensure reproducibility of results.	13. 3 replicates, 2 repeats
	13. Plot a graph as shown below.	

Table showing effect of temperature / °C on percentage of betacynin found in bathing solution /%

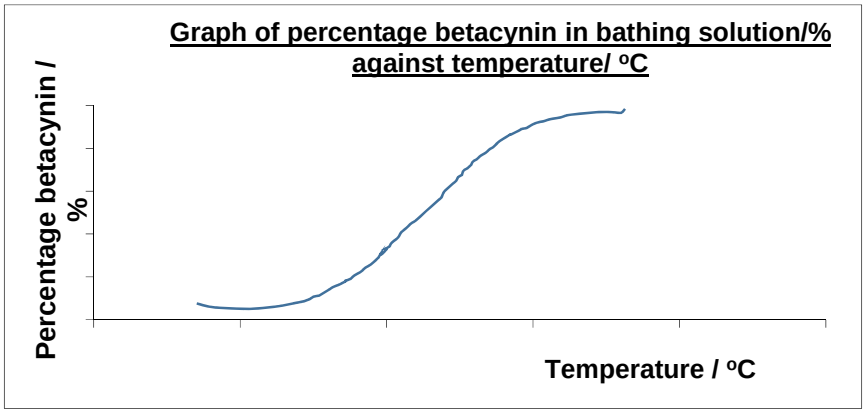
Temperature / °C	percentage of betacynin / %			
	Reading 1	Reading 2	Reading 3	Average
10				
30				
50				
70				
90				

OR

Table showing absorbance readings of bathing solutions after 5min incubation at varying temperatures / °C

Temperature / °C	Absorbance			
	Reading 1	Reading 2	Reading 3	Average
10				
30				
50				
70				
90				

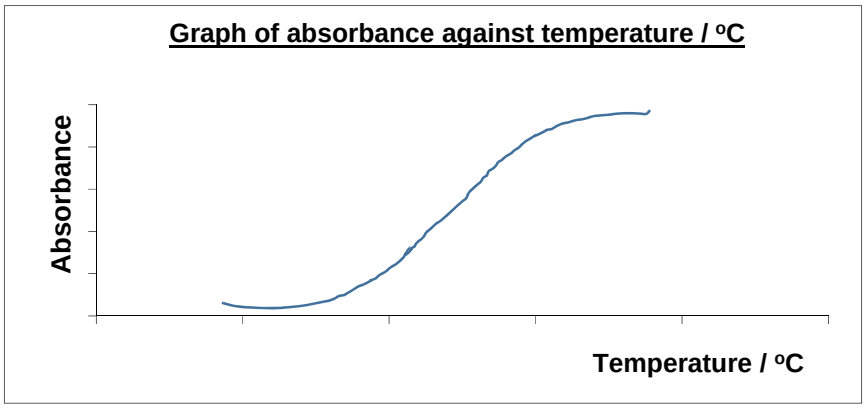
14. appropriate table with correct headings with units for recording observation of red colouration



15. graph with correct headings / units

16. Predicted trend

OR



Risk and precaution	Cut beetroot using scalpel against a white tile in a direction away from your body (side-ways or downwards) and others to prevent injury. Use oven mittens when handling beaker with hot water to prevent getting scalded.	17. Safety

Essay Answers

5(a) Biofuels can be obtained from the conversion of cellulosic biomass, which is both abundant and renewable. However, the enzymes and pretreatment processes involved are very expensive. One approach is to genetically engineer plants to produce cellulase so as to enhance the conversion of cellulose into fermentable sugars and reduce the need for pretreatment processes.

Describe how one can mass produce more plants that has already been genetically modified to synthesize cellulase. [7]

1. Obtain an **explant from plant meristematic tissue** (e.g. shoot tip) from plant that has already been genetically modified to synthesize cellulase;
2. **Culture in a medium** (with mineral nutrients, carbohydrate source, and plant growth regulators);
3. under **aseptic conditions** (e.g. surface sterilization, use of laminar flow cabinet);
4. Formation of **mass of undifferentiated cells** known as **callus**;
5. **Subculture** to increase number of callus with desired gene;
6. **Increase cytokinin to auxin ratio for shoot formation**;
7. **Increase auxin to cytokinin ratio for root formation**;
8. **Acclimatize plantlets** by growing in **sterile soil** in a greenhouse;

7 Max.

5(b) Explain the significance of genetic engineering in GM salmon and Bt corn in solving the demand for food in the world. [7]

Inability to cope with demand for food in the world

1. Food production must increase in order to cope with the **increase in human population** as **traditional methods for growing food may not be sufficient** to meet the demands**;**

GM salmon

2. In normal salmon, the gene that controls the production of growth hormone is activated by light, so the **fish usually grow only during the warm summer months**;
3. Genetically engineer GM salmon by the insertion of a **growth hormone gene** from a Pacific Chinook salmon and an **active promoter** from an ocean pout placed upstream of the growth hormone gene;
4. The active promoter allows the **growth hormone to be expressed all year round / GM salmon can grow all year round**;
5. This results in the GM salmon **reaching market size in a shorter time**, thereby **increasing the supply of salmon**;

Bt corn

6. **Insects can cause damage to crops** both in the field and during storage in silos;
7. Genetically engineer **maize/potato** by insertion of a **Bt-toxin gene** from the bacteria ***Bacillus thuringiensis*** that codes for the production of a crystalline Bt-toxin protein;
8. When insects eat Bt toxins, **toxin is broken down by the digestive enzymes into toxic proteins** that paralyzes the insect's digestive system and forms holes in the gut wall, **killing the insect**;
9. This results in **increased crop yield and quality**;

7 Max.

5(c) Discuss the social and ethical implications of Bt corn. [6]

1. **Bt toxic effects on non-target organisms**;
    - Organisms that are predators and parasites of pests are of benefit to agriculture, helping to regulate the population of the pests. However, unforeseen effects of the accumulation of Bt toxins on these organisms could cause them to die instead.
2. **Religious / Dietary restrictions** in food choices;
    - Some religious and ethnic groups have restrictions in the food that they can consume due to their religious/personal beliefs. GM food may further complicate their food choices.
3. **Allergies** to new proteins synthesised;
    - The Bt protein may lead to unexpected allergic reactions that consumers may not be aware of.
4. **Monopolization / Concentration of economic power** into a few large multinational companies;
    - As GM research is heavily funded by private companies, there is a fear that there might be **monopolization of agriculture by certain companies** since research and production of GM food is impeded by the protection of intellectual property.
    - There may also be possible **conflicts of interest** between the need for a private company to make money and the application of privately owned technology to solving food and economic problems in poor countries.
5. **Erosion of rural communities;**
    - Increased usage of GM food may lead to increased dependence on industrialized nations by developing countries. Thus, Bt corn can be as a power grab that threatens the sustainability of rural communities.
    - Alternatively, increased cultivation of Bt corn may lead to increased deforestation for farming and transport infrastructure, forcing smaller farmers out of their jobs.
    - Cultivation of other crops may also decrease, increasing the income divide due to the reliance on foreign imports.
6. **Tampering with nature / "Playing God"**;
    - Some religious groups have strong moral objections to scientists moving DNA from one species to another, breaking the natural species barrier.
7. **Labeling of GM food**;
    - Some members of the public may be fearful of eating 'weird' food and refuse to eat Bt corn. These people would like GM food to be labeled for transparency.
    - However, proponents of GM foods feel that there is "no difference" between GM crops and traditionally-bred crops and thus there is no need for labeling.

AVP (1 mark per implication with elaboration);

6 Max.