Rewarding Learning

Centre Number

71

Candidate Number

ADVANCED
General Certificate of Education
2010

Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and Evolutionary Trends

[AB221]

AB221

TUESDAY 8 JUNE, MORNING

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.
Answer **all nine** questions.
You are provided with **Photographs 5.4A** and **B** for use with Question 4 in this paper.
Do not write your answers on this photograph.

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.

6249.09 **R**

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

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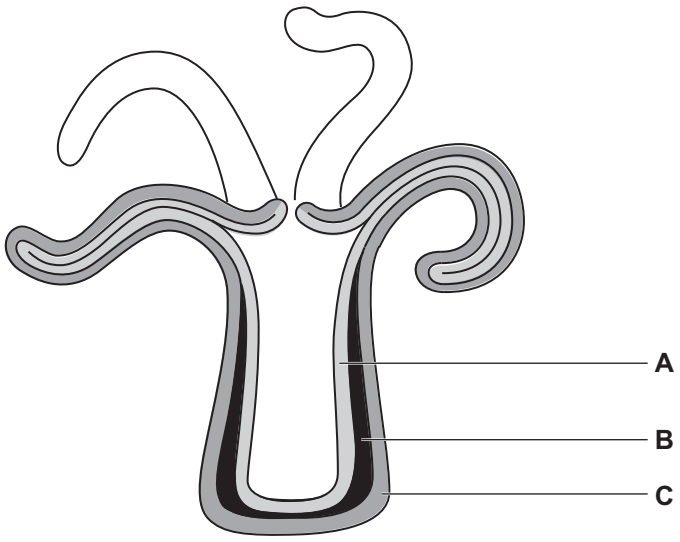
Section A

1 **(a)** The diagram below represents the body plan of *Hydra*, a member of the phylum Cnidaria.



Name the layers **A**, **B** and **C**.

A _____

B _____

C _____ [2]

(b) Describe **three** features found in members of the phylum Annelida, which are not found in *Hydra*.

1 _____

_____

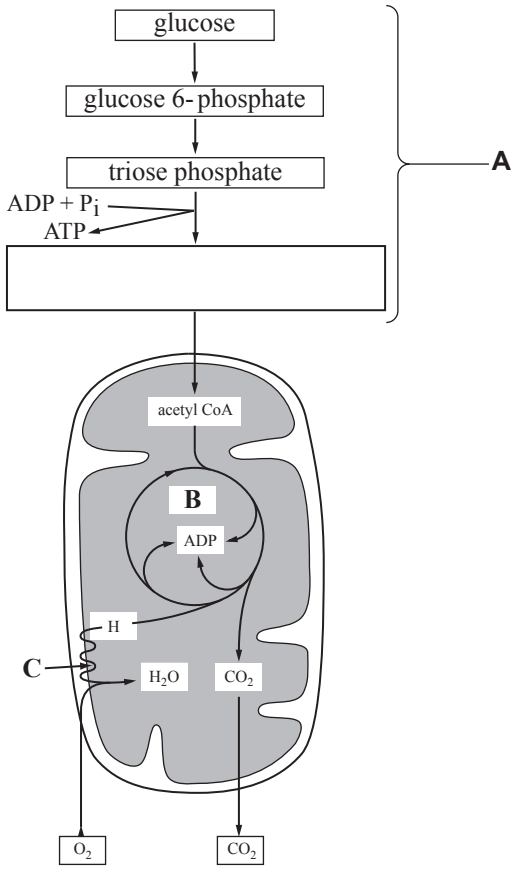
2 _____

_____

3 _____

_____ [3]

2 The diagram below summarises the various stages involved in the respiration of a glucose molecule.



(a) (i) **Complete the diagram** by naming the missing compound in the empty box. [1]

(ii) State where in the cell process **A** occurs.

_____ [1]

(iii) Name each of the processes which take place at locations **B** and **C**.

B _____

C _____ [2]

(b) The diagram summarises the respiration of glucose. Describe how fatty acids are respired.

_____

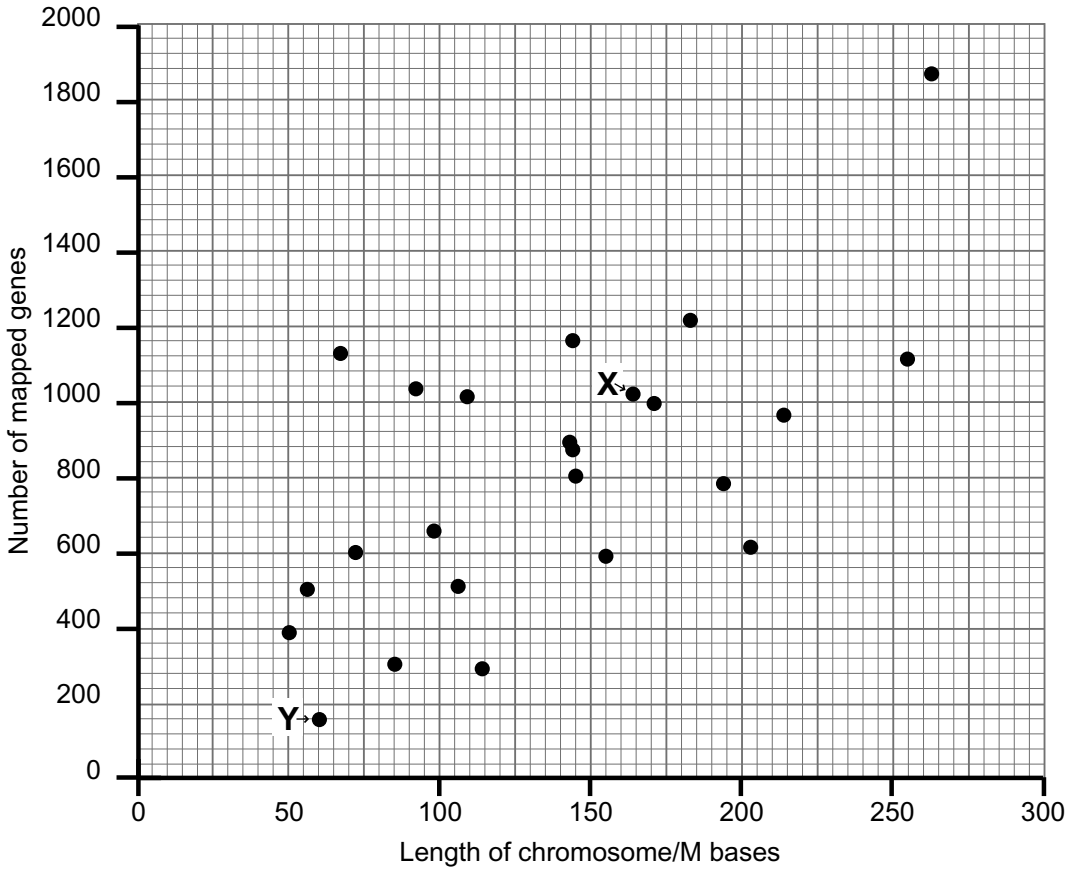
_____

_____

_____ [2]

3 The Human Genome Project was organised to sequence all the nucleotides and map the genes present in human DNA.

The graph below shows the number of mapped genes for different sized chromosomes.



(a) Describe the trend evident in the graph.

_____

_____ [1]

(b) The sex chromosomes, **X** and **Y**, are identified in the graph. Compare the number of genes in these chromosomes with other similar sized chromosomes.

X _____

_____

Y _____

_____ [2]

(c) Explain the significance for males of the difference between the number of the genes on the **X** and **Y** chromosomes.

_____

_____ [1]

4 **Photograph 5.4A** shows moss of the genus *Polytrichum.*

(a) **(i)** Identify the stages in the moss life cycle indicated by **X** and **Y.**

X _____

Y _____

[2]

(ii) State the ploidy of the cells in stage **X** shown in photograph **5.4A**.

_____ [1]

Plants of the genus *Polytrichum* are upright and have well-developed rhizoids. They form dense tufts as shown in photograph **5.4A**. These features allow *Polytrichum* species to grow on rocks and walls, both of which are relatively dry.

(iii) Suggest how the following features allow these plants to grow in relatively dry areas.

- Well-developed rhizoids

_____

_____

- Growth in dense tufts

_____

_____ [2]

(iv) Explain how the plant is supported to keep it upright.

_____

_____ [1]

(b) **Photograph 5.4B** shows a moss plant of the genus *Sphagnum*. This moss covers the waterlogged soils of peat bogs. The lower part of the plant is dead and there are no rhizoids. Water and mineral ions are absorbed directly through the 'leaf-like' structures.

Suggest reasons for the following features, characteristic of *Sphagnum*.

- The absence of rhizoids and the dead lower part of the moss

_____

_____

_____

_____

- The ability to absorb water and minerals ions into the 'leaf-like' structures, an ability not shared by the leaves of ferns or flowering plants, members of the division Tracheophyta.

_____

_____

_____

_____ [4]

5 The enzyme ribulose bisphosphate carboxylase (Rubisco) catalyses the reaction between ribulose bisphosphate (RuBP) and carbon dioxide.

Genetically transformed plants can be produced using antisense RNA which results in the synthesis of less Rubisco enzyme. These are called 'reduced Rubisco plants'. They grow slowly and are stunted.

(a) (i) State the product of the reaction between ribulose bisphosphate and carbon dioxide.

_____ [1]

(ii) In the Calvin cycle, ribulose bisphosphate is regenerated from triose phosphate. State what else is required for the regeneration of ribulose bisphosphate.

_____

_____ [1]

(iii) Explain why the 'reduced Rubisco plants' are slow growing and stunted.

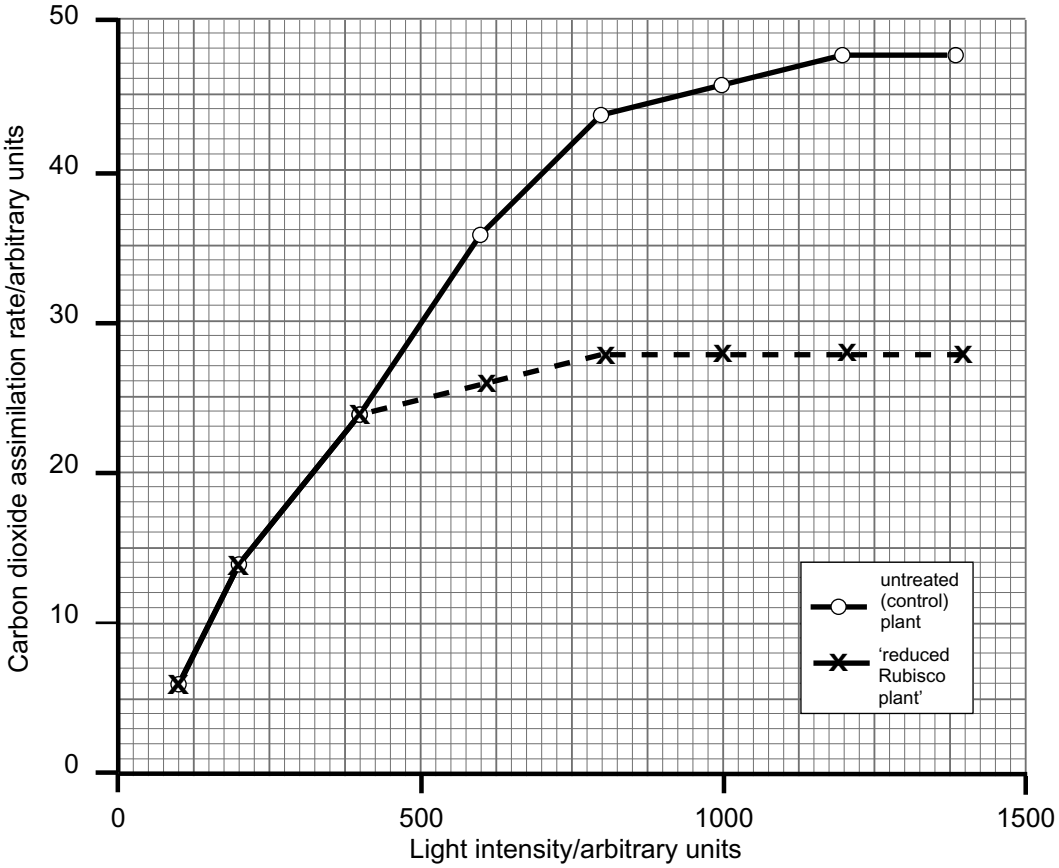
_____

_____

_____

_____ [2]

(b) Leaves from a 'reduced Rubisco plant' and an untreated (control) plant were used in a series of experiments. The graph opposite shows the rate of carbon dioxide assimilation by both plants at different light intensities. A temperature of 25ºC and a high concentration of carbon dioxide were maintained at all light intensities.



(i) Explain the similar assimilation rates of both plants in low light intensities.

_____

_____

_____

_____ [2]

(ii) Explain the different assimilation rates of the plants in high light intensities.

_____

_____

_____

_____ [2]

(c) A second experiment was designed to measure the rate of carbon dioxide assimilation for both plants at varying carbon dioxide concentrations.

In this experiment it would be necessary to maintain a temperature of 25ºC and a high light intensity.

(i) Explain why a relatively high temperature of 25ºC should be maintained in the experiment.

_____

_____

_____

_____ [2]

(ii) Predict the result of this second experiment for both the 'reduced Rubisco plant' and the untreated (control) plant.

_____

_____

_____

_____ [2]

(iii) Explain the result for the 'reduced Rubisco plant'.

_____

_____

_____ [1]

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(Questions continue overleaf)

6 **(a)** In a survey of the relative sizes of island-dwelling mammalian species, each species was compared with mainland relatives. Four groups of mammals were surveyed. In each case the number of island-dwelling species 'smaller than' or 'the same size as' or 'larger than' related species on the mainland were recorded. The results are shown in the table below.

	Number of island-dwelling species		
	Smaller than	**Same size**	**Larger than**
Lagomorphs (rabbits and hares)	4	4	1
Rodents (mice and rats)	6	3	60
Carnivores	13	1	1
Artiodactyls (even-toed mammals such as deer)	9	2	0

State **two** conclusions which might be drawn from the results.

1. _____

_____

2. _____

_____ [2]

(b) Field mice of the species *Apodemus sylvaticus* are common throughout Ireland. It was considered that the field mice of Rathlin Island are larger than the mainland field mice in Northern Ireland. The table below summaries data collected for the mass of a sample of adult field mice trapped on Rathlin Island and the mainland.

		Location of field mice	
		Rathlin	**Mainland**
Number of mice in the sample	(n)	17	120
Mean mass of mice	$(\overline{x})$	33.15	23.8
Standard deviation of the mean	$(\hat{\sigma}_{\overline{x}})$	2.56	1.65

A *t*-test can be used to compare the mean mass of the Rathlin and the mainland mice.

(i) State the null hypothesis for this test.

_____

_____

_____ [1]

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

Answer _____ [2]

(iii) State the degrees of freedom used in reading the statistical table.

_____ [1]

(iv) State the probability value for the calculated *t*.

_____ [1]

(v) State your decision about the null hypothesis.

_____

_____ [1]

(c) The mice population on Rathlin is isolated from mainland mice. In this island population large size may provide a selective advantage.

(i) Explain the evolution of large size on Rathlin Island.

_____

_____

_____

_____ [2]

(ii) Explain what may eventually lead to a new mouse species on Rathlin.

_____

_____

_____

_____ [2]

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(Questions continue overleaf)

7 Labrador retrievers are dogs with black, brown or yellow coats. The coat colour is controlled by two independently-inherited genes which are not sex-linked.

The alleles of a pigment gene at the **B/b** locus determine the amount of black pigment produced. The presence of a **B** allele results in a black coat. A brown coat is produced by the **bb** genotype.

A second gene at the **E/e** locus influences the expression of the alleles at the **B/b** locus. The presence of the **E** allele allows the alleles at the **B/b** locus to be expressed. A yellow coat is always produced if the genotype is **ee**, no matter which alleles are present at the **B/b** locus.

(a) (i) State the genotype of a pure breeding brown Labrador.

_____ [1]

(ii) State the genetic term which describes the relationship between the **B/b** and **E/e** loci.

_____ [1]

(b) Two black dogs known to be heterozygous for both genes (**BbEe**) were crossed. Determine the expected proportions of the offspring produced with respect to both genotypes and phenotypes. Show your working in a genetic diagram in the space below.

[5]

(c) A litter of pups, which resulted from a cross between a yellow male Labrador and a black female, consisted of 7 yellow and 3 black pups.

(i) With respect to the alleles at the **E/e** locus only, state the genotypes for the male and female parents.
Give a reason for each of your answers.

- yellow male _____

_____

_____

- black female _____

_____

_____ [2]

(ii) Suggest an explanation for the lack of brown pups in the litter.

_____

_____

_____

_____ [2]

8 Read the following passage concerning the gene coding for the muscle protein, dystrophin. Mutant alleles of this gene result in a lack of dystrophin, which leads to the progressive muscle-wasting disease, Duchenne muscular dystrophy (DMD).

The gene for dystrophin is located on the X-chromosome. Sequencing techniques have shown that the gene contains 2.4 million nucleotide pairs. However, only 11,055 nucleotides codes for a dystrophin. The 79 coding regions (exons) within the gene are interrupted by non-coding regions (introns).

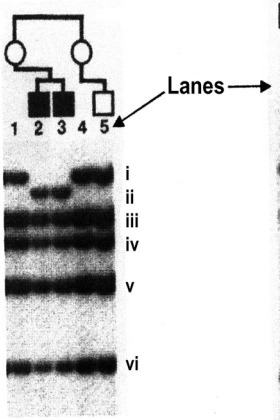
The disease DMD, is inherited as a sex-linked trait. DMD is rarely found in females, although they can be carriers of the mutant allele. Affected males show symptoms at five years old and most are wheelchair dependent at 12 years old.

However, in a study of 77 cases of DMD, 43 had no family history of the disease. Mutations in the female ovary can result in ova (eggs) having the allele causing DMD. This is not detected in DNA analysis of other tissues of the female, such as blood.

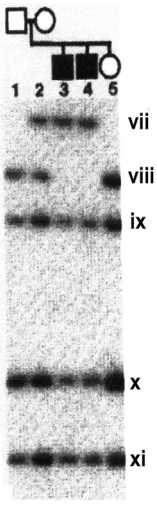
An analysis of the DNA, using blood samples, from two families with DMD sons is shown below. The restriction enzyme *Bgl*II was used to cut the DNA in the region of the dystrophin gene and cDNA probes were used to detect the different genetic markers (RFLPs). The diagrams below show the genetic markers (RFLPs) found in the parents and offspring in the two families. In family **A** the probe used identified markers **i** to **vi**. In family **B** the probe used identified markers **vii** to **xi**.

Family **A**

Lane	Family member
1	Sister 1 (parent)
2	DMD son of sister 1
3	DMD son of sister 1
4	Sister 2 (parent)
5	Normal son of sister 2



Family **B**



Lane	Family member
1	Father
2	Mother
3	DMD son
4	DMD son
5	Normal daughter

Using this information, and your own understanding, answer the questions which follow.

(a) Calculate how many amino acids are in the protein, dystrophin [line 3]. (Show your working.)

Answer _____ [1]

(b) Explain the term 'family history' [line 10].

_____

_____ [1]

(c) Mutations in the gene involve the deletion of a nucleotide [line 11].

Describe how the deletion of a nucleotide will change the gene and explain how the primary structure of the protein is altered.

_____

_____

_____

_____ [2]

(d) **(i)** In family **A**, compare the genetic markers identified by the genetic probe in the DMD sons and other members of the family.

_____

_____

_____

_____ [2]

(ii) In family **B**, the genetic marker **vii** is present in both the DMD sons and their mother. Explain why their mother does not suffer from DMD.

_____

_____

_____

_____ [2]

(iii) Comment on the inheritance of DMD in the two families.

_____

_____

_____

_____

_____

_____ [3]

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(Questions continue overleaf)

Section B

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

9 **(a)** Write an account of the role of nucleic acids in the synthesis of proteins. [10]

(b) Knowledge of the role of nucleic acids has been exploited to provide new sources of medically important proteins and new crops from genetically modified organisms.

Discuss the safety precautions currently employed to overcome potential hazards of using genetically modified organisms and some of the ethical issues regarding the benefits and risks of gene technology.

[6]

(a) Write an account of the role of nucleic acids in the synthesis of proteins.

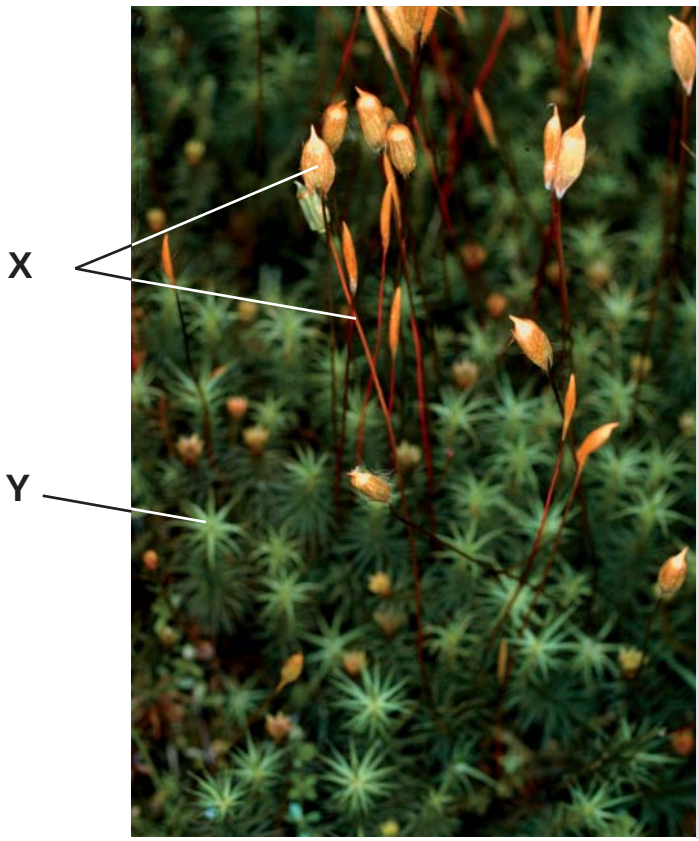
(b) Discuss the safety precautions currently employed to overcome potential hazards of using genetically modified organisms and some of the ethical issues regarding the benefits and risks of gene technology.

THIS IS THE END OF THE QUESTION PAPER

GCE Biology Advanced (A2)
Assessment Unit A2 2
Biochemistry, Genetics and Evolutionary Trends
Summer 2010

Photographs 5.4 A and B
(for use with Question 4)

A **B**



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