Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
January 2007
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

BIOLOGY/HUMAN BIOLOGY (SPECIFICATION A) BYA5
Unit 5 Inheritance, Evolution and Ecosystems

Wednesday 24 January 2007 9.00 am to 10.30 am

For this paper you must have:
- a ruler with millimetre measurements.
- a calculator.

Time allowed: 1 hour 30 minutes

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- You will be marked on your ability to use good English, to organise information clearly and to use accurate scientific terminology where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1		9	
2			
3			
4			
5			
6			
7			
8			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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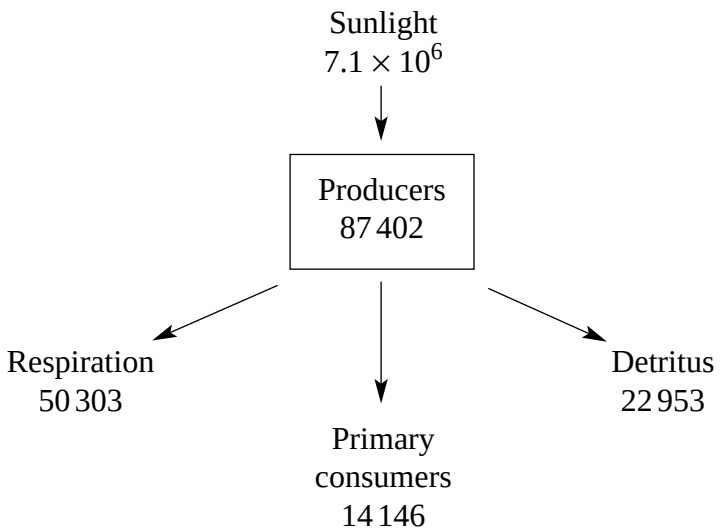
Answer **all** questions in the spaces provided.

1 The diagram shows the transfer of energy through producers in an aquatic ecosystem. The figures are in kJ m^{-2} $year^{-1}$.



(a) What is an ecosystem?

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(1 mark)

(b) The percentage of the light energy trapped by the producers is very low. Give **two** reasons why.

1 .....

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2 .....

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(2 marks)

(c) The biomass of primary consumers is less than the biomass of producers. Explain why.

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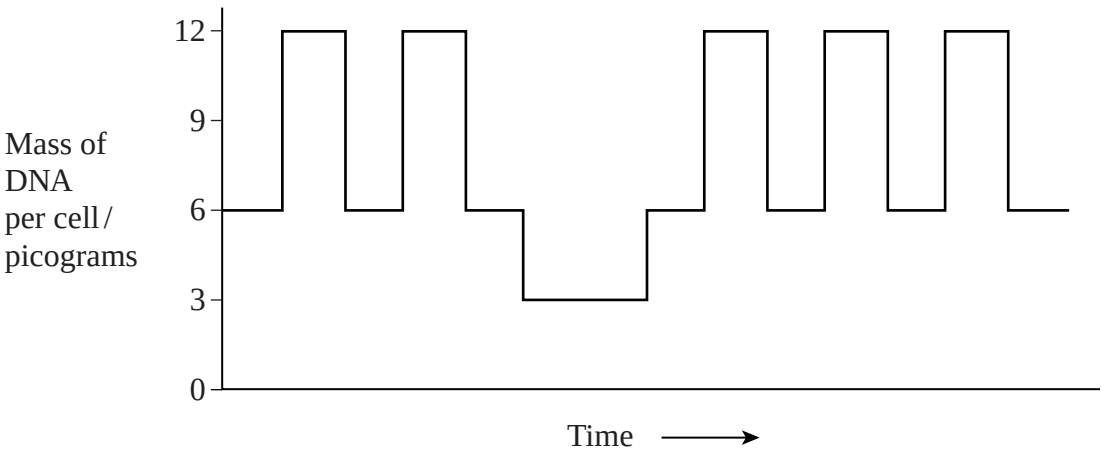
(2 marks)

2 (a) The graph shows the mass of DNA present in a human cell during sperm production, fertilisation, and early development of the embryo.



(i) What mass of DNA would be present in a diploid human cell at the start of interphase?

..... picograms *(1 mark)*

(ii) Write the letters **F** and **S** on the graph, as follows:

F to show the point of fertilisation,
S to show completion of the second division of meiosis.

(2 marks)

(b) Give **two** ways in which meiosis causes genetic variation.

1 .....

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2 .....

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(2 marks)

5

3 In fruit flies, eye colour is determined by a gene with four alleles. The allele for red eye, $\mathbf{C^R}$, is dominant to the other three alleles. The allele for white eye, $\mathbf{C^w}$, is recessive to all the other alleles. The allele for apricot eye, $\mathbf{C^a}$, is dominant to the allele for honey eye, $\mathbf{C^h}$.

(a) Complete the table to show all the diploid genotypes that can be produced by crosses involving these alleles. Give the phenotype of each genotype.

Alleles	$\mathbf{C^R}$	$\mathbf{C^a}$	$\mathbf{C^h}$	$\mathbf{C^w}$
$\mathbf{C^w}$	....	....	....	$\mathbf{C^wC^w}$ white
$\mathbf{C^h}$	....	....	$\mathbf{C^hC^h}$ honey	
$\mathbf{C^a}$	....	$\mathbf{C^aC^a}$ apricot		
$\mathbf{C^R}$	$\mathbf{C^RC^R}$ red			

(3 marks)

(b) Another gene has five alleles. How many different diploid genotypes are possible with five alleles?

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(1 mark)

4

4 Oxygen is produced in the light-dependent reactions of photosynthesis.

(a) In which part of a chloroplast do the light-dependent reactions occur?

.....

(1 mark)

(b) Light of different colours was shone on Canadian pondweed. The table shows the amounts of oxygen released.

Colour of light	**Number of bubbles of oxygen released per minute in five trials**							
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Mean**	**Standard deviation**	**Range**
Violet	22	19	26	18	17	20.4	3.65	9
Blue	38	25	33	26	37	31.8	6.06	13
Green	21	12	12	11	7	12.6	5.13	14
Yellow	14	13	13	11	12	12.6	1.14	3
Red	20	17	18	14	15	16.8	2.39	6

It is better to use the mean and standard deviation rather than the range to describe variation in these results.
Use the data to explain the advantage of using the mean and standard deviation.

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(2 marks)

(c) Scientists investigated photosynthesis in single-celled algae. They did two experiments.

In the first experiment, they supplied the algae with water molecules labelled with the isotope of oxygen, ^{18}O. The oxygen gas released by the algae contained ^{18}O.

In the second experiment, they supplied the algae with carbon dioxide molecules labelled with ^{18}O. The oxygen gas released by the algae did **not** contain ^{18}O.

Use this information to explain why the following equation is **not** an accurate summary of photosynthesis.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

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(2 marks)

5

Turn over for the next question

5 (a) Some students planned to estimate the population of thistles in a field measuring 100 m by 50 m. Describe how they should use a 1 m quadrat frame to do this.

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(3 marks)

(b) The students then estimated the population of snails in a small pond. They collected 31 snails from the pond. They then marked the snails' shells with paint and released them back into the pond. One day later, the students captured 69 snails, 6 of which had paint marks on their shells.

Give **one** criticism of the method used. Explain why this would reduce the accuracy of the population estimate.

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(2 marks)

5

6 The Old Order Amish of Lancaster County, Pennsylvania, are an isolated human population. Marriages occur almost exclusively within the population. Nearly all can trace their ancestry back to a small group of people who settled in the area in the 18th century.

Microcephaly is a condition which occurs in this population with a frequency of 1 in every 480 births. It is caused by a recessive allele of a single gene. Sufferers usually die within six months of birth.

(a) The incidence of microcephaly in this population is very high compared to non-isolated populations. Suggest **two** reasons for this high incidence.

1 .....

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2 .....

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(2 marks)

(b) (i) A student used the Hardy-Weinberg equation to estimate the percentage of parents who are heterozygous for microcephaly in this population.
What answer should the student have obtained? Show your working.

Answer ..... *(3 marks)*

(ii) The answer to part (b)(i) is likely to be lower than the actual percentage of parents heterozygous for microcephaly in this population. Explain why.

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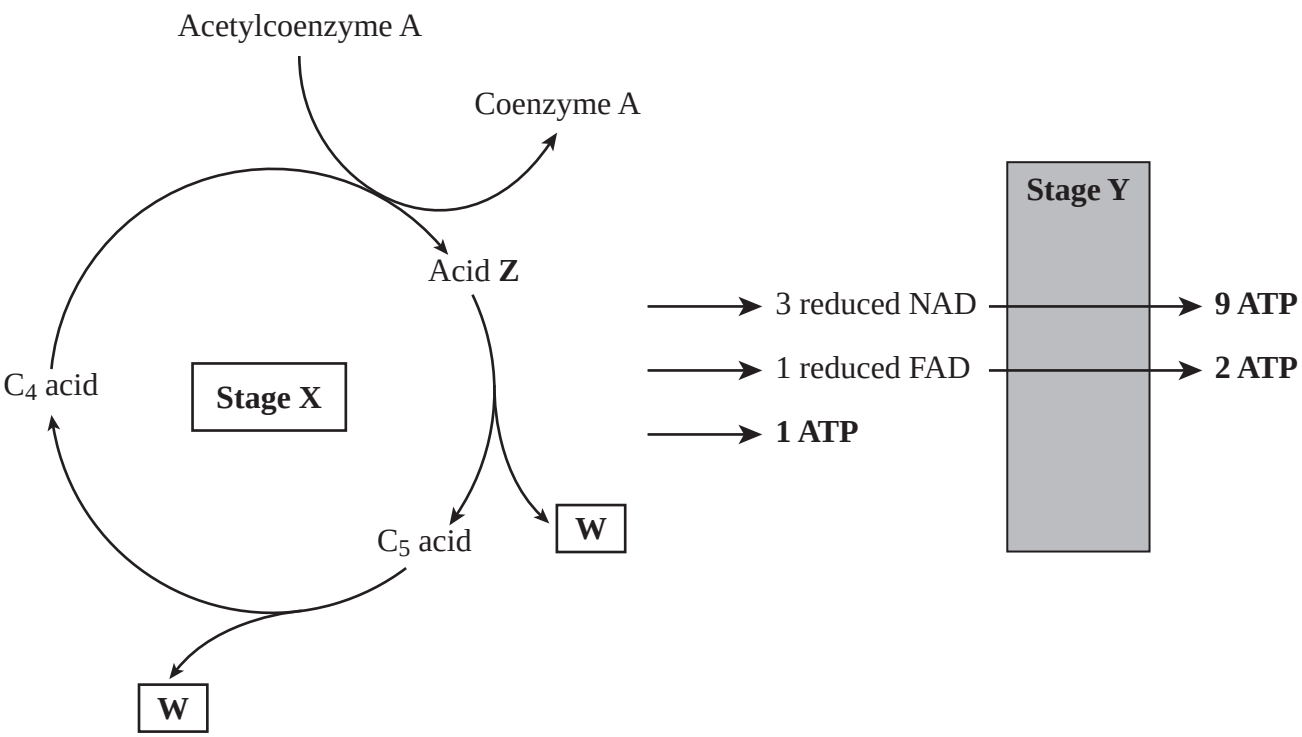
(1 mark)

6

7 In aerobic respiration, acetylcoenzyme A is broken down as shown in **Figure 1**.

Figure 1



(a) (i) Name

Substance **W**, ...

Stage **X**. .....

(2 marks)

(ii) How many carbon atoms are there in one molecule of acid **Z**? .....

(1 mark)

(iii) Write the word 'oxygen' on **Figure 1** to show where oxygen gas is used.

(1 mark)

(b) Stearic acid is a fatty acid.
Equation 1 shows aerobic respiration of stearic acid.

Equation 1 $C_{17}H_{35}COOH + 26O_2 \longrightarrow 18CO_2 + 18H_2O$ + energy
Stearic acid

Calculate the respiratory quotient (RQ) for aerobic respiration of stearic acid.
Show your working.

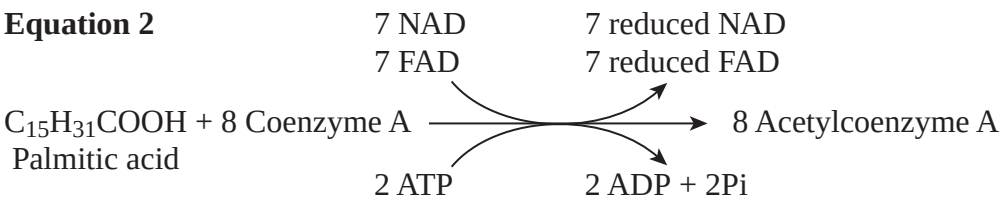
RQ = ...

(2 marks)

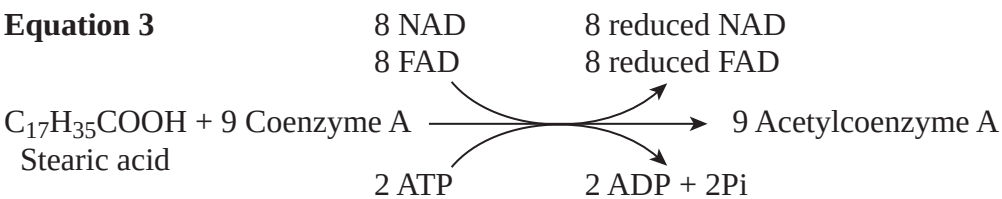
(c) Different fatty acids contain different numbers of carbon atoms.

The first stages in the aerobic respiration of palmitic acid and of stearic acid are given in equations **2** and **3**.

Equation 2



Equation 3



(i) The greater the number of carbon atoms in a fatty acid, the greater the yield of ATP when the fatty acid molecule is respired aerobically. Use **Figure 1**, and equations **2** and **3**, to explain why.

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(3 marks)

(ii) Dinitrophenol (DNP) is a metabolic poison. It specifically prevents oxidative phosphorylation at **Stage Y** in **Figure 1**. However, it does not prevent the oxidation of reduced NAD and reduced FAD.

Palmitic acid was respired aerobically in the presence of DNP. This resulted in a net yield of only 6 molecules of ATP per molecule of palmitic acid.
Use information from **Figure 1** and from **Equation 2** to suggest why.

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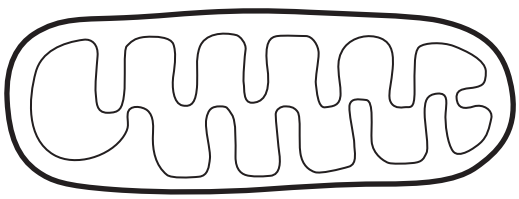
(2 marks)

Question 7 continues on the next page

(d) **Figure 2** shows a section through a cell organelle. Stages **X** and **Y** in **Figure 1** occur inside this organelle.

Figure 2



(i) Name the organelle shown in **Figure 2**.

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(1 mark)

(ii) Label **Figure 2** with the letters **X** and **Y**, as follows:

X to show where **Stage X** occurs,
Y to show where **Stage Y** occurs.

(1 mark)

(e) ATP is better than either glucose or fatty acids as an immediate energy source for cell metabolism. Explain why.

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(2 marks)

15

8 (a) The guinea pig, *Cavia porcellus*, is a small mammal. Complete the table to show the classification of the guinea pig.

Kingdom	
	Chordata
	Mammalia
	Rodentia
Family	Caviidae
Genus	
Species	

(2 marks)

(b) In South America, there are several species of guinea pig. They are thought to have arisen by sympatric speciation.
Explain how sympatric speciation may have occurred.

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(3 marks)

Question 8 continues on the next page

(c) In guinea pigs, hair length and hair colour are controlled by two genes on different chromosomes. The hair may be either long or short and its colour either black or brown.

A male guinea pig and a female guinea pig both had short, black hair. The male was homozygous for hair length, and the female was homozygous for hair colour. Repeated crossings of these two guinea pigs resulted in offspring of four different genotypes, all of which had short, black hair.

Complete the genetic diagram to explain these results. Write in the box the symbols you will use to represent the alleles.

Allele for short hair = ...	Allele for long hair = ...
Allele for black hair = ...	Allele for brown hair = ...

	Male	Female
Parental phenotypes	Short, black hair	Short, black hair
Parental genotypes	……	……
Gamete genotypes	……	……

Offspring genotypes ……

Offspring phenotypes Short, black hair

(4 marks)

(d) In another investigation, the same female guinea pig was twice mated with another male which had long, brown hair. Of the 14 offspring, 10 had short, black hair and 4 had long, black hair. The investigators expected equal numbers of offspring with these two phenotypes. They used a χ^2 test to determine whether the observed results fitted the expected 1:1 ratio.

(i) Give a suitable null hypothesis for the investigation.

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(1 mark)

(ii) Complete **Table 1** to calculate the value of χ^2 for the results.

Table 1

Phenotype	**Observed (O)**	**Expected (E)**	**(O – E)**	**$(O - E)^2$**	**$\frac{(O - E)^2}{E}$**
Short, black hair	10				
Long, black hair	4				
			$\chi^2 = \sum \frac{(O - E)^2}{E} =$		

(2 marks)

(iii) Use **Table 2** to determine whether the null hypothesis is supported by the data. Explain how you arrived at your answer.

Table 2

Degrees of freedom	**Probability value**					
	0.99	**0.95**	**0.10**	**0.05**	**0.01**	**0.001**
1	0.0002	0.0039	2.71	3.84	6.63	10.83
2	0.020	0.103	4.61	5.99	9.21	13.82
3	0.115	0.352	6.25	7.81	11.34	16.27
4	0.297	0.711	7.78	9.49	13.28	18.47

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(3 marks)

9 'Slash and burn' is a system of agriculture used in tropical rainforests. A small area of forest is cleared of trees and cultivated for two or three years. It is then left to recover over many years while other areas are cultivated.

(a) Slash and burn agriculture is **not** suitable for cultivation of large areas of rainforest. Explain why.

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(3 marks)

(b) An alternative to slash and burn is 'alley-cropping'. Alleys up to 6 metres wide are cleared, leaving 'hedges' of natural rainforest species between them. The alleys are permanently cultivated. Many of the trees in the hedges have nitrogen-fixing bacteria in their roots. Plant material cut from the hedges is applied to the soil between the crops in the alleys. Crops can be grown successfully for many years in the alleys.

(i) The presence of trees in the hedges can limit the productivity of crops growing in the alleys. Explain how.

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(3 marks)

(ii) The diversity of animals in the cultivated alleys is lower than that in the hedges. Explain why.

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(3 marks)

(iii) The activities of nitrogen-fixing bacteria, nitrifying bacteria and decomposers help to maintain the fertility of the soil in alley-cropping. Describe how.

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(6 marks)

END OF QUESTIONS

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