Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H1 BIOLOGY 8875/02

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. **Answer each part (a) and (b) on a fresh piece of writing paper.**

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 [30]	
Section B [40]	
1	/ 6
2	/ 7
3	/ 6
4	/ 8
5	/ 5
6	/ 8
Section C [20]	
1 / 2	
Total [90]	

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For Examiner's use

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

Question 1

Fig 1.1 below shows the uptake of an LDL particle into a cell via receptor mediated endocytosis.

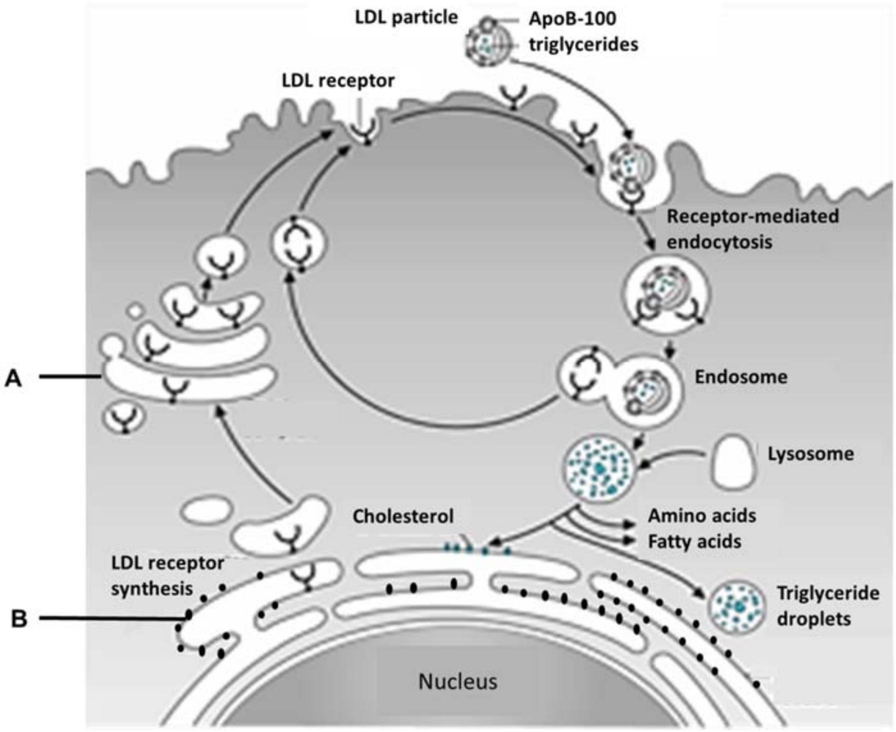


Fig 1.1

(a) With reference to **Fig 1.1**, name the organelles labelled **A** and **B** and explain their role in the expression of the LDL receptor on the cell surface. [4]

A: ....

....

B: ....

....

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

....

....

....

....

Total:[6]

Question 2

For Examiner's use

The enzyme sucrase catalyses the hydrolysis of sucrose to fructose and glucose.

$$\text{sucrose} \xrightarrow{\text{sucrase}} \text{fructose + glucose}$$

P is a newly isolated type of sucrase with unknown optimum pH.

An investigation was carried out to determine the optimum pH of the enzyme **P**. Enzyme **P** was added to sucrose solutions with different pH buffers. The reaction mixture was sampled at 1 minute intervals and a Benedicts test carried out. Average time taken for first appearance of brick red precipitate was recorded in **Table 2.1** below.

pH	Average time taken for brick red ppt to form / s	Relative rate of reaction / s^{-1}
3	20.6	
4	5.0	
5	1.3	
6	1.4	
7	5.6	
8	22.0	

Table 2.1

(a) Calculate the relative rate of reaction for each pH in **Table 2.1**. [1]

(b) Plot a graph of relative rate of reaction / s^{-1} against pH on the grid provided to determine the optimum pH of enzyme **P**. [3]

For Examiner's use

(c) Explain the effect of pH on enzyme **P**'s activity. [3]

Total:[7]

For Examiner's use

Question 3

Fig 3 shows the different phases of the cell cycle. The arrows indicate the checkpoints of the cell cycle.

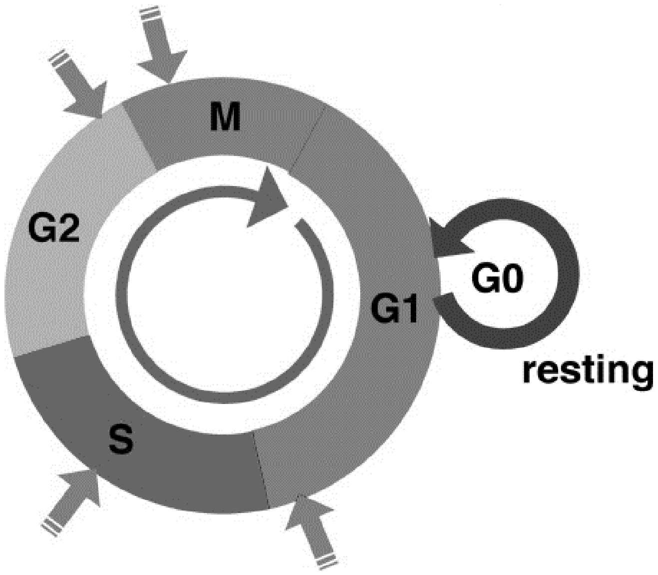


Fig 3

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

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

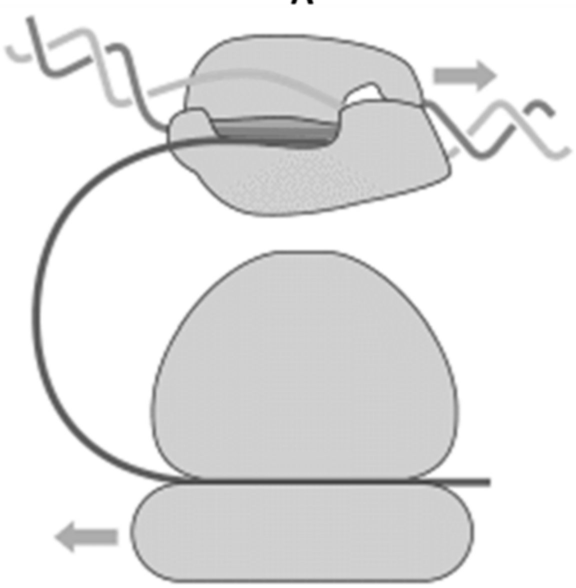
Total: [6]

For Examiner's use

Question 4

(a) **Fig 4** shows transcription and translation occurring simultaneously.

A



B

Fig 4

(i) Identify structures **A** and **B** and state how their structures differ. [2]

(ii) List two other ways by which the process of transcription differs from translation. [2]

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(b) Describe how eukaryotic ribosomes are formed. [4]

Total: [8]

For Examiner's use

Question 5

The Rhesus blood group is genetically controlled. The gene for the Rhesus blood group is found on chromosome 1 and has two alleles. The allele for Rhesus positive, **R**, is dominant to that for Rhesus negative, **r**.

Another gene coding for the ABO blood groups is found on chromosome 19 and both genes play an important role in the determination of suitable donors for blood transfusion.

Fig 5 shows the inheritance of the Rhesus blood group in one family.

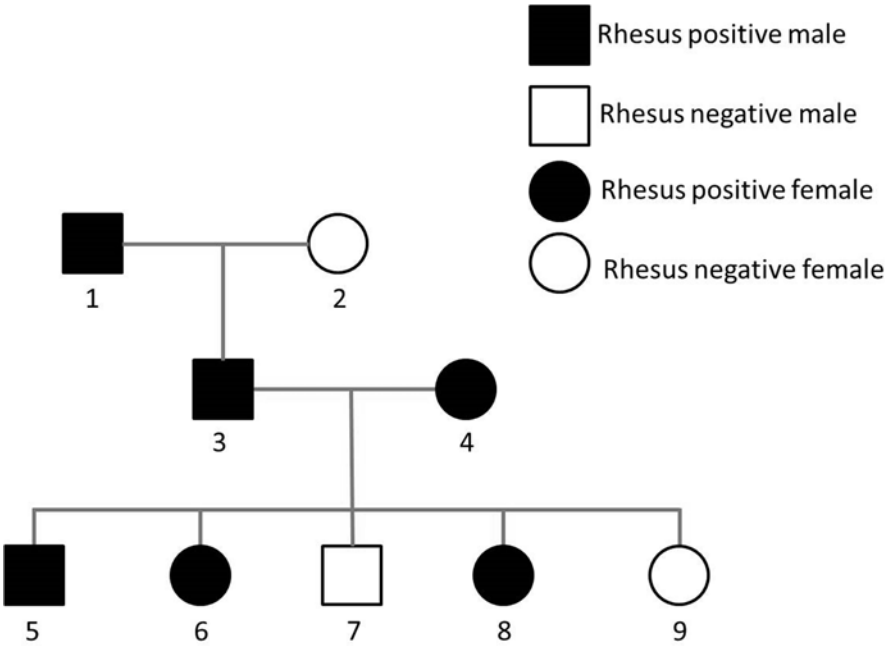


Fig 5

(a) Give **one** piece of evidence from **Fig 5** that shows **R** is the dominant allele in the determination of the Rhesus phenotype. [1]

(b) Individual **9** with blood group B married a male with blood group A who is Rhesus positive. The couple had a daughter who is Rhesus positive with the blood group AB and a son who is Rhesus negative with the blood group O.

Using appropriate symbols, illustrate the information in a genetic diagram. [4]

Total: [5]

For Examiner's use

Question 6

(a) Cytochrome c is a protein found in all eukaryotes. In humans it consists of 102 amino acids. Biologists have compared the amino acid sequence in some other species with that in humans. The table shows amino acids 9 to 13 in the amino acid sequences of cytochrome c from four species.

	Amino acid in this position in cytochrome c				
Species	9	10	11	12	13
Human	Ile	Phe	Ile	Met	Lys
Chicken	Ile	Phe	Val	Gln	Lys
Dogfish	Val	Phe	Val	Gln	Lys
Chimpanzee	Ile	Phe	Ile	Met	Lys

(i) What do the results suggest about the relationship between humans and the other three species? [2]

(ii) Comparing the base sequence of a gene provides more information than comparing the amino acid sequence for which the gene codes. Explain why. [2]

(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.

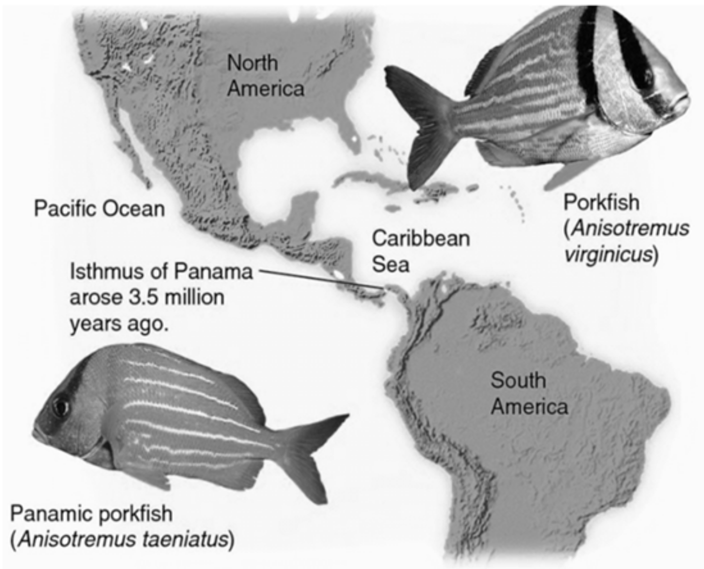


Fig 6

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

Total:[8]

Section C: Free-Response Question (20 marks)

Answer only **one** question.
Write your answers on the writing paper provided.
Answer each part (a) and (b) on a fresh piece of writing paper.

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) 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]

OR

Question 2

(a) Compare DNA replication in eukaryotic cells and the polymerase chain reaction (PCR). [8]

(b) Explain the method and principles of gel electrophoresis. [5]

(c) Describe the unique features of stem cells and with reference to **named examples**, outline the normal functions of stem cells in a living organism. [7]

Total: [20]

END OF PAPER

DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2016
YEAR SIX
H1 BIOLOGY (8875)

Suggested Answers

1(a)
A: Golgi apparatus;
chemically modifies the LDL receptors (e.g. glycosylates);
packages LDL receptors the into vesicles to be inserted (targeted) into the plasma membrane;
2 max

B: Rough endoplasmic reticulum;
translation of LDL receptor mRNA at bound **ribosome**s;
transport of newly synthesized LDL receptor to the cis face of the golgi apparatus within transport vesicles;
2 max

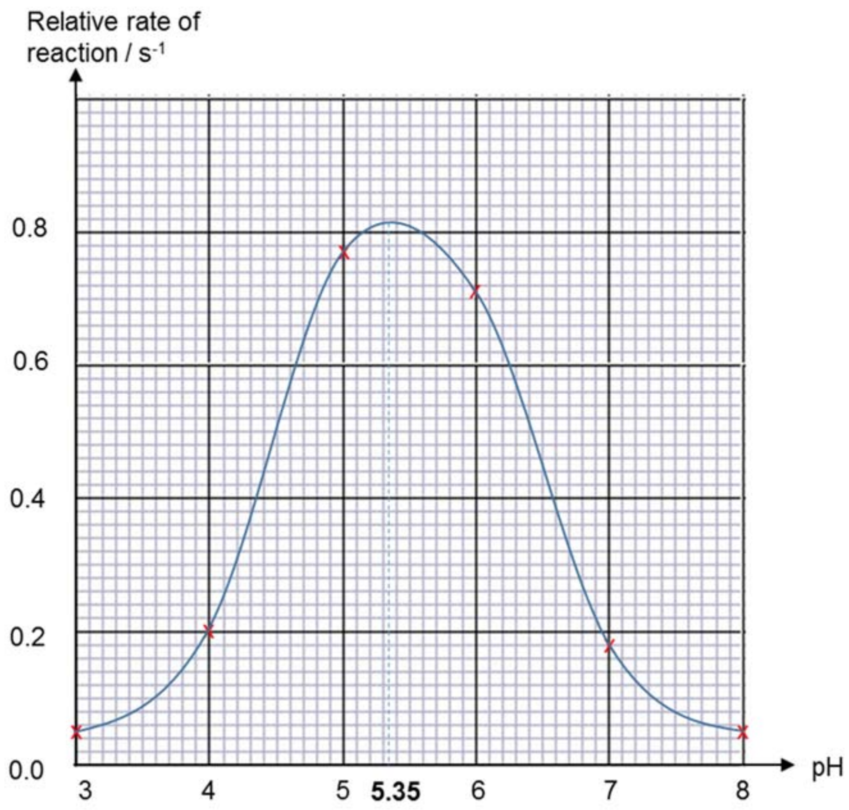
(b)
Fluid nature of phospholipids moving in the membrane allows invagination of plasma membrane/ fusion of two ends of plasma membrane to form endocytic vesicle;
Mosiac – membrane has proteins embedded such as the LDL receptor. Binding of LDL to receptor triggers invagination of the membrane;

2(a)

pH	Average time taken for brick red ppt to form / s	Relative rate of reaction / s^{-1}
3	20.6	**0.0485**
4	5.0	**0.200**
5	1.3	**0.769**
6	1.4	**0.714**
7	5.6	**0.179**
8	22.0	**0.0455**

Correct answers to 3 s.f.;

(b)
Points plotted correctly;
Smooth curve;
Correct optimum pH – 5.35 (A: pH 5.2 - 5.5);



(c)
Enzyme P active over a narrow range of pH (quote values);
Deviation from optimum pH results in disruption of ionic bonds, hydrogen bonds;
Results in change in 3D conformation and active site configuration affecting the fit and binding of the substrate to the active site. Enzyme is denatured;

3(a)

G_1 (**2 max**):check 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 (**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

(b)

Synthesis of proteins/RNA/enzymes;
Formation of new organelles;
ATP production;

4(a)(i)

A = RNA Polymerase, B = Ribosome;
A is made of protein only while B is made up of ribosomal RNA and proteins;

(a)(ii)

	Transcription	Translation
Template	DNA template strand	mRNA;
Products	mRNA, rRNA, tRNA **R!** mRNA only	Polypeptide / protein;
Bonds formed	Phosphodiester bond	Peptide bond;
Monomers	Free RNA nucleotide / ribonucleotide triphosphate / ribonucleotides	Amino acids;
Enzyme involved in catalysis of bond	RNA polymerase;	Peptidyl transferase;

<u>2 max</u>

(b)

- **<u>rRNA</u>** is produced through **transcription** of the **rRNA genes** in the **<u>nucleolus</u>**;
- **Genes of <u>ribosomal proteins</u>** are **transcribed** in **<u>nucleus</u>** to form **<u>mRNA</u>,** which is **translated** in **<u>cytoplasm</u>** to form **<u>ribosomal proteins;</u>**
- **<u>Ribosomal protein</u>** is **transported from the <u>cytoplasm into nucleus</u>** via nuclear pore;
- Partial **<u>assembly of rRNA and ribosomal proteins</u>** into large and small subunits occurs in **<u>nucleolus;</u>**
- The **large and small subunits** are **transported to the cytoplasm,** where they **assemble during translation;**

<u>4 max</u>

5(a)
Rh negative individuals 7 and 9 resulted from Rh positive individuals 3 and 4 → shows that 3 and 4 are heterozygotes (which possess the genotype Rr, hence individuals 7 and 9 had genotypes rr);

(b)
<u>Symbols:</u>

Let R represent the allele for Rh positive
r represent the allele for Rh negative
I^A represent the allele for blood group A
I^B represent the allele for blood group B
I^O represent the allele for blood group O
I^A and I^B are co-dominant alleles, both dominant over I^O ;

Parental phenotypes:	Rh negative, blood group B mother	X	Rh positve, blood group A father
Parental genotype:	**rr I^BI^O**	X	**Rr I^AI^O**
gametes:	**(r I^B)** **(r I^O)**	X	**(R I^A)** **(R I^O)** **(r I^A)** **(r I^O)**

;

	(R I^A)	**(R I^O)**	**(r I^A)**	**(r I^O)**
(r I^B)	Rr I^AI^B	Rr I^BI^O	rr I^AI^B	rr I^BI^O
(r I^O)	Rr I^AI^O	Rr I^OI^O	rr I^AI^O	rr I^OI^O

;

Offspring genotypes:	Rr I^AI^B	Rr I^AI^O	Rr I^BI^O	Rr I^OI^O	rr I^AI^B	rr I^AI^O	rr I^BI^O	rr I^OI^O
Offspring phenotypes:	Rh positive Blood group AB	Rh positive Blood group A	Rh positive Blood group B	Rh positive Blood group O	Rh negative Blood group AB	Rh negative Blood group A	Rh negative Blood group B	Rh negative Blood group O
Phenotypic ratio:	1:	1:	1:	1:	1:	1:	1:	1

;

6(a)(i)
Most closely (related) to chimpanzee / most recent common ancestor;
Least (related) to dogfish / least recent common ancestor;

(ii)
Reference to base triplet/triplet code / more bases than amino acids / longer base sequence than amino acid sequence;
Introns/non-coding DNA;
Same amino acid may be coded for / DNA code is degenerate;

2 Max.

(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

1(a)

Marking Point		Krebs cycle	Calvin cycle
1	**Location**	Mitochondrial matrix	Chloroplast stroma
2	**Substrate**	<u>Acetyl-CoA and oxaloacetate</u> combines to form citrate	<u>CO_2 and Ribulose bisphosphate</u> (RuBP)
3	**Products**	Each glucose molecule gives rise to: 6 <u>NADH</u> 2 <u>$FADH_2$</u> 2 <u>ATP</u> 4 <u>CO_2</u>	For every 3 molecules of CO_2 that enter the cycle, one triose phosphate / G3P 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 susbstrate 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

<u>**8 Max.**</u>

1(b)

Similarities

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

Why these similarities exist

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

<u>**6 Max.**</u>

1(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. 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.

2(a) Compare DNA replication in eukaryotic cells and the polymerase chain reaction (PCR). [8]

Similarities

1. Both use DNA as a template for the synthesis of a complementary daughter strand;
2. Parental template is read from 3' to 5' and the new daughter strand is synthesized in 5' to 3' direction;
3. Both involve the formation of phosphodiester bonds between deoxyribonucleotides;

Difference

Features	**DNA replication**	**PCR**
4. Separation	Separation of double helix by **helicase**	Separation by heating to **high temperature / denaturation**;
5. Replicated section	**Entire** DNA molecule replicated	A **section** of DNA replicated;
6. Primers used	**RNA** primers	**DNA** primers;
7. DNA ligase	Requires DNA ligase	Does not require DNA ligase;
8. Presence of lagging strands	Presence of Okazaki fragments	No Okazaki fragments;
9. Polymerases involved	**DNA** polymerase III	**Taq** DNA polymerase needed;
10. Accuracy of replication	**Proofreading** ability of DNA pol	Taq polymerase **lacks proofreading** ability;
11. Start of replication	**Origins of replication**	Where **primers binds**;
12. Synthesis of Primers	Primers are made by **primase or** primers excised	Primers are added / made in the lab **or** primers not excised;
13. Temperature	Occurs at body temperature	Annealing 50-60°C Elongation 72°C and denaturation 90°C
14. Aim / Purpose	Occurs prior to cell division to replace dead cells lost due to wear and tear	To amplify DNA for forensics analysis

(b) Explain the method and principles of gel electrophoresis. [5]

1. **Gel electrophoresis is a procedure for separating a mixture of DNA fragments by size through an agarose gel in an electric field;**
2. **DNA samples are mixed with loading dye/bromophenol blue to help DNA to sink to the bottom of the well/help in monitoring the progress of the electrophoresis before they are loaded in the wells near the cathode/negatively-charged electrode;**
3. **An electric field is applied across the gel;**
4. **Negatively charged DNA fragments will migrate towards the positive electrode / anode;**
5. **Agarose gel acts as a molecular sieve. The larger the molecular weight of the DNA fragment, the slower the migration / the shorter the distance migrated through the gel from the well;**
6. **After gel electrophoresis, the DNA is the gel is stained with ethidium bromide. DNA appears as bands when viewed under UV light;**
7. **These bands will be compared to the DNA marker / DNA ladder to estimate / calibrate their molecular weight;**

(c) Describe the unique features of stem cells and with reference to **named examples**, outline the normal functions of stem cells in a living organism. [7]

Unique features

1. Stem cells are unspecialized / undifferentiated that can divide by mitosis.
2. Ability to differentiate to produce specialized cells under appropriate molecular signals;
3. Telomerase activity – able to divide indefinitely;
4. and self renewal (maintain a pool of stem cells in adults);
5. ref. to asymmetrical division (description or annotated drawing);

Normal functions w examples

e.g. embryonic stem cells:

6. found in the inner cell mass of the blastocyst;
7. pluripotent – divides and differentiates to give rise to all types of cells that make up the whole an organism except the extra-embryonic tissues. function: formation / development of fetus;
8. ability to divide and further differentiate into multipotent stem cells that are found in adult tissues needed to maintain the tissues that they are found in;

e.g blood stem cells:

9. found in the bone marrow;
10. multipotent, gives rise to various blood cells like red blood cells, white blood cells and platelets. function: continual replacement of blood cells;
11. Blood cells are responsible for constant maintenance and immune protection of every cell type of the body / give functions of blood cells (RBC, WBC)