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DUNMAN HIGH SCHOOL

Preliminary Examination

Year 6

H1 BIOLOGY

8875/02

Paper 2 Structured and Free-Response Questions

15 September 2015

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

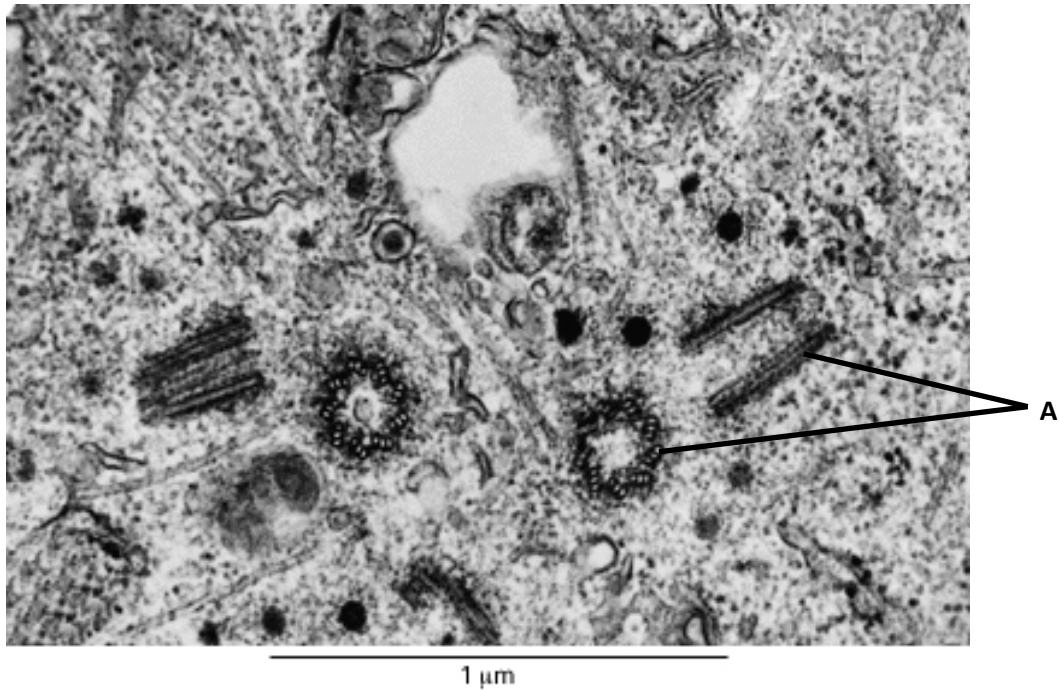
Essential working must be shown.

The intended marks for questions or parts of questions are given in brackets [].

For Examiner's Use	
Section A [30]	
Section B [40]	
1	/ 5
2	/ 5
3	/ 5
4	/ 5
5	/ 5
6	/ 5
7	/ 10
Section C [20]	
1 / 2	
Total [90]	

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Section B: Structured Questions (40 marks)Answer **all** questions in this section.*For
Examiner's
use***Question 1****Fig. 1.1** below is an electron micrograph showing part of an animal cell.**Fig1.1**

- (a) (i) Name the structures labeled A. [1]

A :

- (ii) Describe **two** structural differences between structure **A** and cellulose. [2]

- (iii) Name the process the cell is undergoing and explain your answer. [2]

Total: [5]

Question 2*For
Examiner's
use*

- (a) Hydrolase is a group of enzymes which catalyse the hydrolysis of chemical bonds and can be found in plants. Describe the roles of the proteins involved in hydrolase mRNA synthesis. [2]

- (b) Hydrolase can be found in lysosome. Action of hydrolase can lead to autolysis by causing conformational change to the shape of ribosome. Describe the action of hydrolase on ribosomes and how this could cause cell death. [3]

Total:[5]

Question 3

In the pea plant (*Pisum sativum*), the timing of flowering is controlled by multiple alleles. Investigators have found evidence for four different alleles at this flowering locus that can exert temporal control of flowering:

- F^V very early flowering
- F^E early flowering
- F^M mid flowering
- F^L late flowering

F^L is dominant over F^M , F^E and F^V .

F^M is dominant over F^E and F^V .

F^E is dominant over F^V .

Another **A/a** gene locus on a different chromosome codes for the colour of the flower which is either purple or white.

Table 3.1 below shows the results of crosses between a mid flowering plant with purple flowers with three other different plants:

Cross	Parents	Offspring
1	mid flowering, purple flowers x early flowering, purple flowers	50% mid flowering, 25% early flowering, 25% very early flowering; All purple flowers
2	mid flowering, purple flowers x mid flowering, white flowers	75% mid flowering, 25% early flowering; 50% purple flowers, 50% white flowers
3	mid flowering, purple flowers x late flowering, purple flowers	50% late flowering, 25% mid flowering, 25% early flowering; 75% purple flowers, 25% white flowers

(a) Draw a genetic diagram to explain the results of Cross 3. [4]

(b) Describe one difference between inheritance caused by multiple alleles and polygenic inheritance for a characteristic. [1]

Total: [5]

Question 4

(a) Fig. 4.1 outlines the early stages of respiration.

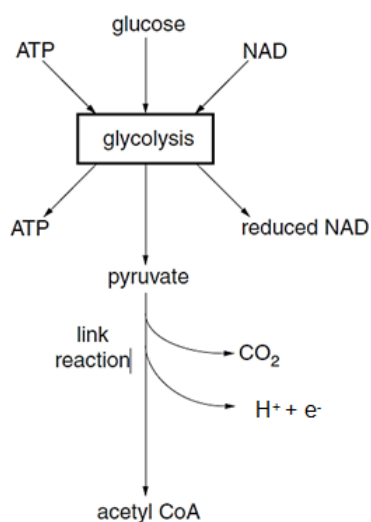


Fig. 4.1

With reference to **Fig. 4.1**,

(i) Explain why ATP is needed at the start of glycolysis. [1]

(ii) Explain the fate of the hydrogen atoms released by pyruvate during the link reaction. [4]

Total: [5]

Question 5

Woolly mammoths are extinct mammals that are related to elephants of the *Mastodon* genus. Woolly mammoths existed around 200,000 years ago during the Ice Age, where the climate changed and temperatures in the Arctic drastically decreased. These mammoths had various adaptations to reduce heat loss, such as having thick fur, small ears and small tails. During the Ice Age, the population of the woolly mammoths was significantly larger than the population of mastodons.

As a result of climate change of increasing temperatures, woolly mammoths went extinct approximately 4000 years ago. However, the population of mastodons increased in number.

- (a)** Explain why population is considered the smallest unit of evolution. [2]

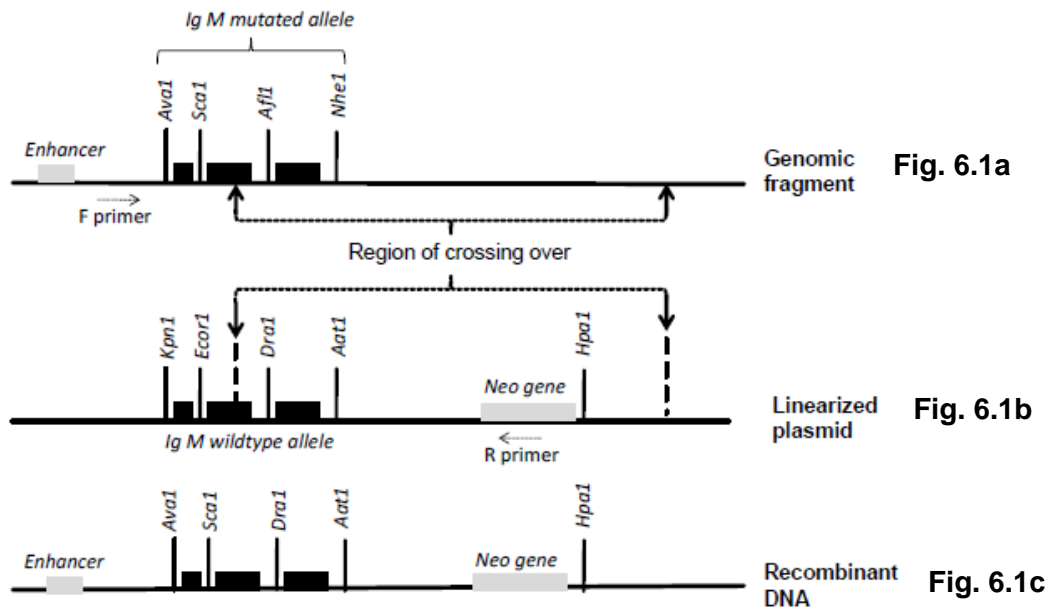
- (b)** Explain how natural selection resulted in the population changes of the mastodons. [3]


Total: [5]

Question 6

- (a) **Fig. 6.1** below shows a schematic diagram of targeted gene replacement in a mammalian cell involving the gene *Ig M*. Targeted *Ig M* gene replacement is a method of replacing *Ig M* mutated allele (Fig. 6.1a) in the genome in a cell with wildtype allele (Fig. 6.1b) via crossing over, giving rise to the recombinant DNA (Fig. 6.1c).

The wildtype allele is carried by a linearised plasmid (Fig. 1.1b) and introduced into the cell. As shown in **Fig. 6.1b**, the linearised plasmid contains an antibiotic (neomycin) resistance gene (*Neo gene*), wildtype allele with the exons represented by the black boxes, as well as several restrictions sites in between the exons. In this technique, the enhancer of the *Neo gene* on the linearised plasmid was removed prior to the therapy.

**Fig. 6.1**

Legend	
Exon	
Restriction sites on mutated allele	<i>Ava1, Sca1, Afl1, Nhe1</i>
Restriction sites on wildtype allele	<i>Kpn1, Ecor1, Dra1, Aat1</i>
Naturally occurring restriction site on linearised plasmid	<i>Hpa1</i>

- (a) Although the mutated and wildtype alleles have homologous regions, different restriction sites are present on them. Explain the presence of these different restriction sites. [2]

*For
Examiner's
use*

- (b) With reference to **Fig. 6.1**, explain how the Neo gene allows the transformed cells with recombinant DNA to be distinguished from the transformed cells which did not undergo recombination in their DNA. [3]

Total:[5]

Question 7

- (a) YieldGard, a type of Bt corn that produces a single type of Bt protein, was planted in Midsouth, USA. A Bt resistance monitoring programme showed that the frequency of resistance to the Bt protein in YieldGard increased significantly in sugarcane borers (SCBs). SCBs not only feed on sugarcane, but also other crops such as corn.

To counter the Bt-resistant SCBs, Bt corn expressing multiple types of Bt proteins were recently employed in a greenhouse trial. The trial included a non-Bt control corn and three types of Bt corn:

- Non-Bt control corn – does not produce Bt protein,
- YieldGard® – produces a single type of Bt protein,
- Genuity® VT Triple Pro™ – produces three types of Bt proteins, and
- Genuity® SmartStax™ – produces six types of Bt proteins.

Newly hatched larvae of three SCB populations were manually placed on mature corn plants in the greenhouse. The larvae often bore into the corn stalk and develop tunnels within them. Larval tunnelling by borers inside each stalk was recorded after 21 days as shown in **Fig. 7.1**.

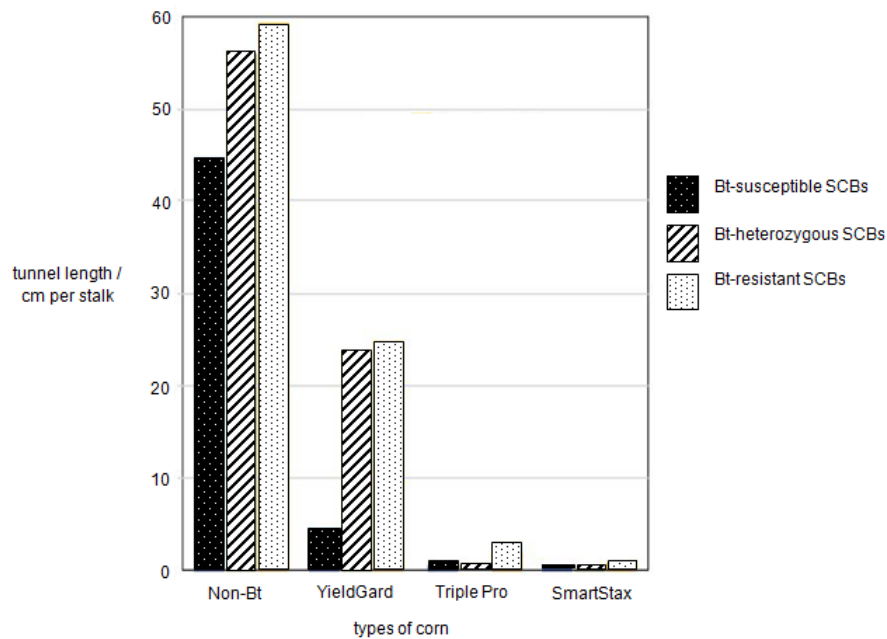


Fig. 7.1

With reference to **Fig 7.1**,

- (i) Suggest and support with data which type of Bt corn will best increase crop yield. [2]

- (ii) Explain why YieldGard is no longer optimal for cultivation when all three types of SCBs are present. [2]

- (iii) Discuss the environmental, ethical or social implications of the above genetically modified Bt plants. [3]

- (b) Discuss the need to compare among the three different populations of SCBs. [2]

- (c) Pesticide resistance describes the decreased susceptibility of a pest population to a pesticide that was previously effective at controlling the pest. Pest species evolve pesticide resistance via natural selection; the most resistant specimens survive and pass on their genetic traits to their offspring.

Suggest how Triple Pro and SmartStax effectively manages Bt resistance in SCBs. [1]

Total: [10]

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) (i) Compare the structure of glucose and fatty acid molecules. [4]
- (ii) Describe how structure of amylopectin relates to its function. [6]
- (b) Explain with examples, how homology (anatomical, embryological and molecular) supports Darwin's theory of natural selection. [10]

OR

Question 2

- (a) Compare the structure of the tropocollagen and DNA double helix. [10]
- (b) (i) Describe the evolution of mitochondria and chloroplast from prokaryotes using the endosymbiosis theory. [4]
- (ii) Describe and explain the advantages of molecular (nucleotide and amino acid sequences) methods in classifying organisms. [6]

Total: [20]

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**DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2014
YEAR SIX
H1 BIOLOGY (8875)**

Suggested Answers

Structured Question Answers

1(a) (i) centrioles

(ii)

made of amino acids/tubulin vs β -glucose;
many different types of amino acids vs one type of β -glucose;
microtubules arranged in nine triplets vs many chains crossed-linked/joined together (to form microfibrils);
occur in pairs vs chains grouped to form macrofibrils; peptide bonds vs glycosidic bonds;
hollow cylinder vs solid/compact/non-hollow structure;

(ii)

Cell division /mitosis /meiosis / prophase (I/II)/ interphase;
R! metaphase,anaphase

There are two pairs/sets of centrioles in the cell;
R! '2' alone

2(a)

RNA polymerase – Adds RNA nucleotides in a 5' to 3' direction of newly synthesized mRNA strand;
(General) Transcription factor – Binds to promoter to recruit RNA polymerase to form transcription initiation complex to initiate transcription;
Specific transcription factors (activators / repressors) – Regulates transcription by binding to enhancers or silencers;
2 max

(b)

Hydrolase catalyses the hydrolysis of / break chemical bonds which keep ribosome 3D structure ideal for translation;
Thus ribosome conformation changes and will not be able to bind to mRNA / tRNA thus will not be able to translate;
Leads to loss of protein essential for cell survival e.g. respiratory enzymes;

3(a)

Parental phenotype: mid flowering, late flowering,
 purple flowers x purple flowers

Parental genotype: $F^M F^V Aa / F^M F^E Aa$ x $F^L F^E Aa$;

Gametes $(F^M A)$ $(F^M a)$ $(F^V A)$ $(F^V a)$ $(F^L A)$ $(F^L a)$ $(F^E A)$ $(F^E a)$;

gametes	$F^L A$	$F^L a$	$F^E A$	$F^E a$
$F^M A$	$F^L F^M AA$ late flowering, purple flowers	$F^L F^M Aa$ late flowering, purple flowers	$F^M F^E AA$ mid flowering, purple flowers	$F^M F^E Aa$ mid flowering, purple flowers
$F^M a$	$F^L F^M Aa$ late flowering, purple flowers	$F^L F^M aa$ late flowering, white flowers	$F^M F^E Aa$ mid flowering, purple flowers	$F^M F^E aa$ mid flowering, white flowers
$F^V A$	$F^L F^V AA$ late flowering, purple flowers	$F^L F^V Aa$ late flowering, purple flowers	$F^E F^V AA$ early flowering, purple flowers	$F^E F^V Aa$ early flowering, purple flowers
$F^V a$	$F^L F^V Aa$ late flowering, purple flowers	$F^L F^V aa$ late flowering, white flowers	$F^E F^V Aa$ early flowering, purple flowers	$F^E F^V aa$ early flowering, white flowers

;

Phenotypic ratio:

6 : 2 : 3 : 1 : 3 : 1
 late flowering, purple flowers late flowering, white flowers mid flowering, purple flowers mid flowering, white flowers early flowering, purple flowers early flowering, white flowers

OR

2 : 1 : 1 : 3 : 1
 late flowering mid flowering early flowering and purple flowers white flowers

Correct offspring genotype with phenotype and ratio;

(b)

In inheritance caused by multiple alleles, **one gene** is involved in determining the characteristic with **each allele having a discernible/** qualitative **effect** whereas in polygenic inheritance, **several genes** are involved in determining the same characteristic with each allele having an **additive/** quantitative **effect**;;

OR

In inheritance caused by multiple alleles, the **phenotypes show discontinuous variation/** fall into discrete classes without intermediates whereas in polygenic inheritance, the phenotypes show **continuous variation/** a range of values from 1 extreme to another;;

4(a)(i)

To phosphorylate the glucose/fructose-6-phosphate / make the glucose molecule more chemically reactive;

4(a)(ii)

H atoms are accepted by NAD to form reduced NAD;

H⁺ ions are actively transported into the mitochondrial intermembrane space via proton pump to generate proton gradient;

H⁺ ions diffuse via ATP synthase into mitochondrial matrix to generate ATP;

H⁺ ions combine with the final electron and hydrogen acceptor oxygen to form water;

5(a)

Individuals do not evolve during their lifetimes even if they accumulate mutations and change phenotypes because of the environment;

Evolution requires descent with modification, it can only be observed in the next generation at a population level;

5(b)

Change in climate / warmer climate acted as selection pressure;

Mastodons with thin fur and large ears were at a selective advantage as they were better adapted for warm climate as compared to the thick fur woolly mammoths;

Mastodons had a higher chance of survival and thus reproduce to give viable offspring, passing the advantageous alleles to them;

Over time, allele frequencies for fur and ears changed such that mastodons increased in number while woolly mammoths decreased in number;

3 max

6

(a)

Mutation and thus changes in DNA sequences;

Creates / destroy / changes new restriction sites;

(b)

Transformed cells with recombinant DNA will survive in the presence of neomycin whilst transformed cell without recombination will not survive;

Neo gene from vector would come under the control of an enhancer;

High expression of neo gene confers resistance against neomycin;.

No /low expression of neo gene due to absence of enhancer in linearized plasmid / absence of Neo gene on genomic fragment;

3 max

7(a)(i)

SmartStax;

The tunnel length / cm per stalk by all three types of sugarcane borers (SCB) are the lowest as compared to other corn, very close to zero indicating the least damage done to the crop and hence highest yield;

7(a)(ii)

Bt-heterozygous SCBs and Bt-resistant SCBs cause significant damage to YieldGard with 25 cm tunnel length as compared to 5 cm of Bt-susceptible SCBs;

Bt-heterozygous SCBs and Bt-resistant SCBs will increase in population size due to being at selectively advantage in the presence of YieldGard and there will still be significant damage to the corn;

7(a)(iii)

Bt plants may cross pollinate with their wild relatives, spreading the Bt gene and causing genetic pollution.

The hybrid plants that contain the Bt gene may kill off other unintended insects and affect ecological balance;

Using 3 or more Bt toxin in Triple Pro and SmartStax may result in accumulation of high amounts of Bt toxins in SCBs. Predators and parasites of SCBs which are of benefit to agriculture could die due to the high levels of toxin;

Triple Pro and SmartStax contains many new transgenic proteins and when consumed by humans may lead to unexpected allergic reactions;

AVP but must be relevant to Bt corn;

3 max

7(b)

Bt-susceptible SCBs acts as a negative control / Bt-resistant SCBs acts as positive control;

Comparison between Bt-resistant and Bt-susceptible populations allows determination of the effect of BT resistance on tunnel length / cm per stalk by SCBs;

7(c)

Having multiple types of Bt toxin proteins present in one plant ensures all the SCBs are killed off, so that no Bt-resistant SCB survive to pass on the advantageous gene to its offspring;

Essay Answers

1(a)(i) Compare the structure of glucose and fatty acid molecules. [4]

	glucose	Fatty acid
1	Can either be a linear structure or ring which is more stable	Linear structure
2	^1C contains an aldehyde group, while $^2\text{C} - ^5\text{C}$ each possess a hydroxyl group (-OH).	Consist of a <u>carboxyl</u> group and R group which is a long hydrocarbon chain of varied length.
3	Smaller molecule.	Larger molecue.
4	Isomers: α and β glucose and fructose.	No isomer
	Max 4	
S	Both contain the elements C, H and O	

1(a)(ii) Describe how structure of amylopectin relates to its function. [6]

1. starch is able to store large amounts of energy as it is made of several hundred / thousands of glucose monomers linked together by glycosidic bonds;
2. amylose has α (1 \rightarrow 4) glycosidic bonds and amylopectin has both α (1 \rightarrow 4) and α (1 \rightarrow 6) glycosidic bonds;
3. α (1 \rightarrow 4) glycosidic bonds gives rise to unbranched chains of glucose monomers which then coil helically due to intrachain hydrogen bonding \rightarrow compact for storage;
4. ref to α (1 \rightarrow 6) glycosidic bonds giving rise to branched structure \rightarrow compact for storage;
5. α (1 \rightarrow 4) glycosidic bonds can be easily broken down by enzymes present in plants and animals releasing glucose for respiration;
6. branched structure allows for quick break down / hydrolysis of starch due to action of debranching enzymes on α (1 \rightarrow 6) glycosidic bonds;
7. Starch is a large molecule with OH groups occupied in intrachain H-bonding \rightarrow insoluble; therefore starch is osmotically inactive / will not affect osmotic concentration in cells \rightarrow can be stored in large amounts in cells;

6 max.

1(b)	Explain with examples, how homology (anatomical, embryological and molecular) supports Darwin's theory of natural selection.
Marking Point	Answer
1	Homology is defined as the similarities between individuals of the same species or among different species that arose from common ancestry;
2	In anatomical homology, comparison of body structures between species provides evidence of inheritance from a common ancestor, and that modifications are adaptations to the special needs of the organism;
3	For example, the forelimbs of all mammals, including humans, cats, whales and bats show the same arrangement of bones from the shoulder to the tips of the digits, even though these appendages can have very different functions;
4	Homologous structures such as the different forelimbs support Darwin's theory of evolution by natural selection whereby new species evolve by descent with modification from their common ancestor;
5	Analogous structures such as the membrane of skin on either side of body are found in both the Australian Sugar Glider and North American Flying Squirrel. This also supports Darwin's theory of evolution by natural selection as the environment selects for the genes which are the most advantageous hence the phenotypes converge;
6	In embryological homology, comparison of early stages of animal development reveals additional anatomical homologies not visible in adult organisms. Embryos that look very similar during the earlier stages of development have a more recent common ancestor;
7	For example, all vertebrate embryos have a tail posterior to the anus, as well as gill pouches. These embryonic structures develop into homologous structures with very different functions, such as gill slits in fishes and parts of ears and throat in humans;
8	Molecular homology is the similarities among organisms at the molecular level. All forms of life use the same genetic machinery of DNA and RNA, and the genetic code is essentially universal;
9	Two organisms with high molecular homology in their genes essential for development and also important functions reflect that they share a common ancestor;
10	For example, haemoglobin amino acid sequence, humans and rhesus monkey could be closely related as there is only a difference of 8 amino acids in the haemoglobin polypeptide sequence;
11	AVP, examples that are sound but not mentioned above;

2(a) Compare between structure of the tropocollagen and DNA double helix. [10]

	tropocollagen	DNA double helix
1	Made up of 3 polypeptide chains wind around each other to give a triple helix	Made up of 2 DNA strands
2	Each polypeptide chain contains about 1000 amino acids	Each strand contains a lot more deoxynucleotide.
3	The amino acid is mostly proline and glycine, and thus very repetitive	Coding DNA is made a unique and non-repetitive sequence of deoxynucleotide.
4.	Glycine, being small in size, is the key to allows the three strands to lie close together to form a tight coil.	Base pairing between a purine and a pyrimidine is essential to keep the width of the DNA double helix at a constant 2nm.
5	Each completed tropocollagen lies parallel in a regularly staggered arrangement with other triple helices to form microfibrils followed by fibrils, joined by covalent bonds between neighbouring triple helices	DNA double helix does not join with other double helix to form a thicker and more stable structure.
6	Fibrils unite to form fibres resulting in great tensile strength.	DNA double helix wind around histone into nucleosome, which go through further condensation to maintain its integrity during nuclear division.
7	Both are made up more than one molecule;	
8	Both structures are made up of chains and strands held together by hydrogen bonds;	
9	Amino acid sequence is tropocollagen is repetitive. And deoxyribonucleotide sequence in non-coding DNA is repetitive too.	

2(b)(i)	Describe the evolution of mitochondria and chloroplast from prokaryotes using the endosymbiosis theory. [4]
Marking Point	Answer
1	Endosymbiosis theory hypothesises that mitochondria and chloroplasts were formerly small prokaryotes that began living within larger cells;
2	The prokaryotic ancestors of mitochondria and chloroplasts had genes which allowed them to be aerobic and photosynthetic gained entry to the host cell as undigested prey or internal parasites;
3	The host cell was probably a heterotroph, an organism that eats other organisms and could use nutrients released from the prokaryotic ancestors;
4	The selection pressure of increasing oxygen and sunlight, selected for those host cells that could effectively utilise oxygen and light to produce more energy;
5	Over a long period of time, the prokaryotic ancestors entered into a mutually beneficial relationship with the host cell and later became the modern eukaryotic cells today;
6	The early origin of mitochondria is supported by the fact that all eukaryotes studied so far have either mitochondria or modified versions of them;

2(b)(ii)	Describe and explain the advantages of molecular (nucleotide and amino acid sequences) methods in classifying organisms. [6]
Marking Point	Answer
1	Molecular evidences are quantifiable as compared to morphological evidence, which are qualitative because they involve visual observation of a phenotype;
2	For example, percentage homology in DNA and amino acid sequences between species as compared to shape of head;
3	Thus molecular evidences are unambiguous and objective while morphological evidences are subjective;
4	Molecular evidences are open to statistical analysis while it is very difficult to do so for morphological evidence as they are qualitative evidences;
5	Statistical analysis can include chi-square or t-test to determine goodness of fit or significant difference between samples;
6	Morphological evidence may be erroneous because morphological similarities between two species may be due to convergence evolution when the species are subjected to similar selective pressure but in fact they are from two different ancestral lineages;
7	For example, sharks and dolphins both have streamlined bodies due to need to swim faster in the sea however, dolphins are mammals while sharks are fishes;