



**Temasek Junior College**  
**Biology Preliminary Examinations 2015**  
**H1 Biology Paper 2 Answers**

- 1 (a) (i) Identify organelles **A** and **B**. [2]  
**A: Rough Endoplasmic Reticulum**  
**B: Golgi apparatus**

- (ii) Describe how a biomolecule synthesized in **A** is transported to **B**. [2]

Proteins synthesized at ribosomes pass through the membrane of the rough Endoplasmic Reticulum (ER) into the ER lumen. ER vesicle containing the proteins buds off and travels along microtubules of the cytoskeleton to cis-face of Golgi apparatus, fuses with the Golgi membrane.

- (b) The passage of most molecules through the cell membrane is regulated by proteins. State the roles of these proteins. [2]

Channel protein provides a hydrophilic channel for hydrophilic molecules to pass through the cell membrane.

Carrier protein transports molecules across the membrane via a conformational change/ allows molecules with shape complementary to its binding site/ substances that can bind to it to enter.

- (c) Numbers 1 and 2 in Fig. 1.3 represent a sequence of events occurring in the cell. Describe the process that is taking place in Fig. 1.3. [4]

Vesicle travel along microtubules of the cytoskeleton towards the cell membrane. Vesicle fuses with the cell membrane and contents of the vesicle is released out of the cell. Exocytosis occurs. Membrane of vesicles contributes to the cell membrane/ forms the cell membrane, resealing the gap in the plasma membrane.

[Total: 10]

2

- (a) State the meaning of the term *allele*. [1]

Alternative form/ variant of a gene that occupy the SAME gene locus on homologous chromosomes.

- (b) State the type of interaction between the two alleles for red and white colours. [1]

**Codominance**

- (c) (i) Using the symbols  $C^R$  for red colour and  $C^W$  for white colour, draw a genetic diagram to find the probability of obtaining a plant with white flowers when plants with flowers that exhibit both red and white colours on petals are crossed. [4]

Parental  
phenotypes

Red and white  
flowers

X

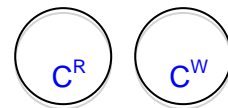
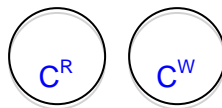
Red and white  
flowers

Parental  
genotypes

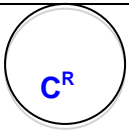
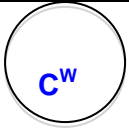
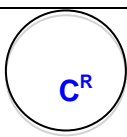
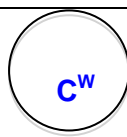
$C^R C^W$

$C^R C^W$

Gametes



**Punnett Square to show fusion of gametes**

<div style="text-align: right; padding-right: 10px;">♀</div> <div style="text-align: center;">     </div>	<div style="display: flex; align-items: center;">♂</div> <div style="text-align: center;">    <math>C^R</math> </div>	<div style="text-align: center;">    <math>C^W</math> </div>
	$C^R C^R$ <b>Red flowers</b>	$C^R C^W$ <b>Red and white flowers</b>
	$C^R C^W$ <b>Red and white flowers</b>	$C^W C^W$ <b>White flowers</b>

Offspring phenotypes	Red flowers	Red and white flowers	White flowers
Offspring phenotypic ratio	1	2	1

Probability of getting a plant with white flowers:  $\frac{1}{4}$  or 25%

(ii) Using Mendel's law of segregation, explain your answer to (c)(i).

Mendel's law of segregation states that the 2 alleles of 1 gene separate from each other into the different gametes during gamete formation. Therefore, for both parents, half of the gametes carry  $C^R$  allele, while the other half of the gametes carry the  $C^W$  allele.

As a result, during random fertilisation of gametes, there is equal probability that a gamete carrying the  $C^R$  allele will fuse with a gamete carrying the  $C^R$  or  $C^W$  allele, and vice versa. Therefore, there is a  $\frac{1}{4}$  chance that a gamete with  $C^W$  allele from one parent will fuse with a gamete with  $C^W$  from another parent.

[Total: 8]

3

(a) (i) State the phenotypic difference between the seeds of the original mainland populations and colonizers of the oceanic islands. [1]

- Seeds of the original mainland populations are smaller than the colonizers of the oceanic islands.
- OR
- Seeds of the original mainland populations are lighter than the colonizers of the oceanic islands.

(ii) Suggest why the seeds from the original mainland populations are short lived. [1]

- They contain limited food reserves.

(b) Explain how natural selection

(i) favours the **initial** colonisation of islands by some mainland plants; [2]

Wind acts as the selection pressure. Small and light seeds that can be carried by wind to be at selective advantage as they would be blown further by wind to reach the islands and live to reproductive age to produce viable and fertile offspring.

- (ii) would operate on plants **after** they have colonised the islands. [2]

Wind acts as the selection pressure. Heavier and larger seeds that cannot be carried by wind to be at selective advantage. Seeds are able to settle on the islands/ could not be blown away from the islands. They are more likely to survive to reproductive age to produce viable and fertile offspring.

- (c) Suggest why this trait is an evolutionary advantage. [2]

Random fusion of gametes between 2 plants/ cross-fertilization increases in genetic variation/ combination of alleles. Variation in the population increases its chances to cope with CHANGES in the environment

- (d) Describe how researchers can determine the evolutionary relationship of the two plant populations. [2]

Involves comparing DNA, RNA and amino acid sequences between organisms, obtained from dead or living samples. Two species that share a DNA nucleotide sequence (and also the specific protein coded for) are likely share a common ancestor.

The more recently two species branched from a common ancestor, the more similar their DNA and amino acid sequences would be.

[Total: 10]

4

- (a) Explain why plasmids can be used to clone genes involving **any** species of organism. [2]

BOTH the plasmid and gene of interest are made up of deoxyribonucleotides, which is the universal genetic material and they contain restriction sites that can be recognized by SAME type of restriction enzymes to facilitate insertion of gene of interest into plasmid (gene cloning)/ formation of recombinant plasmid.

- (b) (i) Explain why **two** different restriction enzymes are used. [2]

This ensures that the transgene will be inserted into the cut plasmid in ONLY ONE orientation. This also ensures that the plasmid does NOT reanneal.

- (ii) With reference to Fig. 4.1, describe how the recombinant plasmid is formed using the 4061 bp transgene. [3]

Use restriction enzymes *Bam*HI and *Hind*III which will cut the plasmid. The restriction fragments are mixed to allow complementary sticky ends of DNA fragments to anneal spontaneously by forming hydrogen bonds (or via complementary base pairing).

DNA ligase is added to join the annealed strands covalently by forming phosphodiester bonds between specific adjacent nucleotides to form a recombinant plasmid.

- (c) Outline how polymerase chain reaction and gel electrophoresis can be used to distinguish between transgenic salmon and non-transgenic salmon.

PCR primers that are specific/ has a complementary sequence to 3' ends that flank the transgene are added and can only bind and amplify the transgene that is only present in transgenic salmon, and NOT non-transgenic salmon.

Gel electrophoresis is then used to separate DNA fragments by size, and the gel is stained with methylene blue. Therefore, a band of 4061bp is seen in the lane containing DNA samples from transgenic salmon and NO band is seen in the lane containing DNA samples from non-transgenic salmon.

- (d) Explain why the development of transgenic salmon raises ethical concerns. [2]

#### Possible threats to the environment

- The introduction of GM salmon into the wild salmon population might upset the balance of the ecosystem and affect the food chains in unpredictable ways.
- The introduction of GM salmon into the wild salmon population might cause a loss of biodiversity/ reduce the genetic variation in the salmon population.
- These genetically-engineered organisms are usually able to withstand environmental stress better than other organisms within the ecosystem, they may outcompete/ drastically reduce the population of wild salmon, which is an endangered species.
- Mating of GM salmon with wild salmon may introduce the genes from ocean pout into the salmon gene pool.

#### Possible threats to human safety

- NO comprehensive studies have been carried out to ascertain the potential dangers of consuming GM salmon. Therefore, if commercial sale and consumption of GM salmon is approved by US FDA, it is likely that other countries (like Canada, Norway, Britain) will also follow suit and allow the sale of GM salmon in supermarkets etc.

Possible objections to animal suffering/ physiological stress of the animal in experiments

[Total: 12]

## SECTION B

- 5 (a) Outline the molecular structure of phospholipids in relation to their function in cell membranes. [6]

Function of phospholipids	Structure	How structure allows it to perform function
The phospholipid bilayer functions as a hydrophobic boundary between the aqueous interior and exterior of the cell.	<p>Phospholipids consists of <u>a glycerol attached to a phosphate head and two hydrocarbon tails from two fatty acids.</u></p> <p>The phosphate head carries an <u>electrical charge</u> and is <u>hydrophilic.</u></p> <p>The <u>hydrocarbon tails are neither charged nor polar</u> and hence <u>hydrophobic.</u></p> <p>Phospholipids are <u>amphipathic.</u></p>	<p>In an aqueous environment, <u>phospholipid molecules assemble themselves into a bilayer.</u></p> <p>The <u>hydrophilic phosphate heads faces outwards</u> and make <u>contact with the aqueous environment on either sides.</u></p> <p>The <u>hydrophobic tails face inwards</u> and are <u>sandwiched / buried between the hydrophilic heads.</u></p> <p>The <u>hydrophilic region allows the hydrophobic boundary to exist in an aqueous environment.</u></p>

- (b) Compare oxidative phosphorylation and photophosphorylation. [8]

**Similarities:**

In both oxidative phosphorylation and photophosphorylation.

(S1) ATP is synthesized.

(S2) the flow of electrons down the ETC is used to create a proton gradient across a membrane.

(S3) there is a flow of electrons down electron carriers of decreasing energy levels.

(S4) protons diffuse down its gradient via the proton channel in the ATP synthase.

(S5) energy released from the diffusion of protons is used to drive ATP synthesis.

## Differences:

Features	Oxidative phosphorylation	Photophosphorylation
(D1) Electron carriers involved	FADH, NADH	NADP
(D2) Function of electron carriers	Electron donors	Final electron acceptor
(D3) Source of electrons/ electron donors	FADH, NADH	H <sub>2</sub> O
(D4) Final electron acceptor	Oxygen	NADP
(D5) Products	FAD, NAD, ATP and H <sub>2</sub> O	NADPH, ATP and oxygen
(D6) Involvement of light	Light is not needed.	Light is needed for photolysis of water.

- (c) Yeast cells undergo respiration to produce carbon dioxide.

Describe an experimental procedure to investigate the effect of temperature on the rate of respiration of yeast cells by measuring the release of carbon dioxide.

[6]

Clear and helpful structure for the protocol

1. Appropriate range of independent variable, which falls within the following range: temperature: 10°C - 70°C
2. 7 data points for independent variable
3. Standardization of
  - volume of yeast suspension
  - amount of air drawn into the syringe
  - duration of respiration (3–5min)
4. Equilibration to ensure that yeast suspension are at the specified temperature (e.g 5 min)
5. Use of thermostatically controlled water bath to ensure that temperature stays constant during the duration of data collection
6. The set-up is air-tight by applying Vaseline at the nozzle of the syringe
7. Mass of carbon dioxide produced obtained by counting bubbles/ amount of water displaced in the measuring cylinder/ any other valid way to quantify the results of Benedict's test
8. Correct / workable description of experimental set-up / annotated diagram
9. Use of appropriate apparatus

Steps taken to ensure reliability and reproducibility

10. Control (boiled and cooled yeast)
11. Reliability: Repeat to obtain 3 readings per temperature
12. Reproducibility: Repeat entire experiment twice using fresh reagents

- 6 (a) Explain how the structure of collagen and haemoglobin are related to their function. [8]

State function of collagen:

To provide strength and resilience to tissues, and to help tissues stretch.

Level of protein structure	Structural features of collagen	Characteristics that it confers on collagen so that it can carry out its function
Primary Structure	Each polypeptide chain has about 1000 amino acid residues, and consists <u>mainly</u> of a <u>REPEAT</u> of <u>glycine, proline and hydroxyproline residues</u> .	Glycine's <u>small R group fits into the centre of the triple helix</u> and <u>allows close association of the three polypeptide chains</u> . OR The <u>rigid peptide bond formed with proline residues</u> helps to <u>stabilize the triple helix</u> .
Secondary Structure	<u>The localised, repetitive folding of 1 polypeptide chain</u> enables the <u>hydrophobic R-groups</u> of proline and hydroxyproline residues are on the <u>exterior</u> of the triple helix.	This renders collagen <u>insoluble</u> , making it a suitable structural protein.
Quaternary Structure	<u>Three helical chains wound round one another to form a triple helix structure</u> with <u>interchain hydrogen bonds</u> formed between the <u>-NH groups on the glycine residues on one chain</u> , and the <u>-CO groups of the proline of an adjacent chain</u> .	Extensive interchain hydrogen bonds <u>stabilize the fibrous structure of collagen</u> and cause it to be <u>rigid</u> .  This enables collagen to have <u>high tensile strength</u> .
	The tropocollagen molecules lie in <u>staggered array</u> in <u>parallel bundles</u> , with <u>covalent cross-links between C and N terminals</u> . This forms the <u>collagen fibrils</u> , which further assemble to form <u>collagen fibers</u>	This gives <u>additional rigidity and tensile strength</u> to collagen.

(H) It functions in the transport of oxygen.

Level of protein structure	Structural features of haemoglobin	Characteristics that it confers on haemoglobin so that it can carry out its function
Tertiary Structure	In each subunit, the <u>hydrophobic amino acid residues are buried in the interior</u> of the folded structure while the bulk of the <u>hydrophilic amino acid residues are on the exterior</u> .	This makes globular haemoglobin molecule <u>soluble in water</u> , which makes it suitable as a transport protein.



	Each subunit contains a haem group, which consists of a <u>porphyrin ring and an iron ion (<math>\text{Fe}^{2+}</math>)</u> .	$\text{Fe}^{2+}$ ion is able to <u>bind reversibly to oxygen</u> , accounting for the oxygen-carrying ability of haemoglobin.
Quaternary Structure	Each haemoglobin has 4 subunits, therefore it has <u>4 haem groups</u> .	<u>One haemoglobin molecule can carry up to 4 oxygen molecules</u> .
	The four subunits are held by various <u>non-covalent interactions</u> .	This allows for cooperative oxygen binding, where <u>binding of oxygen to the haem group of one globin subunit to trigger a conformation change in the other three globin subunits</u> .  This <u>increases the affinity of the other globin subunits to <math>\text{O}_2</math> and faster uptake of <math>\text{O}_2</math> by subsequent haem groups in the same haemoglobin molecule</u> .

(b) Outline the main features of anaerobic respiration.

[6]

In respiration under anaerobic conditions, fermentation occurs to regenerate  $\text{NAD}^+$  so that glycolysis can occur.  $\text{NADH}$  produced from glycolysis is oxidised by pyruvate to give either ethanol (alcohol fermentation) or lactate (lactate fermentation).

Like glycolysis, both alcohol and lactate fermentation occur in the cytosol. Alcohol fermentation occurs in plants and yeast cells. Pyruvate is first decarboxylated to ethanal. The enzyme is pyruvate decarboxylase. Ethanal is then reduced by  $\text{NADH}$  to form ethanol.  $\text{NAD}^+$  is regenerated. The enzyme involved is alcohol dehydrogenase. The ethanol remains unchanged even when aerobic conditions return.

Lactate fermentation in muscle cells of animals. Pyruvate is reduced by  $\text{NADH}$  to lactate.  $\text{NAD}^+$  is regenerated. The enzyme involved is lactate dehydrogenase. When aerobic conditions return, lactate is transported to the liver and converted to pyruvate. Only a small amount of  $\text{NAD}^+$  is regenerated from fermentation. This is sufficient for glycolysis to occur, but not for the subsequent processes. 2 NET ATP is produced during anaerobic respiration (glycolysis).

(c) Compare competitive and non-competitive inhibitors.

[6]

Similarities:

S1 Both lower rate of enzyme activity

S2 Both inhibitors can bind reversibly to the enzyme's active site.

## Differences

	COMPETITIVE INHIBITION	NON-COMPETITIVE INHIBITION
(D1) Site of binding of inhibitor	At the <u>active site</u> of the enzyme	At a region <u>other than the active site</u> of the enzyme
(D2) Structure of inhibitor	<u>Structurally similar</u> to the <u>substrate</u>	<u>NO structural resemblance</u> with the substrate
(D3) Effect of increasing substrate concentration on inhibition reaction rate	At high substrate concentrations, the <u>effects of inhibitor</u> are <u>NOT observed</u> .	At high substrate concentrations, the <u>inhibitory effects</u> are <u>still observed</u> .
(D4) Maximum rate of reaction	Can be <u>attained</u> if <u>substrate concentrations</u> are <u>sufficiently high</u> .	Can <u>never be attained</u> regardless of how high the substrate concentration is