

INNOVA JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATION  
in preparation for General Certificate of Education Advanced Level  
**Higher 1**

CANDIDATE  
NAME

**ANSWERS**

CLASS

INDEX NUMBER

**BIOLOGY**

**8875/02**

Paper 2

**29 August 2017**

**2 hours**

Additional Materials: Answer Paper  
Cover Page

**READ THESE INSTRUCTIONS FIRST**

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

**Section A**

Answer **all** questions.

**Section B**

Answer **one** question.

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

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

For Examiner's Use	
Section A	
1	
2	
3	
Section B	
4 OR 5	
Total	

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



Innova Junior College

**[Turn over**

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

- 1 (a) Describe the importance of ATP in cells, giving **two** examples of processes in which it is used.

1. **ATP is the universal energy carrier in living org**

**where hydrolysis of phosphate grps releases energy;;**

2. **muscle contraction;; OR**

3. **DNA replication;; OR**

**active transport, cell movement, amino acid activation, AVP;;**

[3]

Cells generate ATP by adding a phosphate group ( $P_i$ ) to ADP. During the complete oxidation of glucose, cells have two ways of doing this:

- Substrate level phosphorylation
- Oxidative phosphorylation

Fig 1.1 and 1.2 are diagrams that show the main details of these two processes (not drawn to the same scale).

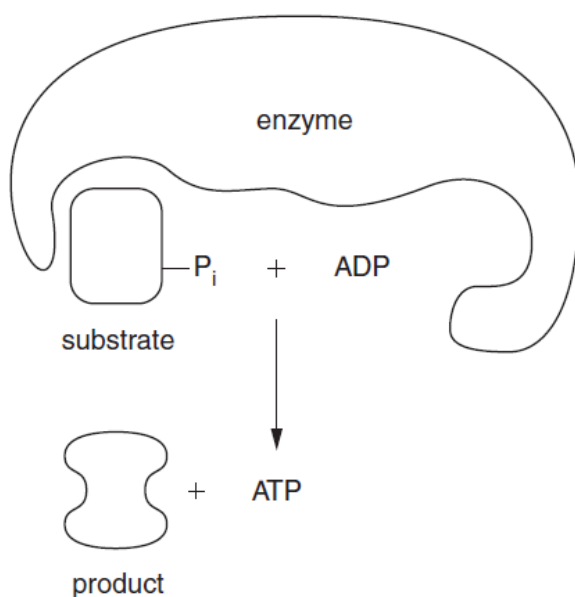


Fig 1.1

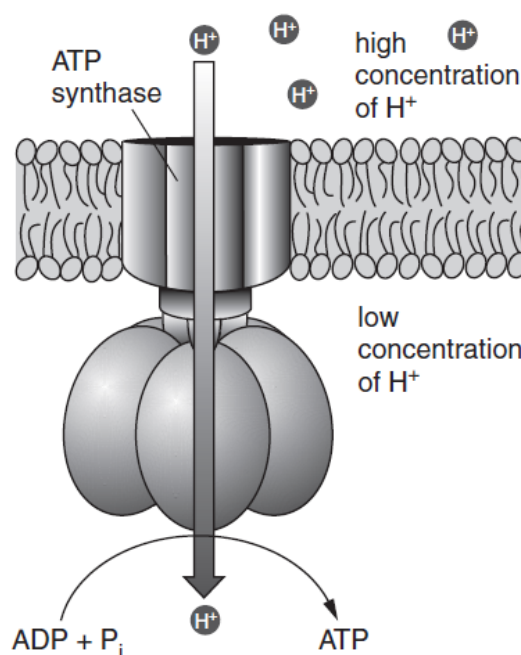


Fig 1.2

- (b) State precisely where these two processes occur in a cell.

*substrate level phosphorylation*

**Cytoplasm @cytosol (during glycolysis)/ mitochondrion matrix (during Krebs cycle);;**

*oxidative phosphorylation*

**inner memb of mitochondrion;;**

[2]

- (c) Compare the relative amounts of ATP produced by the two processes when a molecule of glucose is completely oxidised.

1. **OP pdces more ATP than SLP;;**

2. **SLP pdces 4 ATP (2 in glycolysis, 2 in Krebs Cycle) while OP pdces 28 ATP;;**

[2]

- (d) Only substrate level phosphorylation is possible in the absence of oxygen. Explain why oxidative phosphorylation is not possible in the absence of oxygen.

1.  **$O_2$  is final e- & proton acceptor in ETC**

**producing water in process, catalyzed by cytochrome oxidase;;**

2. **w/o  $O_2$ , there is no flow of e- down ETC**

**thus electrochemical proton grad is not generated across inner mitochondrial memb;;**

3.  **$H^+$  ions does not diffuse across inner mitochondrial memb via ATP synthase catalytic sites of ATP synthase not activated, thus no phosphorylation of ADP with  $P_i$ ;;**

[3]

- (e) Fig 1.3 shows how glucose is transported into a cell via a transport protein held within the cell surface membrane.

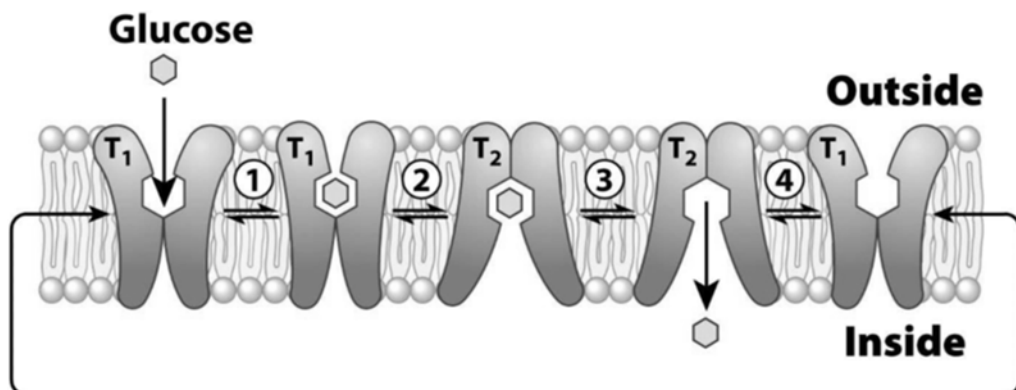


Fig 1.3

- (i) Describe the structure of the cell surface membrane shown in Fig 1.3.

1. **It has a fluid mosaic model composed of phospholipid bilayer & prots;;**

2. **hydrophilic phosphate heads faces aqueous medium while hydrophobic hydrocarbon tails face each other away from aqueous medium;;**

[2]

- (ii) With reference to Fig 1.3, describe how glucose is transported into the cell.

1. **high conc of glucose outside cell, glucose binds complementarily to binding site of carrier prot in T1 conformation;; @transport protein**

2. **upon binding, carrier prot changes from T1 conformation to T2 conformation, where it releases glucose inside of cell;;**

[2]

[Total: 14]

2 Fig. 2.1 shows a diagram of DNA replication.

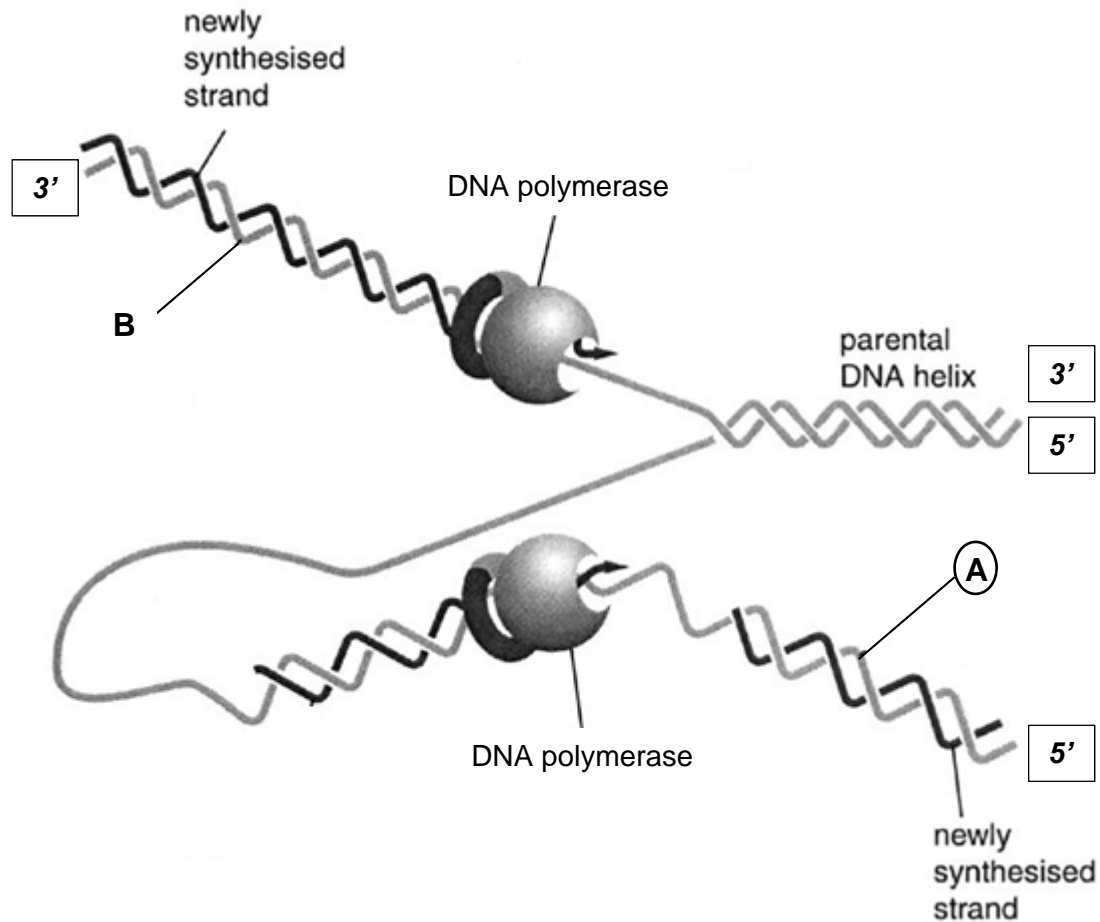


Fig. 2.1

- (a) (i) On Fig. 2.1, indicate 3' and 5' ends on both the parental template strands of the DNA molecule. [1]
- (ii) Circle which strand, A or B, is the lagging strand template used in the synthesis of new DNA daughter strand resulting in Okazaki fragments. [1]
- (b) Explain why the newly synthesised strand is formed continuously from the leading strand template while Okazaki fragments are formed using the lagging strand template.

**1. 2 DNA strands synthesized are antiparallel**

*DNA pol can only add nucleotides to 3' end of growing daughter strand in 5' to 3' direction*

**2. leading strand synthesised in 5' to 3' direction continuously towards replication fork**

*lagging strand synthesised as Okazaki fragments in 5' to 3' direction away from replication fork*

[2]

- (c) Describe how gene mutations may occur during replication of DNA.  
***error in complementary base pairing occurs during DNA replication by DNA pol III;;***  
***point substitution mutations not corrected by DNA repair prots or DNA pol III during proofreading;;***

[2]

Cell cycle checkpoints are used by a cell to monitor and regulate the progress of the cell cycle. Checkpoints prevent cell cycle progression at specific points, allowing verification of necessary phase processes and repair of DNA damage. The cell cannot proceed to the next phase until checkpoint requirements have been met.

Checkpoints typically consist of a network of regulatory proteins that monitor and dictate the progression of the cell through the different stages of the cell cycle. However, these checkpoints may be dysregulated which can result in uncontrolled cell division and eventually cancer.

Fig. 2.2 shows a typical cell cycle with the various checkpoints.

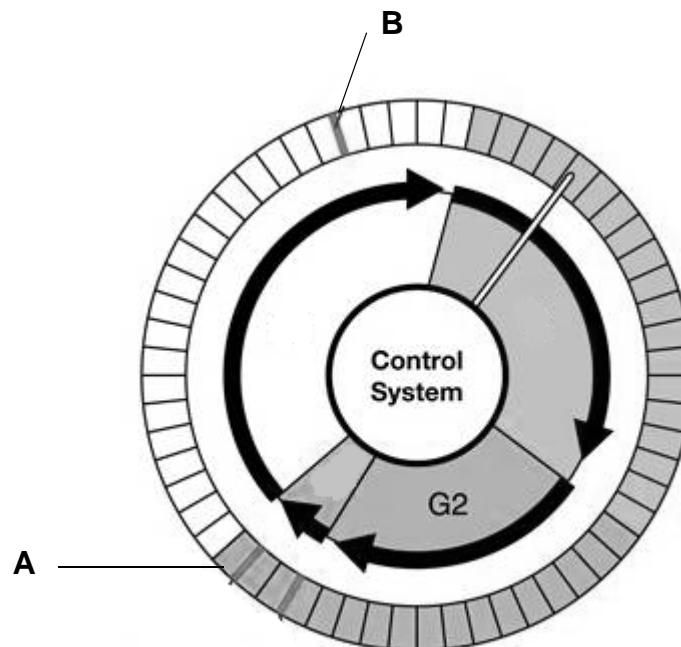


Fig. 2.2

- (d) With reference to Fig. 2.2,
- (i) name checkpoints A and B;
- A** ***spindle/ M phase checkpoint;***
- B** ***G1/ restriction checkpoint/ DNA damage checkpoint;***

[1]

(ii) Describe the role of checkpoints **A** and **B**.

**A** *checks chromosomes are all properly attached to spindle fibres before cell cycle continues;*

**B** *checks for presence of growth factors, DNA damage, cell size, nutrients*

[1]

(iii) Explain what occurs in the G2 phase of cell cycle.

**1. cell's growth phase after DNA replication in S phase of interphase**

*cells continue to build up synthesis ATP (energy), synthesises proteins and organelles (mitochondrion, rER);;*

**2. duplication of centrosome occurs, each containing pair of centrioles**

*prepare cell to enter M phase of cell cycle;;*

[2]

(e) Describe how dysregulation of the checkpoints in cell cycle may lead to cancer.

**1. cells will continue to proceed to next phase of cell cycle continuously bypassing checkpoints**

*cells are not checked for their readiness to proceed to next phase of cell cycle;;*

**2. leads to uncontrolled cell division & over - proliferation of cells**

*resulting in formation of a mass of non-functional cells called tumour resulting in cancer;;*

[2]

(f) Some types of cancer can be treated by chemotherapy, which involves the injection of chemicals into the bloodstream.

Vincristine is a drug used for chemotherapy. This drug works partly by binding to the tubulin protein, stopping the cell from proceeding in the M phase of the cell cycle.

Explain how the use of vincristine will stop the proliferation of cancer cells.

**1. tubulin is a component of spindle fibre/ microtubules**

*when drug binds to tubulin, spindle fibre/ microtubules could not be formed;;*

**2. cells are unable to pass the spindle/ M phase checkpoint**

*Thus does not divide successfully thereby stopping proliferation of cancer cells;;*

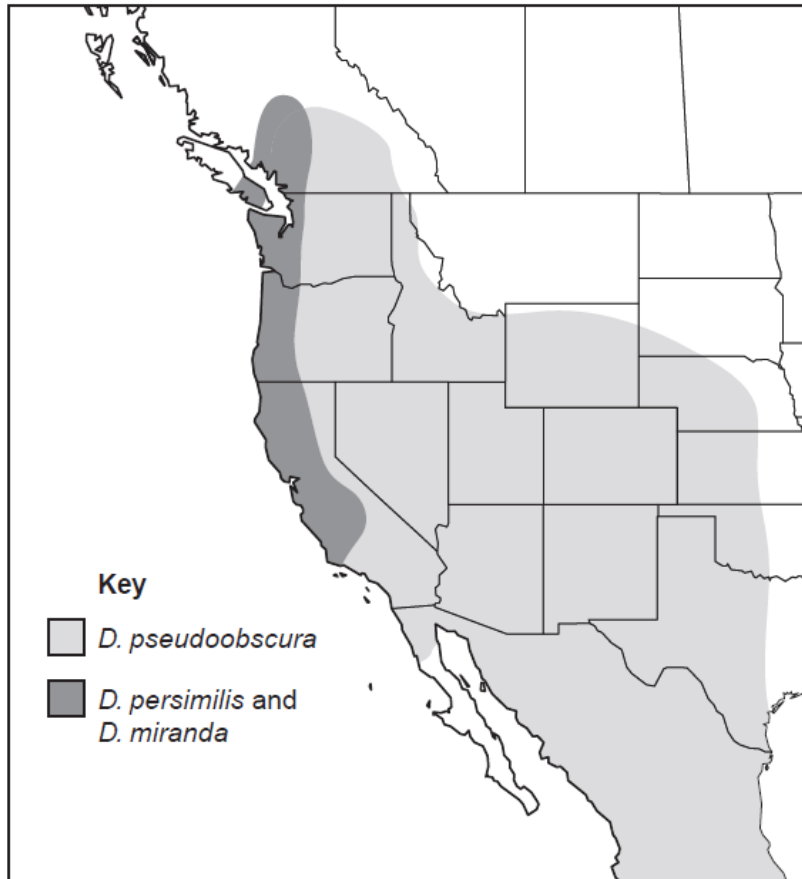
[2]

[Total: 14]

- 3 The fruitfly, *Drosophila*, has many different species. Three of these species, *Drosophila pseudoobscura*, *D. persimilis* and *D. miranda*, are thought to be closely related.

Samples of these three species were collected from the western United States of America.

Fig. 3.1 shows where these species naturally occur.



**Fig. 3.1**

- (a) State what must exist in a population for natural selection to occur.  
**variation;;**

[1]

The base sequences of four regions of DNA of each species were sequenced. The divergence of these base sequences in *D. pseudoobscura* and *D. persimilis* from the sequences in *D. miranda* was calculated. The results are shown in Table 3.

Table 3

DNA region	<i>Drosophila</i> species	percentage divergence of base sequence from that of <i>D. miranda</i>
1	<i>pseudoobscura</i>	2.5
	<i>persimilis</i>	2.4
2	<i>pseudoobscura</i>	8.1
	<i>persimilis</i>	7.3
3	<i>pseudoobscura</i>	2.1
	<i>persimilis</i>	1.7
4	<i>pseudoobscura</i>	1.9
	<i>persimilis</i>	1.7

- (b) With reference to Table 3, describe the evidence that *D. miranda* may be more closely related to *D. persimilis* than to *D. pseudoobscura*.

1. **% divergence of *D. persimilis* from *D. miranda* is less than that of *D. pseudoobscura* from *D. miranda***

-----  
**for all 4 DNA regions;;**

2. **at DNA region 4, % divergence of *D. persimilis* is 1.7 & 1.9 for *D.pseudoobscura***

-----  
**at DNA region 2, % divergence of *D. persimilis* is 7.3 & 8.1 for *D.pseudoobscura*;;**

[2]

- (c) Suggest why there is more divergence in some regions of DNA than in others.

1. **some regions of DNA have higher mutation rates / more prone to mutations**

-----  
**mutation changes are less harmful when exact seq of amino acid is not critical to survival of org;; OR**

2. **lower divergence / mutation rates if DNA is part of an impt gene**

-----  
**mutations in some regions are likely to be fatal hence not seen in popn;**

[1]



- (d) Explain how *D.persimilis* and *D.pseudoobscura* could have speciated from *D.miranda*.

**1. variations exist in the 2 popns of *D. miranda***

*due to diff genetic makeup;;*

**2. diff selection pressures in diff env<sup>tal</sup> cond<sup>ns</sup>**

*those with favourable phenotypes are selected for;;*

**3. survive to reproductive age & pass down advantageous/ favourable alleles to offspring,**

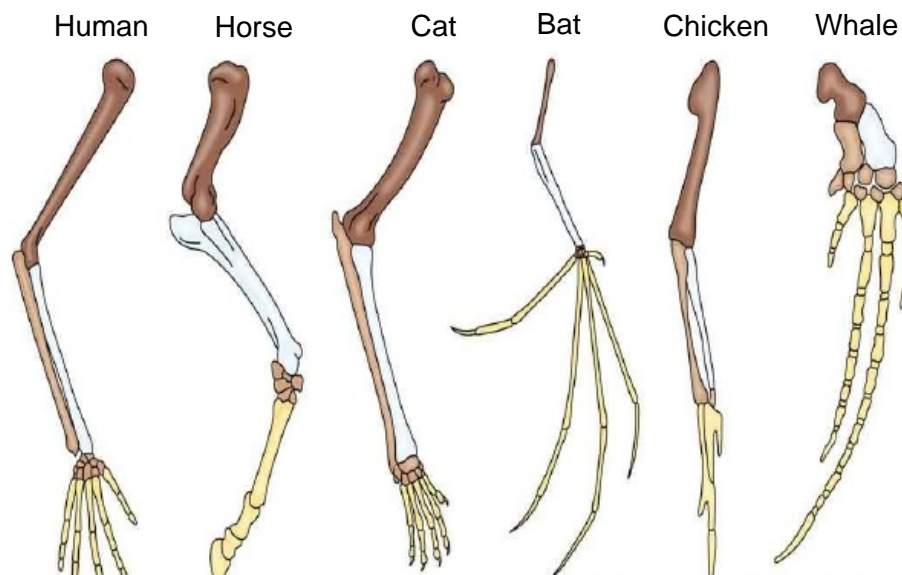
*leading to changes in freq of alleles in gene pool;;*

**4. 2 popns cannot interbreed due to geographical barrier (water bodies/ high mountains), there will be accumulation of genetic differences over time which results in the formation of different species, unable to interbreed to give viable, fertile offspring;;**

[4]

Beside molecular homology, scientists can also use anatomical homology to study the evolutionary relationship among vertebrate species.

Fig. 3.2 shows the relationship between six vertebrate species by comparing the bone arrangement in the forelimbs.



**Fig. 3.2**

(e) Explain what is meant by 'homology'.

**1. Homology refers to similarities due between diff species due to a common ancestor;;**

[1]

(f) Explain how the anatomical homology shown in Fig. 3.2 supports Darwin's theory of evolution.

**1. forelimbs of various species hv same basic pentadactyl/ five digit forelimb struc**

**differences in shape which are largely due to specialisation for a particular function;;**

**2. e.g. whale for swimming, bat for flying etc;;**

**3. struc likely to have originated/ derived from a common ancestor**

**indicating descent with modification over time;;**

[3]

[Total: 12]

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

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

- 4 (a) Describe the polymerase chain reaction and explain the advantages and limitations of the procedures. [12]

**PCR Process (max 6m)**

1. PCR is an *in vitro* method of replicating short DNA seq into millions of copies/ amplifying short DNA seq within short period of time
2. PCR rxn requires forward & reverse primers, heat-stable Taq pol, free deoxyribonucleotides, & target DNA seq to be amplified & buffer soln
3. PCR is carried out in a thermal cycler in 3 step cycle – denaturation, annealing and elongation to take place
4. denaturation takes place at 95°C to separate ds DNA into ss DNA by breaking H-bonds b/w compl bp. ss DNA will then act as template for elongation
5. annealing occurs when rxn mixture is cooled to 55°C to allow forward & reverse primers to bind to complementary seq flanking target seq via H-bonds b/w compl bp.
6. elongation occurs at 72°C when Taq pol synthesizes compl DNA strands by adding free deoxyribonucleotides to free 3'OH ends of primers using target DNA seq as template

each cycle results in doubling of the target DNA seq ( $2^n$ )

**Advantages (max 3m)**

7. Rapid and efficient

Each cycle takes only 3 - 5 min thus large number of DNA molecules to be amplified.

**8. Relatively easy**

*PCR can be performed using relatively simple equipment, a thermal cycler. The process is fully automated with initial setting of conditions, adding all reagents in appropriate amounts and the cycles can run unattended overnight.*

**9. Sensitive and robust**

*The process is sensitive and can amplify minute amounts of target DNA.*

**10. Specific**

*The elongation process in PCR synthesises the target DNA sequence that lies specifically between the forward and reverse primers.*

**11. Relatively high fidelity**

*The amplification is relatively accurate with error rates ranging between 1 in 10,000 bases to 1 in 100,000 bases. Error rates vary with the choice of polymerase.*

**Limitations (max 3m)****12. Primer design**

*base sequence flanking the target sequence needs to be known first in order to synthesize specific primers.*

**13. Limited length of target sequence**

*The length of target DNA restricted to 0.1 to 5 kb with an optimum length of 2 to 3 kb. Further increase in length of target sequence decreases efficiency of amplification because polymerase tends to detach before chain extension is complete.*

**14. Error in replication**

*Taq polymerase lacks proofreading activity. This results in an error rate of approximately 1 in 10,000 bases. If the error occurs early in the PCR cycle, the erroneous sequence will be amplified together with the target sequence.*

- (b) Explain how gel electrophoresis is used to analyse DNA. [8]

(max 8m)

1. *Agarose gel electrophoresis is used in the separation of DNA fragments after digestion by restriction enzymes.*
2. *Agarose powder is dissolved buffer and poured into gel casting tray. A comb is inserted to form wells. After the gel is cooled and harden, it placed in the gel chamber together with buffer and the comb removed.*
3. *DNA fragments are mixed with loading and tracking dye and loaded in wells of the agarose gel near the cathode using a micropipette.*
4. *The loading dye contains glycerol that helps weigh the DNA fragments into the wells.*
5. *Tracking dye containing a low and a high molecular weight coloured compound is added during loading. These coloured compounds act as front and back markers of migration.*
6. *A voltage between 90V to 150V is applied across the gel. The buffer maintains appropriate pH and contains ions that conduct a direct current across the gel.*
7. *DNA fragments which are negatively charged due to presence of phosphate groups, will migrate across the gel from the negative electrode (cathode) towards the positive electrode (anode).*
8. *Agarose gel acts as a molecular sieve to separate nuclei acids by size/ molecular weight/ fragment length. Smaller fragments are less impeded by the gel and migrate faster (further) than larger fragments. @vice versa, idea of migrate rate is inversely proportional to fragment length/ size*
9. *After electrophoresis, DNA fragments of the same size/ length are localised in the same region of the gel forming a band.*
10. *As DNA molecules are not visible to the naked eye. Gels need to be stained with methylene blue/ ethidium bromide for the DNA bands to be seen.*

[Total: 20]

- 5 (a) Describe the unique features of zygotic stem cells, embryonic stem cells and blood stem cells and explain the normal functions of stem cells in a living organism. [10]

**Features**

1. *Zygotic stem cells are produced from the fusion of an egg and sperm cell are they are totipotent;;*
2. *They can differentiate into any cell types to form whole organisms, and so are also pluripotent and multipotent;;*
3. *Embryonic stem cells from the inner cell mass of blastocyst (a hollow ball-shaped mass of cell formed a week after fertilisation) are pluripotent. They are the descendants of totipotent cells;;*
4. *These cells can differentiate into almost any cell type to form any organ or type of cell except extra-embryonic tissues and so are not totipotent but are multipotent;;*
5. *Blood stem cells are from the bone marrow are multipotent;;*
6. *Blood / hematopoietic stem cells are multipotent as they can only differentiate into a limited range of cell type - red blood cells, white blood cells, platelets. They are not totipotent or pluripotent;;*

**Functions**

7. *Embryonic stem cells give rise to all derivatives of the three primary germ layers: ectoderm, endoderm and mesoderm during development;;*
8. *These germ layers subsequently give rise to the multiple specialized cell types that make up the heart, lung, skin, and other tissue;;*
9. *Adult stem cells like blood stem cells maintain the steady state functioning of a cell;;*
10. *by generating replacements for cells lost through disease, tissue injury or normal wear-and-tear;;*

- (b) With reference to two examples, explain how genetic engineering can be used to improve quality and yield of crop plants. [10]

**Example 1: Bt Corn (max 5m)**

1. Corn are often damaged by the larvae (caterpillar) of the moth, European corn borer. The larvae bore and eat into the stem of the corn plant, damaging and often killing it;;
2. The use of spray insecticides is ineffective as the larva is protected from the insecticides once it enters the stem;;
3. Bt corn - corn plant genetically modified to be resistant to insects like the European corn borer by introducing a gene coding for a toxin that kills the larvae;;
4. The cry gene isolated from soil bacterium Bacillus thuringiensis is transformed into corn plants via the use of the Ti plasmid from the bacterium Agrobacterium tumefaciens;;
5. Corn that has been transformed with the cry gene (i.e. Bt corn) is able to produce Bt toxin;;
6. When a larvae feeds on any tissue of the Bt corn plant, it ingests the Bt toxin. The Bt toxin is cleaved by intestinal protease, active Bt toxin binds to receptors on the surface of epithelial cells and inserts into the cell membrane, forming pores. This causes gut cells of insect to lyse, eventually leading to insects' death;;
7. This reduced the use of insecticides while ensuring that corn plants are enable to grow healthily to maturity, thereby ensuring increase in yield;;

**Example 2: Golden Rice (max 5m)**

8. In developing countries, vitamin A deficiency is a leading cause of vision impairment and blindness in children;;
9. Rice grain is a staple food in many developing countries. But the precursor to vitamin A -  $\beta$ -carotene is produced in the rice leaves and not the rice grain which is eaten;;
10. The rice plant can be genetically modified to express  $\beta$ -carotene in its rice

*grain. GM rice is known as Golden Rice due to its yellow-orange colour;;*

- 11. In Golden Rice, two  $\beta$ -carotene biosynthesis genes are inserted into the rice genome to produce enzymes that synthesise and accumulate  $\beta$ -carotene in the rice grain;;*
- 12. they are psy gene from the plant daffodil coding for phytoene synthase and crt1 gene from soil bacterium that codes a bacterial phytoene desaturase which produces the substrates for the subsequent steps to conversion to  $\beta$  carotene;;*
- 13. This allowed  $\beta$  carotene to be produced in the rice grain, improving the quality (nutritional content) of the rice. Golden rice consumed by people will then allow our bodies to produce Vitamin A without the consumption of additional supplements;;*

[Total: 20]