Rewarding Learning

ADVANCED

General Certificate of Education

2015

Centre Number

Candidate Number

Biology

AB221

Assessment Unit A2 2

assessing

Biochemistry, Genetics and Evolutionary Trends

[AB221]

MONDAY 1 JUNE, AFTERNOON

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Write your answers in the spaces provided in this question paper.
There is an extra lined page at the end of the paper if required.
Answer **all eight** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Section A carries 72 marks. Section B carries 18 marks.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You are reminded of the need for good English and clear presentation in your answers.
Use accurate scientific terminology in all answers.
You should spend approximately **25 minutes** on Section B.
You are expected to answer Section B in continuous prose.
Quality of written communication will be assessed in Section B, and awarded a maximum of 2 marks.
Statistics sheets are provided for use with this paper.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

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Section A

Examiner Only	
Marks	Remark

1 An understanding of the structure of DNA has led to the development of gene technology. One application of gene technology is the production of transgenic organisms.

(a) Explain precisely the term 'transgenic organism'.

_____

_____

_____ [1]

(b) Molecules, such as human growth hormone, can be produced via genetic engineering.

Describe the role of the following in genetic engineering:

- reverse transcriptase

_____

_____

_____

- DNA polymerase

_____

_____

_____

- plasmids

_____

_____

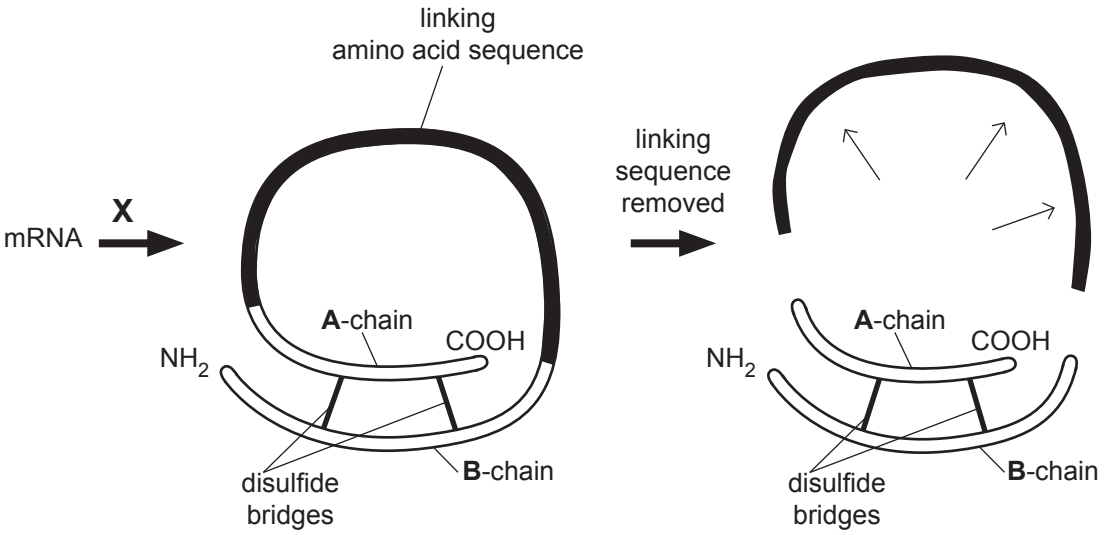
_____ [3]

Examiner Only	
Marks	Remark

2 **(a)** Insulin is a hormone involved in the regulation of blood glucose. It is produced in specialised cells in the pancreas and consists of two polypeptide chains (**A** and **B**) made up of 51 amino acids in total.

Following the formation of an initial 'precursor' molecule, proinsulin, a linking sequence of amino acids is removed to leave the two separate chains which form insulin.

This is summarised in the diagram below.



Proinsulin (precursor molecule)

Insulin (active molecule)

Using the information provided:

(i) Identify process **X**.

X _____ [1]

(ii) State the evidence which indicates that only one gene codes for insulin.

_____

_____

_____ [1]

(b) Ribosomes are small organelles involved in protein synthesis.

Examiner Only	
Marks	Remark

(i) Describe concisely the role of ribosomes in protein synthesis.

_____

_____

_____

_____

_____

_____

_____ [2]

(ii) Many ribosomes often work on the same individual strand of mRNA, in localised 'hot spots' of protein synthesis. In this way, large quantities of a particular polypeptide can be made. Suggest **two** advantages of this.

1. _____

_____

_____

2. _____

_____

_____ [2]

Examiner Only	
Marks	Remark

3 Photosynthesis involves a number of different plant pigments which absorb light energy.

(a) Describe **one** advantage of plants having different pigments to absorb light energy.

_____

_____

_____ [1]

(b) In deciduous trees the leaves emerge in spring and are lost in autumn.

Suggest **one** advantage to trees of losing their leaves in autumn.

_____

_____

_____ [1]

(c) Chromatography can be used to separate and identify the photosynthetic pigments present in a leaf. In an investigation, chromatography was used to compare and contrast the photosynthetic pigments present in the leaves of a particular species. This was done in May (at the start of the growing season) and in October (at the end of the growing season).

The results of the investigation are shown in the table below. Assume the technique used to extract the pigments was equally effective in both May and October.

	May (start of growing season)		**October** (end of growing season)	
Pigment	**Colour of pigment**	**Intensity of colour**	**Colour of pigment**	**Intensity of colour**
Carotene	yellow	4	yellow	5
Phaeophytin	yellow-grey	1	yellow-grey	2
Xanthophyll	yellow-brown	5	yellow-brown	4
Chlorophyll a	blue-green	5	blue-green	1
Chlorophyll b	green	5	green	2

Key

Intensity of pigment colour	
Dense colouration	5
Just visible	1

(i) Using the information provided, explain why the leaves of this species would be coloured green in May but would appear yellow-brown in October.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [3]

(ii) In this investigation it is important to control as many variables as possible. Suggest **one** variable that should be controlled and explain the reason for controlling it.

Variable _____

Reason _____

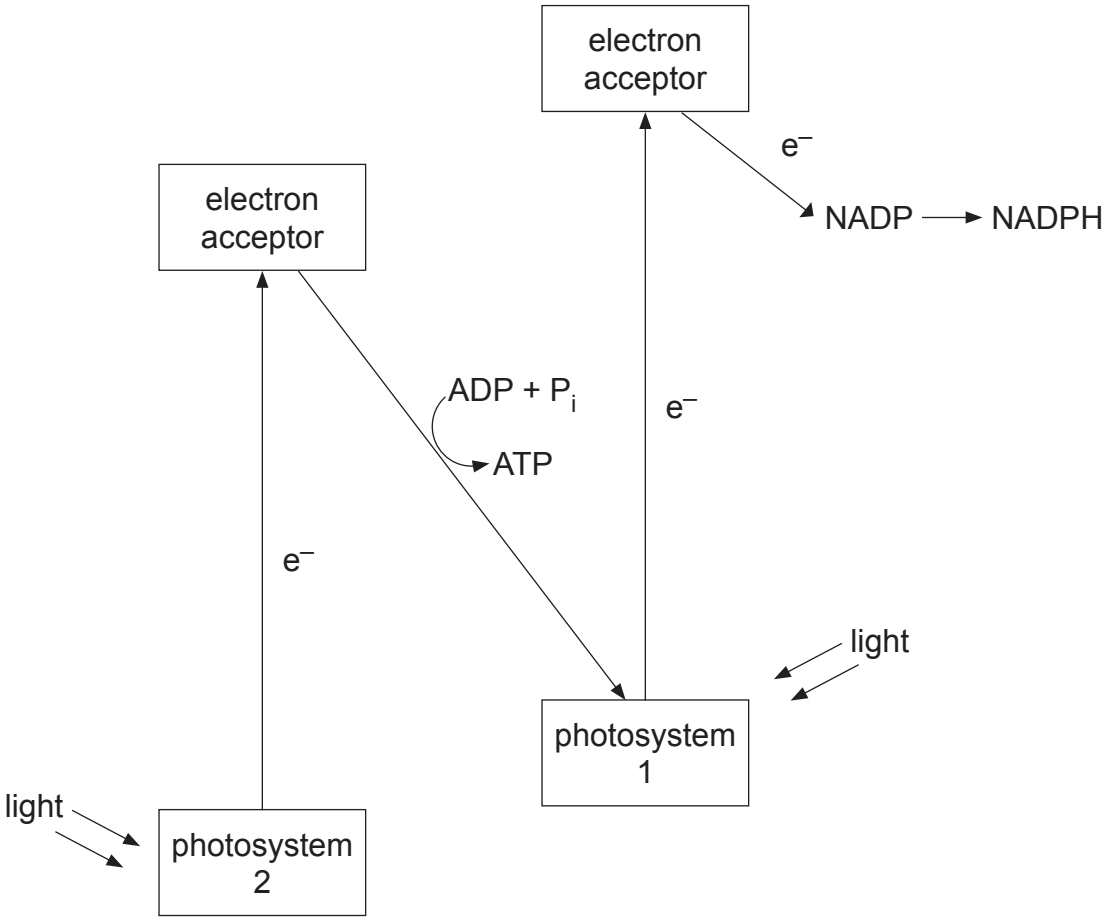
_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) The light-dependent reaction of photosynthesis is summarised in the diagram below. However, the process of photolysis is not included.



(i) Using the diagram and your knowledge, describe what happens to the products of photolysis (the splitting of water) in the above reaction.

[3]

(ii) Describe precisely how the products of the light-dependent reaction are used in the light-independent reaction.

Examiner Only	
Marks	Remark

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_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

4 Sickle cell anaemia is a condition caused by a mutation in a gene that codes for haemoglobin. In a mutated gene, the normal DNA sequence of the base triplet **CTC** is changed to **CAC**.

(a) (i) Name the type of mutation involved.

_____ [1]

(ii) State the change in the affected mRNA codon.

_____ to _____ [1]

The table below shows the 'genetic dictionary' indicating the amino acids coded for by mRNA codons.

second base in codon

first base in codon	U	C	A	G	third base in codon
U	phenylalanine phenylalanine leucine leucine	serine serine serine serine	tyrosine tyrosine stop stop	cysteine cysteine stop tryptophan	**U** **C** **A** **G**
C	leucine leucine leucine leucine	proline proline proline proline	histidine histidine glutamine glutamine	arginine arginine arginine arginine	**U** **C** **A** **G**
A	isoleucine isoleucine isoleucine methionine and start	threonine threonine threonine threonine	asparagine asparagine lysine lysine	serine serine arginine arginine	**U** **C** **A** **G**
G	valine valine valine valine	alanine alanine alanine alanine	aspartate aspartate glutamate glutamate	glycine glycine glycine glycine	**U** **C** **A** **G**

(iii) Using the information in the table:

- State the change in the amino acid coded for as a consequence of the sickle cell anaemia mutation.

  _____ to _____ [1]

- Explain precisely what is meant by the 'degenerate nature of the genetic code'.

  _____

  _____

  _____

  _____

  _____

  _____ [2]

Sickle cell anaemia results in red blood cells becoming more rigid. Many red blood cells in individuals with sickle cell anaemia are therefore less flexible than those in unaffected individuals.

(b) Suggest the effect that sickle cell anaemia has on blood flow in the capillaries of an affected individual.

_____

_____ [1]

Examiner Only	
Marks	Remark

People with two copies of the mutated allele have sickle cell anaemia. These individuals have very restricted oxygen-carrying capacity and have reduced life expectancy.

People with one normal allele and one mutated allele (i.e. heterozygotes) are said to have *sickle cell trait*. These heterozygotes have less efficient oxygen-carrying capacity but can carry out activities that do not require high energy levels.

Evidence shows that heterozygotes have some protection against malaria. Malaria is a disease caused by a parasite which carries out part of its life cycle within the red blood cells. The red blood cells in individuals carrying at least one sickle cell allele are not easily penetrated by the parasite. The parasite is transmitted from person to person by mosquito bites. Mosquitoes are particularly common in hot climates, such as much of central Africa, but are unable to live in colder climates.

(c) Explain why the frequency of the sickle cell allele remains at high levels in parts of Africa yet is very low in northern Europe.

_____

_____

_____

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_____ [5]

Examiner Only	
Marks	Remark

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(Questions continue overleaf)

Examiner Only	
Marks	Remark

5 Ash 'dieback' is a fungal disease which has caused the destruction of many ash *(Fraxinus excelsior)* woodlands in Europe, including well over half of the ash trees in Denmark.

In March 2012, the first case of this infection in Britain was reported. By 2013, the disease had spread across native woodlands in south east England and was also found in other isolated pockets in England, Scotland and Wales.

It is thought that the fungus responsible, *Chalara fraxinea*, was carried to Britain from mainland Europe in infected seedlings and young trees. Once in Britain the infection spread rapidly from tree to tree by wind-borne spores, with a typical dispersal range of up to ten miles.

In early 2013, the only examples of infected ash trees in Northern Ireland were in sites which had been recently planted with commercially grown seedlings. There were no reported cases in native woodland.

(a) Suggest why the first cases of *Chalara fraxinea* infection in Northern Ireland were in new plantations, but not in native woodland.

_____

_____

_____

_____

_____

_____ [2]

(b) Several strategies are being used to control the spread of the disease. One strategy involves developing an understanding of the genome of the ash. In 2013 its genome was sequenced for the first time.

Examiner Only	
Marks	Remark

(i) Explain fully the term 'genome sequencing'.

_____

_____

_____

_____

_____

_____ [2]

(ii) A strain of ash (referred to as 'tree-35') resistant to the fungus has been identified in Denmark. This strain originated around 100 years ago and currently makes up two percent of Danish ash trees.

Suggest how knowledge of the genomes of both the native British ash and 'tree-35' could be used to help conserve native British ash woodland.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

(c) The human genome has also been sequenced. As a result, it is now possible to test an individual for the presence of alleles that increase susceptibility to certain medical conditions, such as some cancers and heart disease.

(i) There has been limited progress in directly linking alleles to conditions such as cancer and heart disease. Suggest **two** reasons for this limited progress.

1. _____

_____

_____

2. _____

_____

_____ [2]

(ii) In terms of treatment, continued research into the link between alleles and disease is likely to be beneficial.

In this context, explain the term 'designer drug' and suggest **one** advantage of developing such drugs.

_____

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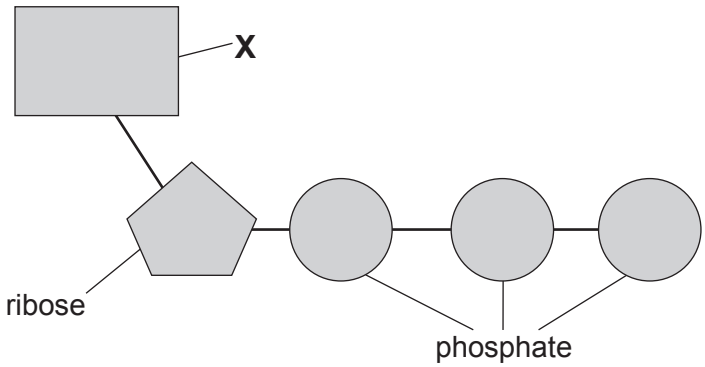
_____ [2]

Examiner Only	
Marks	Remark

6 **(a)** The structure of an ATP molecule is represented in the diagram below.



(i) Identify the part of the molecule labelled **X** in the diagram.

X _____ [1]

(ii) Explain what happens when an ATP molecule is hydrolysed to ADP.

_____

_____

_____ [1]

(iii) Give **two** advantages of using ATP as an immediate energy source within the cell, rather than glucose.

1. _____

_____

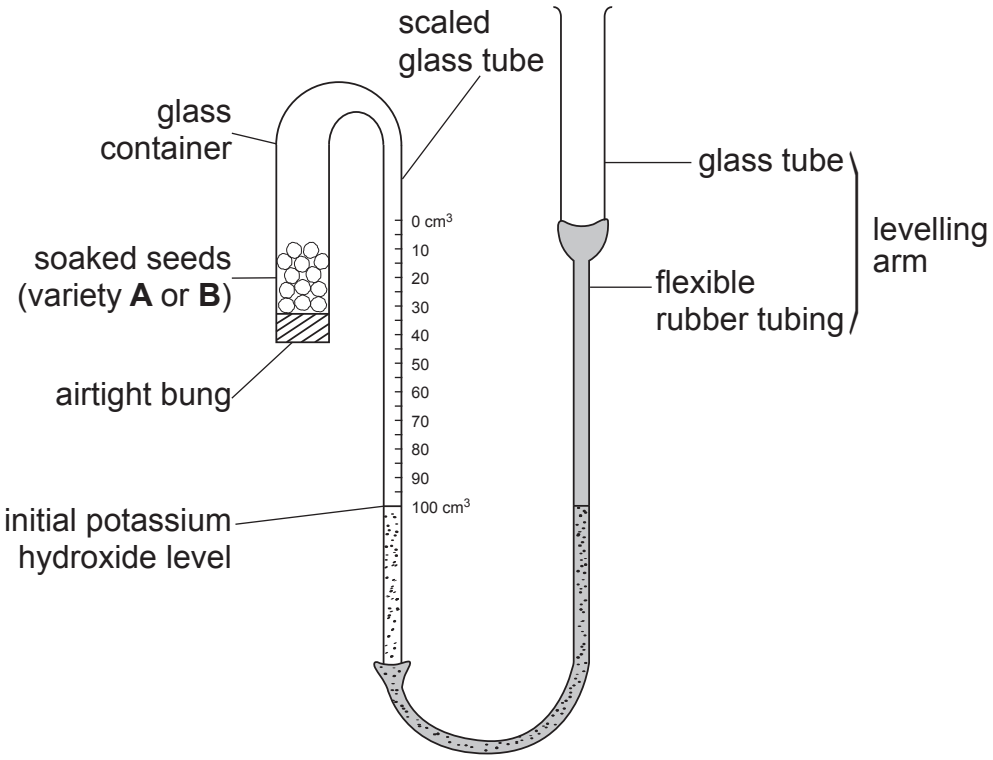
2. _____

_____ [2]

Examiner Only	
Marks	Remark

(b) It was noticed that one variety of a pea species (**A**) had a more rapid growth rate than another variety (**B**). It was suggested that this was due to variety **A** having a faster respiration rate.

In an investigation to compare respiration rates in the two varieties, two sets of the apparatus shown in the diagram below were used. (This apparatus is similar in principle to a standard respirometer.)



For each variety, 10 g of soaked peas were placed in the glass container with an airtight bung. The level of potassium hydroxide was adjusted to 100 cm^3 on the scale by raising or lowering the levelling arm.

Both sets of apparatus were placed in a dark cupboard for 12 hours. The readings on the scales were recorded every two hours.

(i) Explain why the investigation was conducted in darkness.

_____

_____

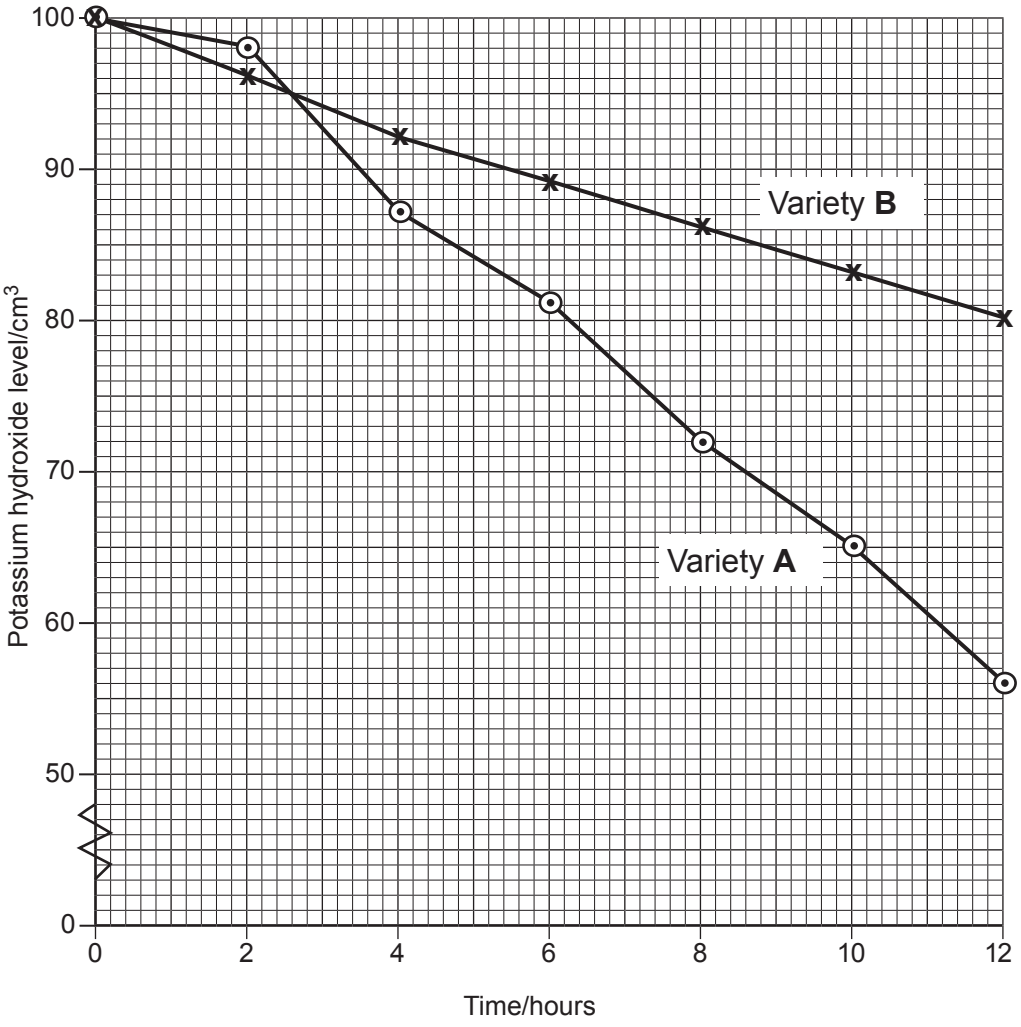
_____

_____

_____

_____ [2]

The results of the investigation are shown in the graph below.



(ii) Suggest an explanation for the faster rate of oxygen uptake in variety **B** between 0–2 hours.

_____

_____

_____ [1]

(iii) Calculate the mean rate of respiration of variety **A** between 2 and 12 hours in cm^3 of oxygen used per gram of pea seed per hour. (Show your working.)

_____ cm^3 oxygen g^{-1} hr^{-1} [3]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

(c) It was suggested that the overall faster respiration rate in variety **A** was due to there being more mitochondria in the cells of variety **A** than in those of variety **B**. Thin sections of pea tissue were prepared from each variety and mitochondria in 100 cells of each variety were counted.

The results are shown in the following table.

	Variety of pea	
	A	**B**
Number of cells in section (*n*)	100	100
Mean number of mitochondria in each cell ($\bar{x}$)	6.3	5.8
Standard deviation (error) of the mean ($\hat{\sigma}_{\bar{x}}$)	0.62	0.68

The *t*-test can be used to compare the number of mitochondria in the two varieties.

(i) State the null hypothesis for this test.

_____

_____

_____ [1]

(ii) Calculate the value of *t* using data from the table above.
(Show your working.)

Answer_____ [2]

(iii) State the probability value for the calculated t.

_____ [1]

(iv) State your decision regarding the null hypothesis and comment on this outcome.

_____

_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

7 The fruit fly, *Drosophila melanogaster*, is ideally suited for genetic investigations and has been widely used for this purpose for many years.

The normal eye colour in *Drosophila* is red but a white-eyed form exists. In the genetics of eye colour, red eye (**R**) is dominant to white eye (**r**) and the inheritance of eye colour is sex linked (in a similar way to sex linked conditions in humans).

(a) State the genotypes of:

- a male with red eyes

  _____

- a female with white eyes

  _____ [2]

(b) In a particular cross, a red-eyed female was crossed with a red-eyed male. The offspring produced are shown in the following table.

	Red eyes	**White eyes**
Males	48	53
Females	102	0

(i) Using a genetic diagram, explain the outcome of this cross.

[3]

Examiner Only	
Marks	Remark

(ii) As with most genetic crosses, the numbers of offspring in this cross do not fit exactly with the predicted ratio. State the name of the statistical test that can be used to identify if observed offspring numbers are significantly different from expected numbers.

_____ [1]

(c) In *Drosophila*, the genes for wing type and body colour are located on separate autosomes and so are independently inherited. Normal wing is dominant to vestigial wing and normal body colour is dominant to ebony body colour.

A cross between a fruit fly with normal wings and normal body colour and one with vestigial wings and ebony body colour produced offspring displaying four different phenotypes.

Using a genetic diagram, explain these results.
(Let **A** = normal wing and **B** = normal body colour)

[4]

(d) Suggest **two** reasons why *Drosophila melanogaster* is ideally suited for genetic investigations.

1. _____

_____

2. _____

_____ [2]

Section B

Examiner Only	
Marks	Remark

Quality of written communication is awarded a maximum of 2 marks in this section.

8 The divisions in the plant kingdom and the phyla in the animal kingdom show progression in levels of organisation across the major groups.

(a) In the plant kingdom, one aspect of this progression involves an increasing ability to survive in drier environments. Describe and explain the levels of progression, in terms of this ability, across the major plant groups (i.e. the mosses, ferns and angiosperms). [10]

(b) In the animal kingdom, the phyla show increasing complexity in the sequence Cnidaria, Platyhelminthes, Annelida and Chordata. Describe and explain how evolutionary progression is evident in this sequence. [6]

Quality of written communication [2]

(a) In the plant kingdom, one aspect of this progression involves an increasing ability to survive in drier environments. Describe and explain the levels of progression, in terms of this ability, across the major plant groups (i.e. the mosses, ferns and angiosperms).

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) In the animal kingdom, the phyla show increasing complexity in the sequence Cnidaria, Platyhelminthes, Annelida and Chordata. Describe and explain how evolutionary progression is evident in this sequence.

Examiner Only	
Marks	Remark

Extra lined page

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER