

CANDIDATE NAME: _____

INDEX NUMBER _____

CG _____



SERANGOON JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2017

BIOLOGY
Higher 1
8875

ANSWER SCHEME

2 hours

Additional materials:
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

For Section A answer **all** questions.

For Section B, answer only one question.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE	
Paper 1 (MCQ)	/30
Paper 2	
Section A	
1	/10
2	/11
3	/10
4	/9
Total	/40
Section B	
6 or 7	/20
P2 Total	/60
TOTAL (P1+P2)	/90
TOTAL (100%)	/100

This question paper consists of 10 printed pages.

Section A [40 marks]

Answer **all questions** in the spaces provided.

Question 1

There have been many breakthroughs in stem cell research in recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

(a) State the type of stem cells involved in the replacement of worn-out cells and repair of damaged tissues, and describe the unique properties of this type of stem cells. [2]

- **Adult stem cells [1]**

Any 2 properties [1]:

- **Undifferentiated cells found in differentiated tissues**
- **Multipotent → Able to differentiate into a limited range of cell types**
- **Able to undergo mitotic cell division for self-renewal**

Stem cells undergo cell division to produce genetically identical daughter cells. **Fig. 1.1** shows two cells, each at a different stage of cell division.

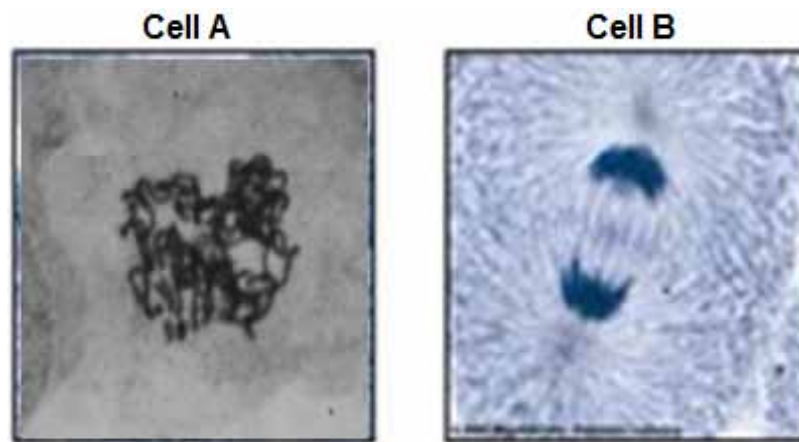


Fig. 1.1

(b)(i) With reference to **Fig. 1.1**, state the stages of cell division in **Cell A** and **Cell B**. [1]

Cell A: Prophase

Cell B: Anaphase

- (ii) The dysregulation of cell cycle can result in cancer. Outline the checkpoints that are present in normal cells to prevent this from occurring. [2]

Any 2

- **G₁ checkpoint:** assesses if the environmental conditions (presence of growth factors and nutrients, absence of DNA damage, adequate cell size) are favourable for cell division to proceed
- **G₂ checkpoint:** assesses if DNA replication is completed and cell size is adequate.
- **M checkpoint:** assesses if all chromosomes are attached to the mitotic spindle at their kinetochores and arrests the mitotic cell at metaphase if centromeres are not properly attached to kinetochore microtubules, hence preventing entry into anaphase.

Fig. 1.2 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

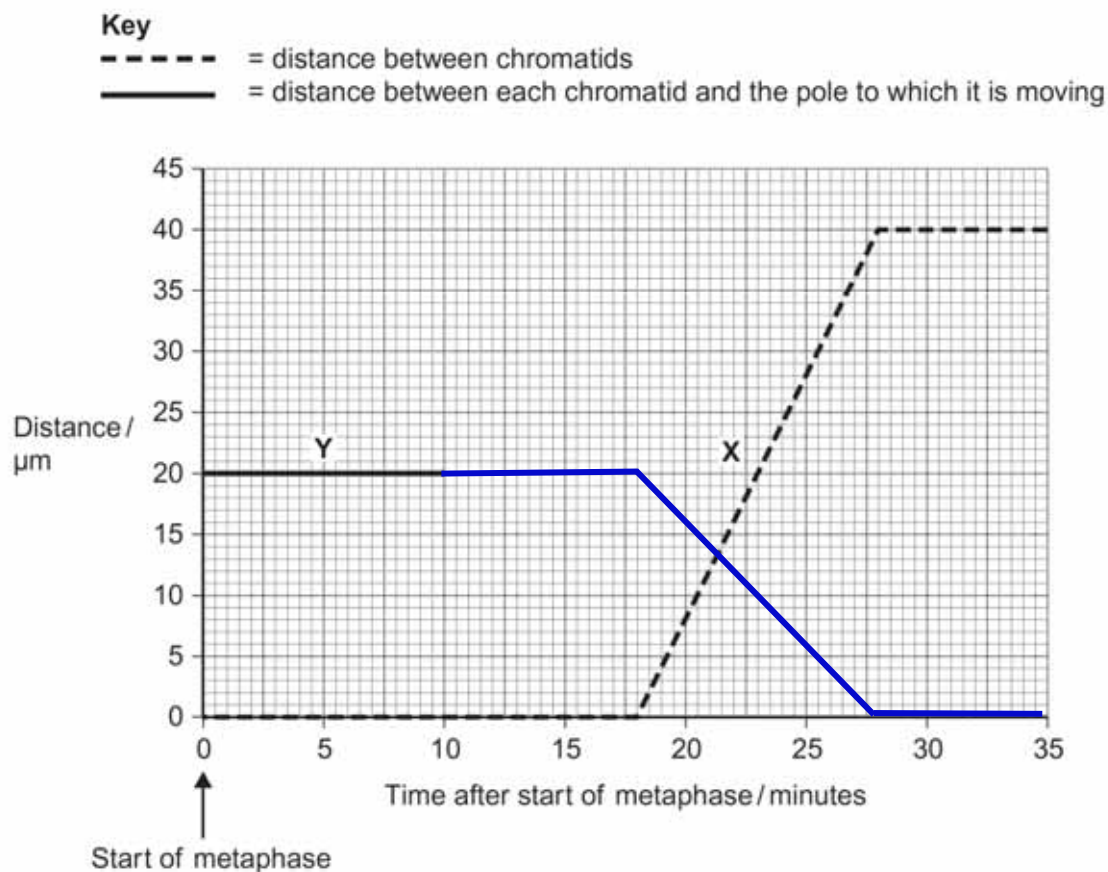


Fig. 1.2

- (c)(i) With reference to Fig. 1.2, state the duration of metaphase in the cell. [1]

- 18 min

(ii) Complete line Y on the graph. [1]

(iii) Account for your answer in (c)(ii). [3]

- Chromosomes align singly at the metaphase plate during metaphase of mitosis OR sister chromatids are attached to microtubules from opposite poles at metaphase
- Sister chromatids start to separate to become daughter chromosomes and migrate towards the opposite poles in anaphase, as shown at 18th min of line X when distance between chromatids starts to increase. Hence distance between chromatid and pole will start to decrease at 18th min.
- Distance between chromatids reach a plateau/maximum at 28th min, chromosomes arrived at opposite poles. Hence, distance between chromatid and pole will be minimum at 28th min.

[Total: 10]

Question 2

A mutation was found in the gene coding for NADP oxidase in a family of flowering plant. NADP oxidase is an enzyme that converts NADPH to NADP⁺.

(a) Explain the role of NADPH in photosynthesis. [2]

- Provides reducing power/H⁺ to reduce
- Phosphoglyceric acid (PGA)/glycerate-3-phosphate (GP) to glyceraldehyde-3-phosphate (GALP)/phosphoglyceraldehyde (PGAL)/triose phosphate (TP)

(b) Using your knowledge of photosynthesis, predict the effect of this mutation on plants. [3]

- Mutation will result in low or no NADP oxidase activity
- Less conversion of NADPH to NADP⁺ for light reaction of photosynthesis (OR less reduction of PGA to GALP in Calvin cycle)
- Less ATP is synthesized (or less glucose produced)

Rubisco is an enzyme required in the light-independent stage of photosynthesis. **Fig. 2.1** shows the effect of increasing temperature on the activity of two variations of Rubisco, **Rubisco C** and **Rubisco S**.

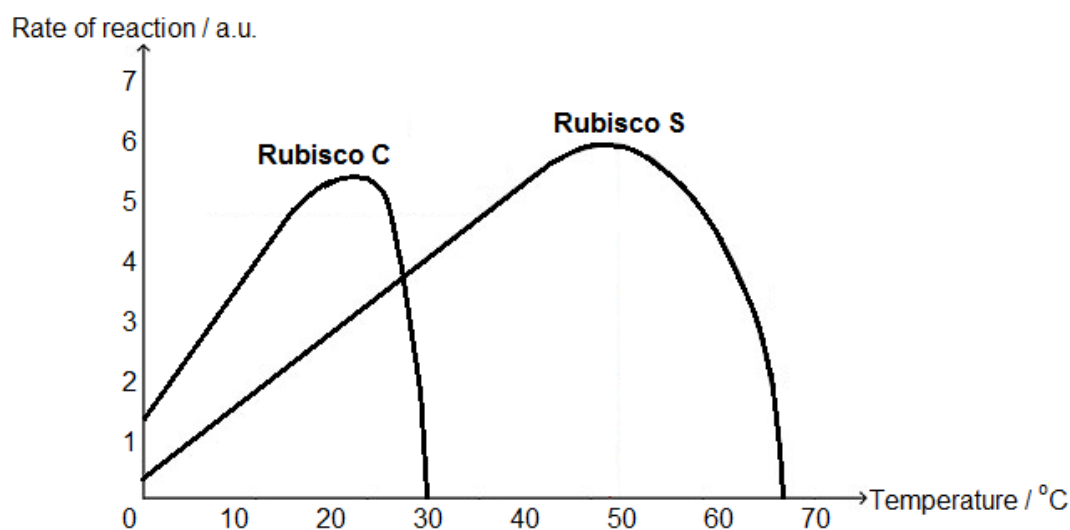


Fig. 2.1

(c) With reference to **Fig. 2.1**, compare the effect of temperature on the two enzymes. [3]

- Both Rubisco C and Rubisco S has an increased rate of reaction as temperature increases up to optimum temperature OR both Rubisco C and Rubisco S are denatured at temperatures higher than optimum.
- Rubisco C has a lower optimum temperature of 20°C as compared to Rubisco S at 50 °C where rate of reaction is at a maximum
- Rubisco C reaches a lower maximum rate of reaction of 5.5 a.u. at a faster rate as compared to Rubisco S which reaches a maximum rate of reaction of 6 a.u at a slower rate.

(d) Explain how different alleles give rise to different Rubisco structure. [3]

- Different alleles have different DNA nucleotide sequence that results in a different mRNA/codon sequence after transcription
- Thus will result in different amino acid sequence / primary structure after translation
- Different R group interactions between amino acids affects folding of the polypeptide chain, giving rise to different 3D conformation in the tertiary structure

[Total: 11]

Question 3

Fig. 3.1 shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X** present in brown adipocytes.

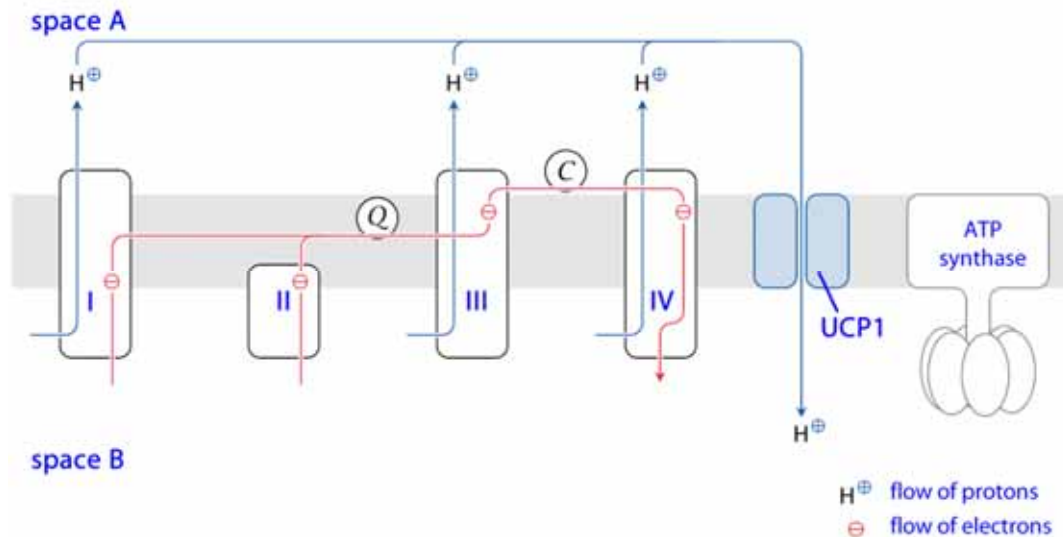


Fig. 3.1

(a)(i) State the identity of organelle **X**.

[1]

Mitochondrion

(ii) Outline how ATP is usually synthesised in the inner membrane of organelle **X**.

[4]

- **NADH and FADH₂ carry hydrogen in the form of protons and electrons where proton remain in the matrix and electrons are passed along the progressively lower energy electron carriers in the electron transport chain.**
- **Energy released is used to pump H⁺ from the matrix to the intermembrane space via active transport which sets up a concentration gradient (high H⁺ conc in intermembrane space, low conc in the matrix)**
- **H⁺ diffuse down the concentration gradient from the intermembrane space to matrix via the stalked particle**
- **Provides a proton motive force that drives the synthesis of ATP by ATP synthase by phosphorylation of ADP and inorganic phosphate (chemiosmosis).**

- (b)** Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on ATP synthesis and suggest the physiological significance of brown adipose tissue. [3]

- As UCP1 allows protons to leak back into the matrix without passing through the ATP synthase,
- Loss of H^+ concentration gradient, no ATP will be synthesized
- The energy released from the spontaneous flow of protons through UCP1 is lost as heat, which helps to keep the organisms warm.

- (c)** In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase. Using relevant information from **Fig. 6.2**, suggest and explain why more ATP is produced from NADH. [2]

- NADH donates electrons to complex I while $FADH_2$ donates to complex II. The energy released from transfer of electrons through the complexes is used to pump protons across the inner membrane.
- NADH allows for more chances to pump more protons across the gradient, which powers the ATP synthase and gives us 3 ATP per molecule of NADH, while $FADH_2$ produces 2 ATP during the ETC because it gives up its electron to complex II, bypassing complex I.

[Total: 10]

Question 4

The table below shows the amino acid differences in the cytochrome b protein between various vertebrates.

	Human	Elephant	Platypus	Ostrich	Starling	Crocodile	Lungfish	Coelacanth	Goldfish	Shark
Human		26	40	43	41	47	83	70	68	71
Elephant			45	45	48	50	84	72	63	74
Platypus				54	52	51	89	74	70	76
Ostrich					26	36	91	75	68	73
Starling						47	91	77	67	70
Crocodile							85	78	70	77
Lungfish								90	94	86
Coelacanth									83	78
Goldfish										88
Shark										

(a) Explain how differences in amino acid sequences in the cytochrome b chain allow the establishment of the phylogenetic tree. [2]

- Percentage of amino acid difference indicates relatedness where few difference indicates recent common ancestor
- Provides quantitative data to construct phylogenetic tree

(b) Suggest why homology still features prominently in evolutionary studies despite the advantages that molecular evidence can confer. [1]

Any 1

- Less expensive as it does not rely on machines
- DNA/protein samples might be limited or unavailable

Giant anteaters, armadillos and Australian numbats (*Myrmecobius fasciatus*) have many similar traits. This led some to believe that they were closely related.

Table 4.1 shows the comparison of four characteristics between the three mammals.

Mammal	Characteristics			
	Diet	Body	Snout	Tongue
Armadillo	Feed on insects	Covered by bony keratinised plates	Pointy snout	Long tongues
Giant Anteater	Feed on ants and termites	Covered by hair	Elongated narrow snout	Long tongues
Numbats	Feed on termites	Covered by hair	Narrow snout	Long tongues

(c) Explain why variation is important in selection. [2]

- Genetic variation results in variation in phenotype between individuals in a population
- Giving rise to different reproductive success between individuals OR
- Under a particular selective pressure, individuals with the advantageous variation are selected for.

(d) Explain how the evolution of long tongues in numbats supports Darwin's theory of natural selection. [4]

- Genetic variation give rise to different tongue lengths in (ancestral) numbats
- Under a selection pressure of limited food/ big termite nests/ deep termite nests/AVP
- Numbats with longer tongues have a selective advantage/ will be selected for because they can probe deeper into termite nests / AVP
- Numbats with longer tongues will survive, reproduce and pass down alleles encoding for longer tongues to the next generation
- Over time, the frequency of alleles coding for long tongues will increase.

[Total: 9]

Section B [20 marks]

Answer **one** question in this section.

Write your answers on the separate writing paper provided.

Your answers may be illustrated by large, clearly labeled diagrams, ONLY where appropriate.

Your answers must be in continuous prose.

Question 5

(a) Using the induced-fit hypothesis, explain the mode of action of enzymes. [6]

1. Enzyme specific in its action due to complementary 3D configuration/conformation of active site to that of substrate;
2. The induced fit model suggests that the enzyme and the substrate do not fit together exactly;
3. Effective collisions between enzymes and (specific) substrate molecules result in substrate binding to active site of enzyme;
4. The enzyme undergoes a 3D conformation change, which improves the fit between substrate and enzyme;
5. to form enzyme-substrate (ES) complexes;
6. Product formed that no longer fits into active site and is released;

(b) With reference to haemoglobin, explain the significance of bonds in maintaining the protein's structure and function. [8]

1. Peptide bonds between amine groups and carboxyl groups of amino acids at primary structure of organisation
2. Hydrogen bonds between –CO and –NH groups of the polypeptide backbone;
3. Ref. to overall 3D configuration/ globular shape of haemoglobin;
4. Each globin polypeptide is folded such that the bulk of the hydrophobic amino acid residues are buried in the interior of the globular structure;
5. Ref. to haem binding pocket lined with hydrophobic amino acids to provide a hydrophobic environment for hydrophobic haem group to bind;
6. Hydrophilic amino acid residues are on the outside;
7. Haemoglobin is soluble in aqueous medium and hence a good transport protein for oxygen in blood;
8. The two polypeptide chains in each dimer are held together by mainly hydrophobic interactions;
9. The two dimers are held together by weak hydrogen and ionic bonds;
10. Resulting in the ability of the two dimers to move with respect to each other;
11. This allows for cooperativity;
12. When an oxygen molecule binds to/is released from 1 haemoglobin subunit, the binding/ release induces a conformational change in the remaining subunit;
13. Which increases/ lowers the affinity for oxygen of the remaining three oxygen binding sites respectively;
14. This facilitates the loading and unloading of oxygen;

(c) Discuss the social implications of genetically modifying plants. [6]

- 1) Use of vectors which confer antibiotic-resistance might result in these genes being passed on to other potential harmful bacteria which hampers treatment.
- 2) New allergens produced that are dangerous to people with allergy who consume them.
- 3) Genetically modified crops might establish themselves as weeds as they are able to withstand unfavourable environmental conditions.
- 4) Spread of resistance from genetically modified crops to weeds might result in the production of superweeds that are resistant to herbicides.
- 5) Genetically engineered organisms, if introduced into the environment, might upset the balance of the ecosystem as it might lead to increased competition for space and nutrients.
- 6) Loss of biodiversity

OR

Question 6

(a) Compare competitive and non-competitive inhibition of enzyme action. [6]

(b)

Features	Competitive	Non-competitive
Structure of inhibitor	Resembles substrate;	Does not resemble substrate;
Binding site of inhibitor	Binds to active site of enzyme;	Binds to enzyme at a region other than the active site;
Mechanism of inhibition	Blocks substrates from binding to active site of the enzyme;	Blocks substrates from binding to active site by changing the conformation of the active site;
Effect of high substrate concentration on inhibition	Inhibition can be reversed at high substrate concentration;	Inhibition cannot be reversed at high substrate concentration;
Achieving V_{max}	V_{max} in the presence of inhibitor can be very close to that of reaction in the absence of inhibitor;	V_{max} in the presence of inhibitor is less than that of reaction in the absence of inhibitor;
Similarities:		
1. At low substrate concentration, rate of reaction in the presence of inhibitors is		

slower than that in the absence of inhibitor;

(c) Describe the process of mitosis and its importance in living cells.

[8]

Process of mitosis: any 6 from PMAT (at least one from each stage)

Prophase:

- Chromatin condenses to chromosome
- Sister chromatids joined at centromere
- Centrioles migrate to opposite poles
- Mitotic spindles begin to form; nuclear envelope disintegrates
- Nucleolus disappears

Metaphase:

- Centrioles reached opposite poles
- Spindle fibres attached to kinetochore
- Chromosomes align on metaphase plate

Anaphase

- Centromeres divide
- Sister chromatids separate and move to opposite poles
- Shortening of kinetochore microtubules/spindle fibres

Telophase

- Chromosomes reached opposite poles
- Chromosomes uncoiled to chromatin fibers
- Spindle fibers disintegrates
- Nuclear envelope reforms
- Nucleoli reappears,
- Forms two genetically identical daughter nuclei

Importance (max 2):

- Maintains genetic stability to produce genetically identical nuclei
- Increase number of cells for growth
- Asexual reproduction
- Replace damaged cell and regeneration

(d) Discuss the ethical implications of genetically modifying plants.

[6]

- **GM plants grown as crops may lead to consumers having allergies as foreign proteins are produced in the plants, companies need to label their GM crops for consumers to make informed choices / consumer safety is compromised;**
- **Animal genes may be introduced to plant genomes, leading to concern of vegetarians or some religious groups which followers are not allowed to consume certain animals;**
- **GM crops lead to benefits that rich countries can enjoy due to more financial resources at the expense of poorer countries (e.g. increasing dependence of poor countries on rich countries for expensive GM crops), increasing rich-poor divide;**

- GM crops can produce higher quality food to allow large companies that develop the technology / reduce costs to increase profit margins to out-compete small scale farmers, increasing rich-poor divide;
- Patenting the GM crops reduces them to the level of objects and if patenting is not allowed, a company might not be able to protect the results of their research program.
- Tampering with nature, where the mixing of genes among species may be seen as violation of organisms natural intrinsic values, crossing species boundaries;

END OF PAPER