

**H1**ANDERSON JUNIOR COLLEGE  
HIGHER 1

NAME

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INDEX NUMBER

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**BIOLOGY****8875/02**

Paper 2 Core Paper

**13 September 2017****Tuesday****2 hours**

Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name and PD group on all the work you hand in.

Write in dark blue or black pen.

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

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

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

All working for numerical answers must be shown.

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

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

Calculators may be used

For Examiner's Use	
<b>PAPER 1</b>	
<b>1-30</b>	
	<b>30 marks</b>
<b>PAPER 2</b>	
<i>Section A</i>	<i>40 marks</i>
<b>1</b>	
<b>2</b>	
<b>3</b>	
<i>Section B</i>	<i>20 marks</i>
<b>5 or 6</b>	
<b>PAPER 2</b>	
	<b>60 marks</b>
<b><u>TOTAL</u></b>	
	<b><u>90 marks</u></b>

## Section A

Answer **all** the questions in this section.

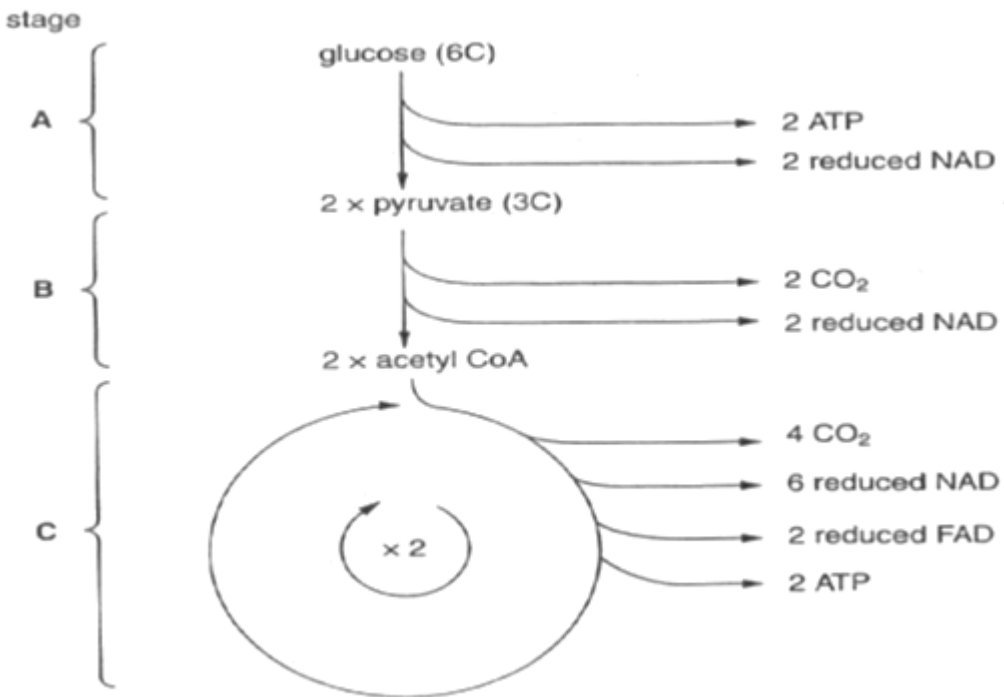
1	<p>Fig 1.1 shows an outline of the first three stages of aerobic respiration.</p>  <p style="text-align: center;">Fig. 1.1</p>	
	<p>(a) For each glucose molecule, state the total number of molecules of ATP formed as a result of stages A to B, including any ATP produced through oxidative phosphorylation of the products. Assume that 1 NADP synthesizes 2.5 ATP and 1 FADH<sub>2</sub> synthesizes 1.5 ATP. <b>Show your working.</b></p>	
	<p><b>A:</b></p> <p>_____</p> <p><b>B:</b></p> <p>_____</p> <p><b>C:</b></p> <p>_____</p>	[3]
	<p>A: <math>2 + 2(2.5) = 7</math> ATP;          B: <math>2(2.5) = 5</math> ATP;          C: <math>2 + 6(2.5) + 2(1.5) = 20</math> ATP;          Must show working to get 1 m for each stage</p>	
	<p>(b) Many enzymes are involved in Krebs cycle. An experiment was carried out to investigate the effect of temperature on respiration. Isolated liver mitochondria were placed in five reaction tubes, with contents and temperature of reaction tube as shown in Table 1 below. The corresponding rates of oxygen uptake were measured. Results are shown in Table 1.</p>	

Table 1				
Tubes	Temperature/ °C	Volume of solution added/ cm <sup>3</sup>		Rate of oxygen uptake / a.u
		Buffered isolated liver mitochondria	2% pyruvate solution	
1	35	Boiled and cooled	0.01	1.1
2	25	2.00	0.01	7.2
3	35	2.00	0.01	15.1
4	45	2.00	0.01	13.2
5	55	2.00	0.01	1.1

(i)	Enzymes are essential in helping to speed up the rate of metabolic reactions such as those in the Krebs cycle. Explain how enzymes help to speed up rate of reaction.
	<ul style="list-style-type: none"> <li>• Lowers activation energy;</li> <li>• Shape of active site is complementary to substrate;</li> <li>• Ref. to catalytic and contact residues;</li> <li>• Holding substrates in precise orientation;</li> <li>• Causing physical stress in the bonds, making easier for bond breakage/formation;</li> <li>• Provides favourable microenvironment for reaction to take place;</li> </ul>
(ii)	Pyruvate has to be used as a substrate for this experiment instead of glucose. Explain why.
	<ul style="list-style-type: none"> <li>• Pyruvate can enter mitochondrion while glucose cannot;</li> <li>• Ref. to pyruvate carrier proteins embedded in mitochondrial membrane but not glucose carrier proteins</li> <li>• Enzymes for glycolysis is not present in mitochondrial only tubes;</li> <li>• glucose cannot be converted to pyruvate for aerobic respiration to occur.</li> </ul> <p>Any 2, 2 m</p>
(iii)	With reference to Tubes 2 – 4 from Table 1, account for the effect of temperature on rate of oxygen uptake.
	<ul style="list-style-type: none"> <li>• Ref. to increasing rate of oxygen uptake with temperature + quotation of data with appropriate units;</li> <li>• As temperature increases, increase in kinetic energy of enzyme and substrate;</li> <li>• More effective collision between enzyme and substrate molecules, more enzyme-substrate complexes formed per unit time;</li> <li>• More NADH (and FADH<sub>2</sub>) molecules formed per unit time;</li> <li>• More oxygen used as final electron acceptor per unit time;</li> </ul>
(iv)	With reference to Table 1, briefly explain the results to Tube 5.
	<ul style="list-style-type: none"> <li>• Ref. to rate of oxygen uptake similar to tube 1 + quotation of data;</li> <li>• Enzymes are denatured, active site configuration is lost and no longer complementary to substrates;</li> </ul>

- 2 Fig. 2.1 shows a part of a pancreatic cell. The pancreas is important in regulating the level of blood glucose in the body by secreting insulin at high blood glucose level.

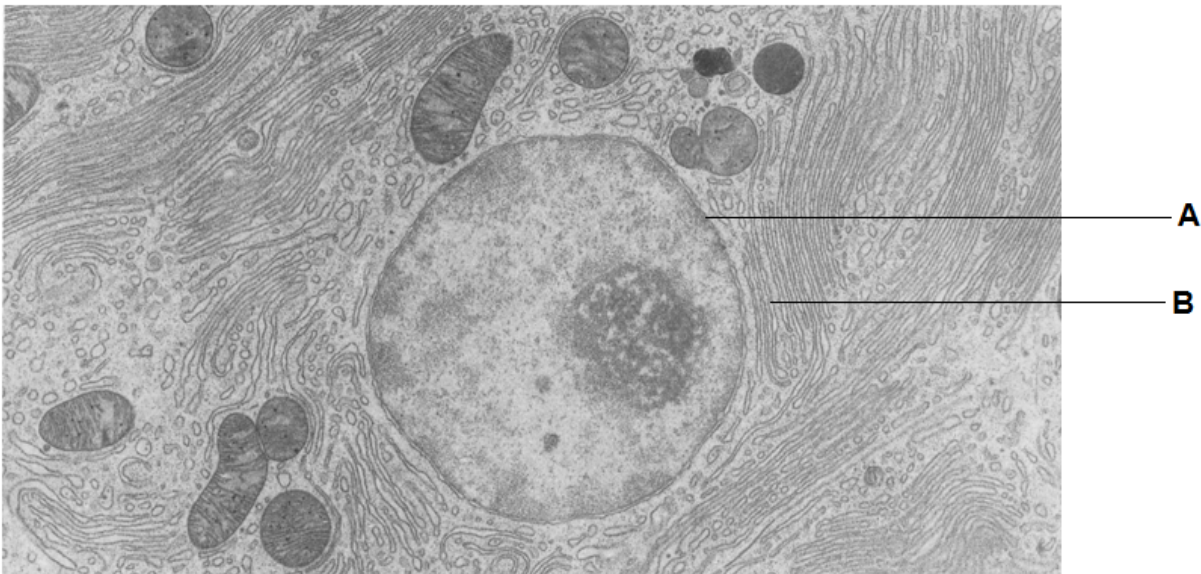


Fig 2.1

- (a) (i) State organelle A and B and describe the relationship between the two organelles in a pancreatic cell.

- A: nucleus; B: rough ER;
- Ref. to nucleus containing insulin gene that will be transcribed to insulin mRNA;
- Ref. to nucleus containing nucleolus that transcribes rRNA genes to form ribosomal subunits;
- Ref. to ribosomes embedded on rER;
- Ref. to mRNA from nucleus exported via nuclear pore to cytoplasm;
- Ref. to insulin mRNA being transcribed at ribosomes embedded on rER;

- (ii) State one other organelle you can observe in Fig. 2.1 and how it is important to the function of a pancreatic cell.

- Mitochondria;
  - Synthesizes ATP from aerobic respiration for protein synthesis/ AVP;
- Or
- sER;
  - synthesize lipids to replace endomembranal systems such as rER/ GA;

- (b) Fig. 2.2 shows a diagrammatic depiction of the process that occurs at organelle B.

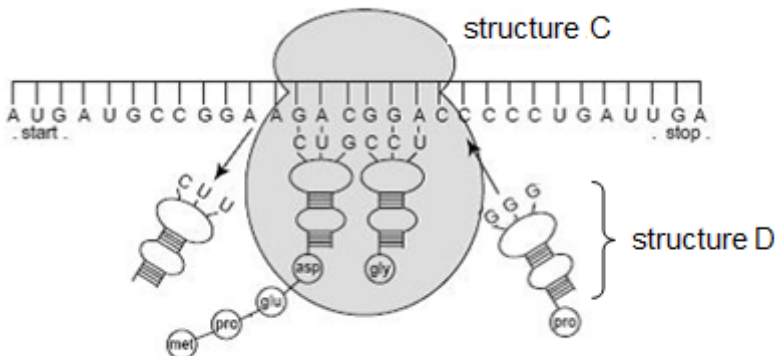


Fig. 2.2

Starting from the position of the ribosome as shown in Fig. 2.2, outline the steps that occur to produce the complete polypeptide.

- Peptidyl transferase catalyses formation of peptide bond between amino acids;
  - Ribosome moves along mRNA in 5' to 3' direction / downstream;
- 
- Ref. to amino acids are carried by specific tRNAs to ribosomes / aminoacyl tRNA recruited to ribosome and anticodons complementary base pairs to codon of mRNA;
- 
- Until stop codon reached, release factor binds at A site;
  - Covalent ester bond between amino acid and terminal acyl-tRNA hydrolysed, polypeptide released;

(c) **Fig. 2.3A** shows a DNA base sequence. It also shows the effect of two mutations on this base sequence. **Fig. 2.3B** shows DNA triplets that code for different amino acids.

Original DNA base sequence	A	T	T	G	G	C	G	T	G	T	C	T
Mutation 1 DNA base sequence	A	T	T	G	G	A	G	T	G	T	C	T
Mutation 2 DNA base sequence	A	T	T	G	G	C	C	T	G	T	C	T

Fig. 2.3A

DNA triplets	Amino acid
GGT, GGC, GGA, GGG	Gly
GGT, GTA, GTG, GTC	Val
ATC, ATT, ATA	Ile
TCC, TCT, TCA, TCG	Ser
CTC, CTT, CTA, CTG	Leu

Fig. 2.3B

Some mutations affect the amino acid sequences while others do not. Using the information in **Fig. 2.2A** and **Fig. 2.2B** and a **feature of the genetic code**, explain

		(ii)	why mutation 1 has no effect on the protein structure		
			<ul style="list-style-type: none"><li>genetic code is degenerate;</li><li>base substitution on the last codon from GGC to GGA encodes for the same amino acid, gly;</li><li>no change in amino acid sequence, no change in R group interactions, no change in protein folding;</li></ul>		
		(ii)	why mutation 2 could lead to the formation of a non-functional enzyme.		
			<ul style="list-style-type: none"><li>genetic code is unambiguous;</li><li>mutation from GTC to CTC changes the amino acid encoded for from val to leu;</li><li>change in R group interactions, change in protein folding, change in active site configuration;</li></ul>		
				[Total: 14 m]	
3	(a)	State the structural features of DNA that make it a stable molecule.			[2]
		[Any 2] <ol style="list-style-type: none"><li>complementary bases / base pairing, hold(s) strands together</li><li>(because of) many hydrogen bonds</li><li>sugar-phosphate backbone / AW, with covalent / phosphodiester, bonds</li></ol>			

DNA polymerase is an enzyme involved in the replication of DNA.

One of the substrates required by DNA polymerase is ATP.

ara-ATP is a chemical that affects DNA polymerase activity.

In an investigation, the effect of different concentrations of ATP on the rate of DNA synthesis was determined:

- with no ara-ATP
- with a low concentration of ara-ATP
- with a high concentration of ara-ATP.

The results of the investigation are shown in Fig. 3.1.

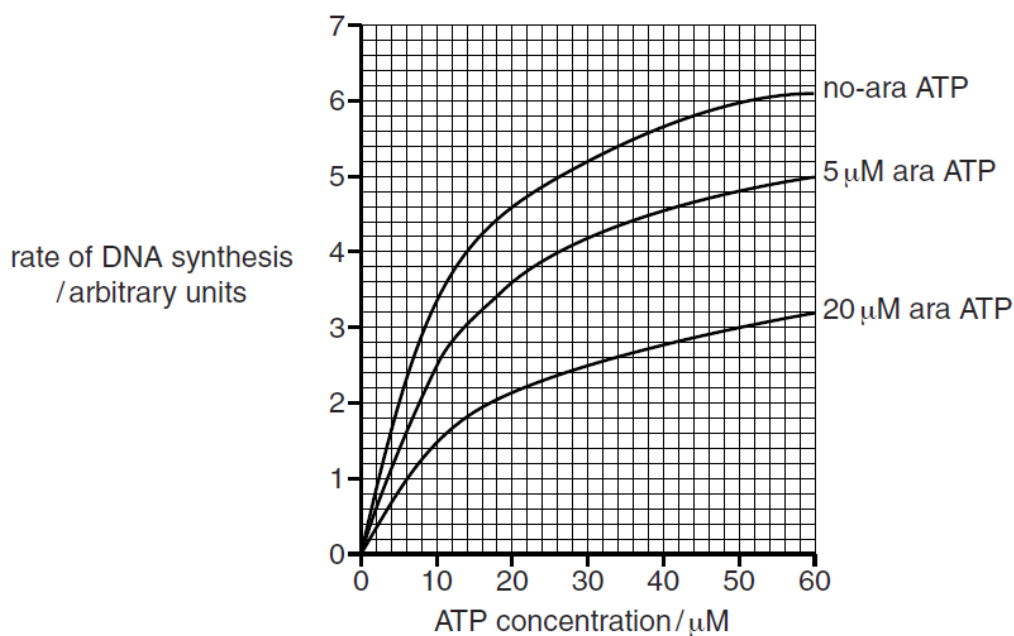


Fig. 3.1

(b) Explain, in terms of mode of action of enzymes, the results of the investigation shown in Fig. 3.1. [4]

1. increasing concentration of ara-ATP (can be comparison between 0 and 5 / 20 or between 5 and 20) decreases enzyme activity, ref. to rate of DNA synthesis for enzyme activity
2. ara-ATP acting as an inhibitor
3. substrate unable to bind with active site / fewer enzyme-substrate complexes (formed)
4. further detail
  - for either *competitive* inhibition e.g. competes with substrate for (binding to) the active site / similar, structure / shape, as substrate or complementary shape to active site
  - OR
  - for *non-competitive inhibition* e.g. binds to site other than active site / changes shape of active site

Colour blindness is a genetic condition characterised by the inability of the brain to perceive certain colours accurately.

- The most common form is termed red-green colour blindness (RGC).
- RGC results from a recessive allele.
- 0.6% of females worldwide have RGC.
- 8.0% of males worldwide have RGC.

The results of the investigation are shown in Fig. 3.2.

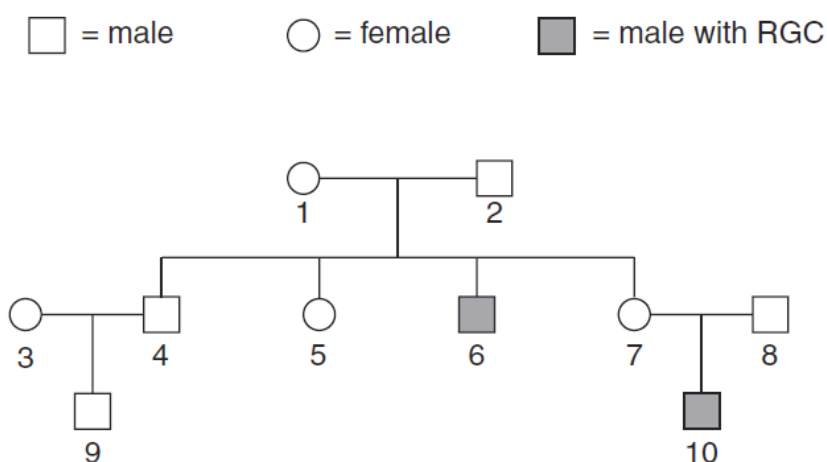


Fig. 3.2

(c)	Define the term <i>recessive</i> .	[1]
	allele which does not have its effect in heterozygote	
(d)	Explain why females are less likely than males to have RGC.	[2]
	1. gene / allele, on X chromosome / sex linkage 2. female, needs 2 RGC alleles / homozygous recessive / can be heterozygous 3. male needs only 1 RGC allele to be affected	
(e)	With reference to Fig. 3.2, and using the symbols <b>R</b> for the dominant allele and <b>r</b> for the recessive allele, state the genotypes of the individuals <b>1</b> and <b>6</b> .	[2]
	1 $X^R X^r$ 6 $X^r Y$	
<b>[Total: 11 m]</b>		

**Section B**  
**Answer EITHER 4 OR 5.**

Write your answers on the separate answer paper provided.  
Your answer 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 how gel electrophoresis separates DNA, and explain why it is useful in genetic fingerprint. [10]

#### Principles

- DNA and loading dye are added into the wells at the cathode/ negative electrode end.
  - A direct current is switched on.
  - DNA is negatively charged due to the phosphate group.
  - Hence it migrates towards the anode/ positive electrode
  - Separation is by size as agarose gel acts as molecular sieve;
  - The larger the mass, the slower it would travel/ found closer to cathode (or vice versa);
  - Buffer solution in which the gel is placed in conducts electricity;
- (Compulsory 5 marks from above) Any 5 below:

#### Usefulness

- Allows comparison of genetic fingerprints in a **named** case;
- E.g. criminal case, detection of genetic disease, paternity testing
- Each individual has a unique genetic fingerprint;
- As each individual has alleles that give rise to the bands/ reference to bands obtained after DNA is cut with restriction enzyme;
- Similarity between genetic fingerprint implies inheritance of genes/ genetic similarity/ genetically related;
- Reference to DNA ladder to allow estimation of band size.
- Award 1 mark for an annotated diagram to illustrate;

(b) Describe the features of zygotic stem cells and embryonic stem cells that distinguish them from each other. [3]

Feature	Zygotic Stem Cell	Embryonic Stem Cell
Potential to give rise to cell types	<b>Totipotent</b> -have the capacity to give rise to all cell type of the body and to form an entire organism	<b>Pluripotent</b> - capable of generating all cell types of the body except extra-embryonic tissues e.g. the amnion, chorion, and other components of the placenta.
Normal Function	divide by mitosis to form a compact ball of cells known as morula, which further divides to form a blastocyst. The blastocyst eventually develops into a growing foetus.	differentiate into cells of different cell types, tissues and organs in a <b>developing foetus</b> . Specifically, it first gives rise to cells that form the three embryonic <b>germ layers</b> – endoderm, mesoderm and ectoderm.
Formation process	Formed by union of <b>sperm</b> and <b>egg</b>	Formed from differentiation of zygotic stem cell
Location	Found within zygote	Found within embryo/ <b>blastocyst</b>
Therapeutic use	None (Ethical concerns)	Embryonic stem cells induced to differentiate to specialised cells such as nerve cells for Parkinsons or heart muscle

cells for heart disease.

Also ethical concerns. Possible solution – iPSC and cybrids.

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

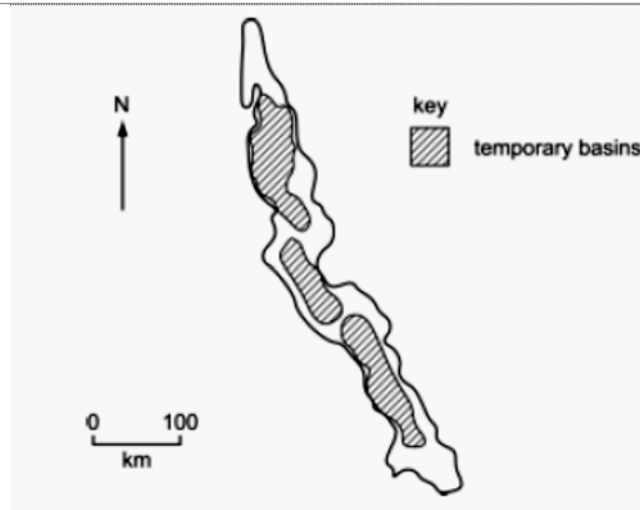
[7]

- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Allow for more people to be fed with a given amount of resources.
- Bt corn, Golden Rice and GM Salmon have the capability of producing more yield with a given number of resources, as compared to traditional methods. Helps to cut down cost of production.
- Bt corn has the capability of producing better quality crops as the crystallized protein has an insecticidal effect.
- Mixing genes among species may be argued to be creating a new 'species' through artificial means.
- There is a risk of the genetically modified organism escaping and its effect on the environment and biodiversity is unknown.
- The effects of GM products on human health are still not fully known. The effects may only be known after a long period of exposure.
- There is no law making it mandatory for GM food to be labelled.  
Allergic reactions may occur if people unknowingly consume products containing introduced genes.

OR

- 5 (a) In Lake Tanganyika in Africa, there are six species of fish of the genus *Tropheus* and a much larger number of distinctly coloured subspecies of each of the six species. *Tropheus* species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika.
- The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake.
- Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again.
- Fig. 5.1** shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.

[10]



Using Darwin's theory of natural selection, explain how did the six species and subspecies of each species arise on Lake Tanganyika.

- Mutations/ different alleles in the genetic sequence of population of fish;
- Genetic variation leads to phenotypic variation in the population of fish;
- Different parts of the shore/rocky habitat exerts different selection pressure;
- Phenotypes that have selective advantage are selected for, go on to survive, reproduce and pass down favourable alleles/ converse argument;;
- Overtime, allele frequency of population changes;
- Fish with advantageous traits increase in population;
- Genetic drift event occurs independently in different parts of the shores;
- Gene pool between population of fish diverges;
- Population of fish becomes reproductively isolated;
- Because of habitat differentiation/ behavioural isolation/ avp;
- No gene flow;
- Do not interbreed to produce viable and fertile offsprings, forming six species of fish;
- Formation of 3 temporary basins resulted in geographical isolation;
- Ref. to different environment and selection pressure in the 3 basins;
- No gene flow between species of fish in the 3 basins, many subspecies arise;

**(b)** Discuss advantages of using molecular data in determining evolutionary relationships.

[3]

- Analysis of molecular data is objective since differences in DNA/RNA/ proteins can be objectively compared by analyzing nucleotide and amino acid sequences.
- Data obtained from sequence comparisons are quantitative and can be used to measure degree of relatedness between different organisms based on calibrated molecular clocks, the number of nucleotide/amino acid
- differences can be used to estimate the time of divergence between two closely related species
- Molecular methods are able to differentiate two organisms with similar morphologies/ convergent evolution based on molecular differences.
- Molecular methods are also useful for studying evolutionary relationships between groups of organisms that have very little common ground for morphological comparison e.g. mammals and bacteria
- All known life forms can be compared since all organisms possess nucleic acids as the genetic material.

- Scientists are able to use both living and dead specimen material in classification of organisms.
- Molecular methods also reveal that some major phenotypic differences may actually be due to small genetic differences

Any 3

(c) Describe how mitosis ensures genetic stability.

[7]

- Definition of genetic stability: Genetical stability means daughter cells have the same number of chromosomes and same genes as the parent cells.
- (Compulsory one mark for first point) Any 6 below:
- At prophase, each chromosome comprises of genetically identical sister chromatids joined at centromere.
  - No crossing-over at prophase ensures that the chromatids are genetically identical.
  - Due to semi-conservative replication of DNA during S phase of interphase earlier before mitosis.
  - At metaphase, chromosomes align singly along equator.
  - Correct attachment of spindle fibres during metaphase ensure no non-disjunction later.
  - At anaphase, centromere of each chromosome divides.
- To consider following marking points?
- Genetically identical sister chromatids separate to form genetically identical chromosomes.
  - Spindle fibres pull equal number of chromosomes to each pole.
  - Cytokinesis (separation of cytoplasm) during telophase ensures two genetically identical daughter cells.
  - Mitosis forms 2 nuclei/ cells with **same number of chromosomes** as the parent cells/ has **complete set of genome**;
  - During prophase, chromatin fibres (fully) condense into discrete chromosomes to ensure that **even distribution** of the genetic material is **manageable**;
  - Chromosomes appear as double arm structures with **genetically identical** sister chromatids join at the centromeres;
  - The sister chromatids are genetically identical with **same base sequences, same alleles of genes**;
  - The sister chromatids are products of **semi-conservative** DNA replication that took place in **S phase of interphase** before mitosis begin;
  - During prophase, the nuclear envelope disintegrates/ break down to allow for the attachment of kinetochore microtubules to the centromeres of the chromosomes;
  - During prophase, **homologous chromosomes do not pair up** and thus **no crossing over** occurs, that allow sister chromatids to remain genetically identical throughout mitosis;
  - All the chromosomes lined up singly at the metaphase plate during metaphase; they do not pair up and orientation of each chromosome does not affect the gene sequence each daughter cell receives because the sister chromatids are genetically identical/ each pole will receive one DNA molecule of each chromosome;
  - Microtubules attached to a particular chromatid all comes from one pole of spindle and those attached to its other sister chromatids come from the opposite pole ensures each pole will receive one DNA molecule of each chromosome/ Centrioles migrate to opposite poles of the cells and organises spindle fibers that attach to each chromosomes at the centromere via kinetochores to ensure one complete set of genetic material is pulled to opposite poles;
  - During telophase, chromosomes decondense to form chromatin and nuclear envelope reforms around each set of chromosomes at opposite poles of the cell, forming 2 nucleus containing identical genetic information;
  - During cytokinesis, cell membrane undergoes cleavage to form 2 genetically identical daughter cells

