

**AQA, OCR, Edexcel**

**A Level**

# **A Level Biology**

**Inheritance, Ecology and  
Succession Questions**

Name:

**M M E**

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Total Marks:

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**Q1.** In cats, males are XY and females are XX. A gene on the X chromosome controls fur colour in cats. The allele **G** codes for ginger fur and the allele **B** codes for black fur. These alleles are codominant. Heterozygous females have ginger and black patches of fur and their phenotype is described as tortoiseshell.

(a) Explain what is meant by **codominant** alleles.

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.....(1)

(b) Male cats with a tortoiseshell phenotype do **not** usually occur. Explain why.

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.....(1)

(c) A tortoiseshell female was crossed with a black male. Use a genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

Use  $X^G$  to indicate the allele **G** on an X chromosome.  
Use  $X^B$  to indicate the allele **B** on an X chromosome.

Genotypes of offspring .....  
Phenotypes of offspring .....  
Ratio of phenotypes .....(3)

(d) Polydactyly in cats is an inherited condition in which cats have extra toes. The allele for polydactyly is dominant.

(i) In a population, 19% of cats had extra toes. Use the Hardy-Weinberg equation to calculate the frequency of the recessive allele for this gene in this population. Show your working.

Answer = .....

(2)

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- (ii) Some cat breeders select for polydactyly. Describe how this would affect the frequencies of the homozygous genotypes for this gene in their breeding populations over time.

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 .....(1)

(Total 8 marks)

- Q2.(a)** In fruit flies, the genes for body colour and wing length are linked. Explain what this means.

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 .....(1)

A scientist investigated linkage between the genes for body colour and wing length. He carried out crosses between fruit flies with grey bodies and long wings and fruit flies with black bodies and short wings.

**Figure 1** shows his crosses and the results.

- **G** represents the dominant allele for grey body and **g** represents the recessive allele for black body.
- **N** represents the dominant allele for long wings and **n** represents the recessive allele for short wings.

**Figure 1**

<i>Phenotype of parents</i>	grey body, long wings	×	black body, short wings
<i>Genotype of parents</i>	<b>GGNN</b>		<b>ggnn</b>
<i>Genotype of offspring</i>			<b>GgNn</b>
<i>Phenotype of offspring</i>	all grey body, long wings		

These offspring were crossed with flies homozygous for black body and short wings.

The scientist's results are shown in **Figure 2**.

Figure 2

**GgNn** crossed with **ggnn**

	Grey body, long wings	Black body, short wings	Grey body, short wings	Black body, long wings
Number of offspring	975	963	186	194

(b) Use your knowledge of gene linkage to explain these results.

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..... (4)

(c) If these genes were **not** linked, what ratio of phenotypes would the scientist have expected to obtain in the offspring?

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.....(1)

(d) Which statistical test could the scientist use to determine whether his observed results were significantly different from the expected results?

Give the reason for your choice of statistical test.

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.....(2)

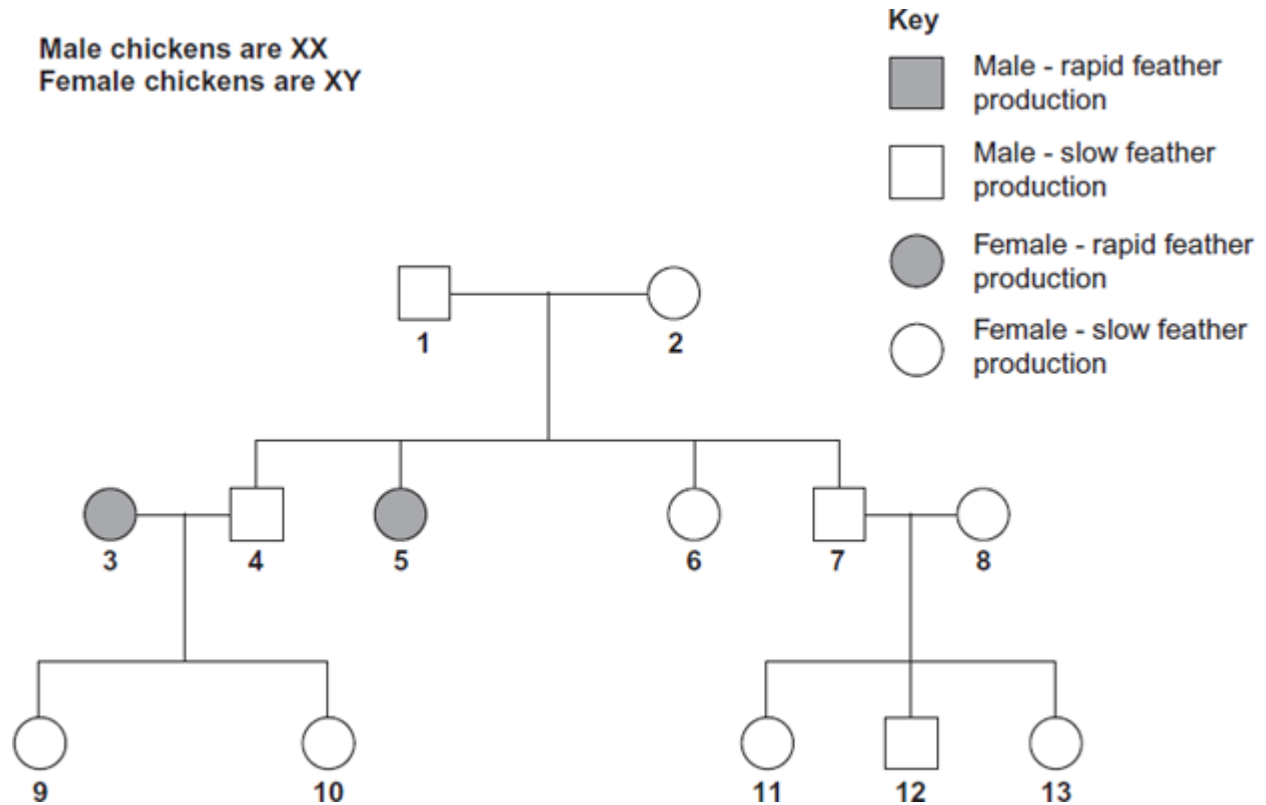
**(Total 8 marks)**

**Q3.**In birds, **males are XX** and **females are XY**.

- (a) Use this information to explain why recessive, sex-linked characteristics are more common in female birds than in male birds.

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 .....(1)

- (b) In chickens, a gene on the X chromosome controls the rate of feather production. The allele for slow feather production, **F**, is dominant to the allele for rapid feather production, **f**. The following figure shows the results produced from crosses carried out by a farmer.



- (i) Explain **one** piece of evidence from the figure which shows that the allele for rapid feather production is recessive.

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 .....(2)

- (ii) Give all the possible genotypes of the following chickens from the figure.

**Chicken 5** .....

**Chicken 7** .....(2)

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- (iii) A cross between two chickens produced four offspring. Two of these were males with rapid feather production and two were females with slow feather production. Give the genotypes of the parents.

.....(1)

- (c) Feather colour in one species of chicken is controlled by a pair of codominant alleles which are **not** sex-linked. The allele **C<sup>b</sup>** codes for black feathers and the allele **C<sup>w</sup>** codes for white feathers. Heterozygous chickens are blue-feathered.

On a farm, 4% of the chickens were black-feathered. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be blue-feathered. Show your working.

Answer ..... %

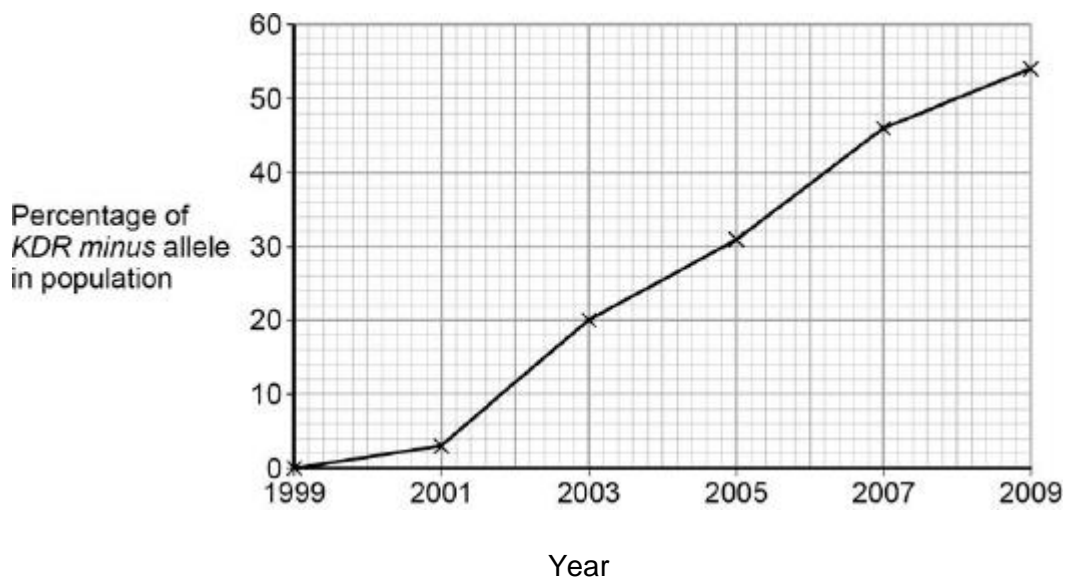
(3)  
(Total 9 marks)

**Q4.** Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria.

Mosquitoes have a gene called *KDR*. Today, some mosquitoes have an allele of this gene, *KDR minus*, that gives them resistance to DDT. The other allele, *KDR plus*, does not give resistance.

Scientists investigated the frequency of the *KDR minus* allele in a population of mosquitoes in an African country over a period of 10 years.

The figure below shows the scientists' results.



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- (a) Use the Hardy–Weinberg equation to calculate the frequency of mosquitoes heterozygous for the *KDR* gene in this population in 2003.

Show your working.

Frequency of heterozygotes in population in 2003 .....

(2)

- (b) Suggest an explanation for the results in the figure above.

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(4)

The *KDR plus* allele codes for the sodium ion channels found in neurones.

- (c) When DDT binds to a sodium ion channel, the channel remains open all the time. Use this information to suggest how DDT kills insects.

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.....(2)

- (d) Suggest how the *KDR minus* allele gives resistance to DDT.

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(2)  
(Total 10 marks)

**Q5.**Schizophrenia is a mental illness. Doctors investigated the relative effects of genetic and environmental factors on the development of schizophrenia. They used sets of identical twins and non-identical twins in their investigation. At least one twin in each set had developed schizophrenia.

- Identical twins are genetically identical.
- Non-identical twins are not genetically identical.
- The members of each twin pair were raised together.

The table shows the percentage of cases where both twins had developed schizophrenia.

Type of twin	Percentage of cases where both twins had developed schizophrenia
Identical	50
Non-identical	15

(i) Explain why both types of twin were used in this investigation.

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.....(2)

(ii) What do these data suggest about the relative effects of genetic and environmental factors on the development of schizophrenia?

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.....(1)

(iii) Suggest **two** factors that the scientists should have taken into account when selecting the twins to be used in this study.

1.....  
2.....

(2)  
(Total 5 marks)



**Q6.** Malaria is a disease that destroys red blood cells. Scientists investigated whether certain red blood cell phenotypes were associated with developing severe or mild malaria. They compared the red blood cell phenotypes of hospital patients suffering from severe malaria with the red blood cell phenotypes of patients suffering from mild malaria. The results are shown in the table.

Red blood cell phenotype	Ratio of patients with severe malaria : patients with mild malaria
Sickle cell trait	0.48 : 1
Blood group A	2.45 : 1
Blood group O	0.96 : 1

(a) Explain the advantage of presenting the results as a ratio.

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.....(2)

(b) What do these data show about the effect of red blood cell phenotypes on the chance of developing severe malaria rather than mild malaria?

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..... (2)

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- (c) The allele for normal haemoglobin in red blood cells is **Hb<sup>A</sup>**. In some parts of Africa where malaria occurs there is a high frequency in the population of the allele **Hb<sup>C</sup>**. Individuals possessing the **Hb<sup>C</sup>** allele have a lower chance of developing severe malaria. Severe malaria causes a large number of deaths in Africa.

Explain the high frequency of the **Hb<sup>C</sup>** allele in areas where malaria occurs.

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(3) (Total 7 marks)

- Q7.** Warfarin is a substance which inhibits blood clotting. Rats which eat warfarin are killed due to internal bleeding. Some rats are resistant to warfarin as they have the allele **W<sup>R</sup>**.

Rats have three possible genotypes:

- W<sup>R</sup>W<sup>R</sup>** resistant to warfarin
- W<sup>R</sup>W<sup>S</sup>** resistant to warfarin
- W<sup>S</sup>W<sup>S</sup>** susceptible (not resistant) to warfarin.

In addition, rats with the genotype **W<sup>R</sup>W<sup>R</sup>** require very large amounts of vitamin K in their diets. If they do not receive this they will die within a few days due to internal bleeding.

- (a) How can resistance suddenly appear in an isolated population of rats which has never before been exposed to warfarin?

.....  
.....(1)

- (b) A population of 240 rats was reared in a laboratory. They were all fed on a diet containing an adequate amount of vitamin K. In this population, 8 rats had the genotype **W<sup>S</sup>W<sup>S</sup>**, 176 had the genotype **W<sup>R</sup>W<sup>S</sup>** and 56 had the genotype **W<sup>R</sup>W<sup>R</sup>**.

- (i) Use these figures to calculate the actual frequency of the allele **W<sup>R</sup>** in this population. Show your working.

Answer .....

(2)

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- (ii) The diet of the rats was then changed to include only a small amount of vitamin K. The rats were also given warfarin. How many rats out of the population of 240 would be likely to die within a few days?

.....(1)

- (c) In a population of wild rats, 51% were resistant to warfarin.

- (i) Use the Hardy-Weinberg equation to estimate the percentage of rats in this population which would be heterozygous for warfarin resistance. Show your working.

Answer ..... %

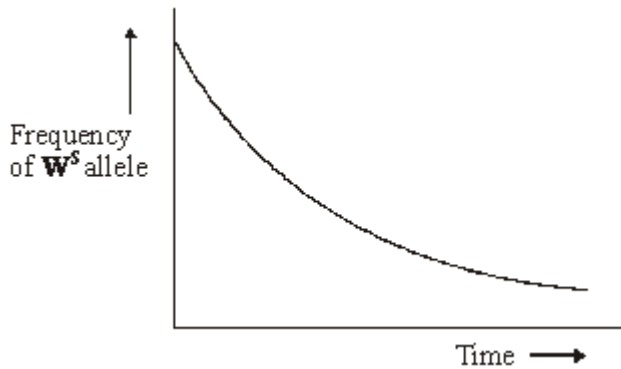
**(3)**

- (ii) If all the susceptible rats in this population were killed by warfarin, more susceptible rats would appear in the next generation. Use a genetic diagram to explain how.

**(2)**

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- (iii) The graph shows the change in the frequency of the  $W^s$  allele in an area in which warfarin was regularly used. Describe and explain the shape of the curve.



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.....(4)

- (iv) Give **two** assumptions that must be made when using the Hardy-Weinberg equation.

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2 .....  
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(2)  
(Total 15 marks)

**Q8.** Lake Malawi in East Africa contains around 400 different species of cichlids which are small, brightly coloured fish. All these species have evolved from a common ancestor.

- (a) Describe **one** way in which scientists could find out whether cichlids from two different populations belong to the same species.

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(2)

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- (b) During the last 700 000 years there have been long periods when the water level was much lower and Lake Malawi split up into many smaller lakes. Explain how speciation of the cichlids may have occurred following the formation of separate, smaller lakes.

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(4)

- (c) Many species of cichlids are similar in size and, apart from their colour, in appearance. Suggest how the variety of colour patterns displayed by these cichlids may help to maintain the fish as separate species.

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(2)

(Total 8 marks)

**Q9.** The production of pigment in rabbit fur is controlled by two genes.

One gene controls whether any pigment is made. This gene has three alleles. Allele **A** codes for the production of one form of the enzyme tyrosinase, which converts tyrosine into a black pigment. Allele **A<sup>n</sup>** codes for the production of a second form of the enzyme, which becomes inactive at temperatures close to a rabbit's core body temperature, so only the face, ears, legs and tail are pigmented. A third allele, **a**, fails to code for a functional tyrosinase.

The other gene controls the density of pigment in the fur. This gene has two alleles. Allele **B** is dominant and results in the production of large amounts of pigment, making the fur black.

Allele **b** results in less pigment, so the fur appears brown.

- (a) How do multiple alleles of a gene arise?

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(2)

(b) The table shows some genotypes and phenotypes.

Genotype	Phenotype
<b>A-B-</b>	all fur black
<b>aaB-</b>	all fur white (albino)
<b>a<sup>h</sup>abb</b>	white body fur with brown face, ears, legs and tail (Himalayan)

(i) What do the dashes represent in the genotype of the black rabbit?

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(1)

(ii) Give all the possible genotypes for a Himalayan rabbit with black face, ears, legs and tail.

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(2)

(iii) Suggest an explanation for the pigment being present only in the tail, ears, face and legs of a Himalayan rabbit.

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(2)

(c) Using the information given, explain why the phenotypes of rabbits with **AABB** and **Aa<sup>h</sup>BB** genotypes are the same.

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(2)

(Total 9 marks)



- S** (c) James Bay is a large ocean bay in northern Canada. It was formed by the melting of glaciers. One species of lemming inhabits the eastern side of James Bay and another species of lemming inhabits the western side. Before the glaciers melted there was only one species of lemming present. Explain how two species of lemming evolved from the original species.

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(4)  
(Total 12 marks)

- Q11.**(a) Explain what is meant by the term phenotype.

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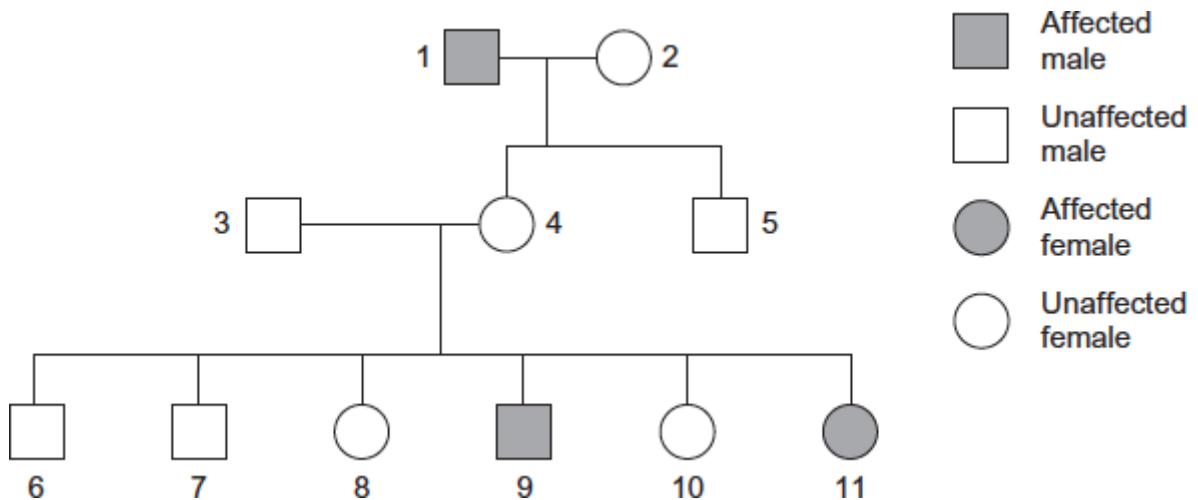
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(2)

- (b) Tay-Sachs disease is a human inherited disorder. Sufferers of this disease often die during childhood. The allele for Tay-Sachs disease **t**, is recessive to allele **T**, present in unaffected individuals. The diagram shows the inheritance of Tay-Sachs in one family.





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- (i) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is recessive.

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.....(2)

- (ii) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is **not** on the X chromosome.

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.....(2)

- (c) (i) In a human population, one in every 1000 children born had Tay-Sachs disease. Use the Hardy-Weinberg equation to calculate the percentage of this population you would expect to be heterozygous for this gene. Show your working.

Answer = ..... % (3)

- (ii) The actual percentage of heterozygotes is likely to be lower in future generations than the answer to part (c)(i). Explain why.

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(1)  
(Total 10 marks)

**Q12.** Ecologists used a method called proportional sampling to estimate the population size of an animal species. This method is based on assumptions. Two of the assumptions are given below.

1. They know the size of the area, **A**, where the animal population lives.
2. The animals are uniformly distributed in this area.

To carry out the method, the ecologists:

- chose a region of known size, **R**, inside area **A**
- counted the number of animals in region **R**. They called this number **S**
- assumed that the number, **S**, would be in proportion to the size of the total population, **P**, in area **A**.

(a) Proportional sampling can be used to estimate the population size of a species that is uniformly distributed.

(i) What is a **species**?

.....  
.....  
.....(1)

(ii) What is meant by **uniformly distributed**?

.....  
.....  
.....(1)

(b) Use the letters **A**, **R** and **S** to write an equation showing how proportional sampling is used to estimate the total size of a population, **P**. Show your working.

**P** = ..... (2)

(c) Population size can be estimated using proportional sampling or mark-release-recapture.

(i) How do the assumptions made in proportional sampling differ from those made in mark-release-recapture?

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(2)

- (ii) Give **one** assumption about the animals caught that is made in both methods.

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 .....(1)

**(Total 7 marks)**

**Q13.** The Solomon Islands are situated in the Pacific Ocean. The nearest large land mass is Australia, which is about 1500 km away. The biggest islands are mountainous, with large areas of tropical forest and a wide range of habitats. Some islands have a very high species diversity, and many species are endemic, that is they occur only in the Solomon Islands.

The table shows the total number of species on the islands in four vertebrate classes and the percentage which are endemic.

Vertebrate class	Total number of species	Endemic species / %
Mammals	53	36
Birds	223	20
Reptiles	61	16
Amphibians	17	53

- (a) How many reptile species are endemic?

.....(1)

- S** (b) Suggest an explanation for the high proportion of endemic species on the Solomon Islands.

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 .....(3)

**(Total 4 marks)**

**Q14.** A student investigated whether the abundance of the orange star lichen on the walls of a building was influenced by the direction the wall faced. The student recorded the number of colonies within a 50 cm<sup>2</sup> quadrat, placed one metre above the ground on each of three walls. A  $\chi^2$  test was applied to the results.

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- (a) Give a null hypothesis for this investigation.

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.....

(1)

- (b) Complete the following table.

	Number of colonies on a wall facing		
	North	South	West
Observed	21	33	54
Expected			

(1)

- (c) How many degrees of freedom were in this  $\chi^2$  test?

.....

(1)

- (d) A  $\chi^2$  value of 15.5 was calculated from these results. This  $\chi^2$  value has a probability of less than 0.001. Explain what this means when applied to this investigation.

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(3)

- (e) Algae are green protocists. Lichens consist of a fungus and an alga living together in a relationship where both organisms benefit. Suggest how the relationship between the alga and the fungus allows the lichen to survive on an inorganic surface such as a wall.

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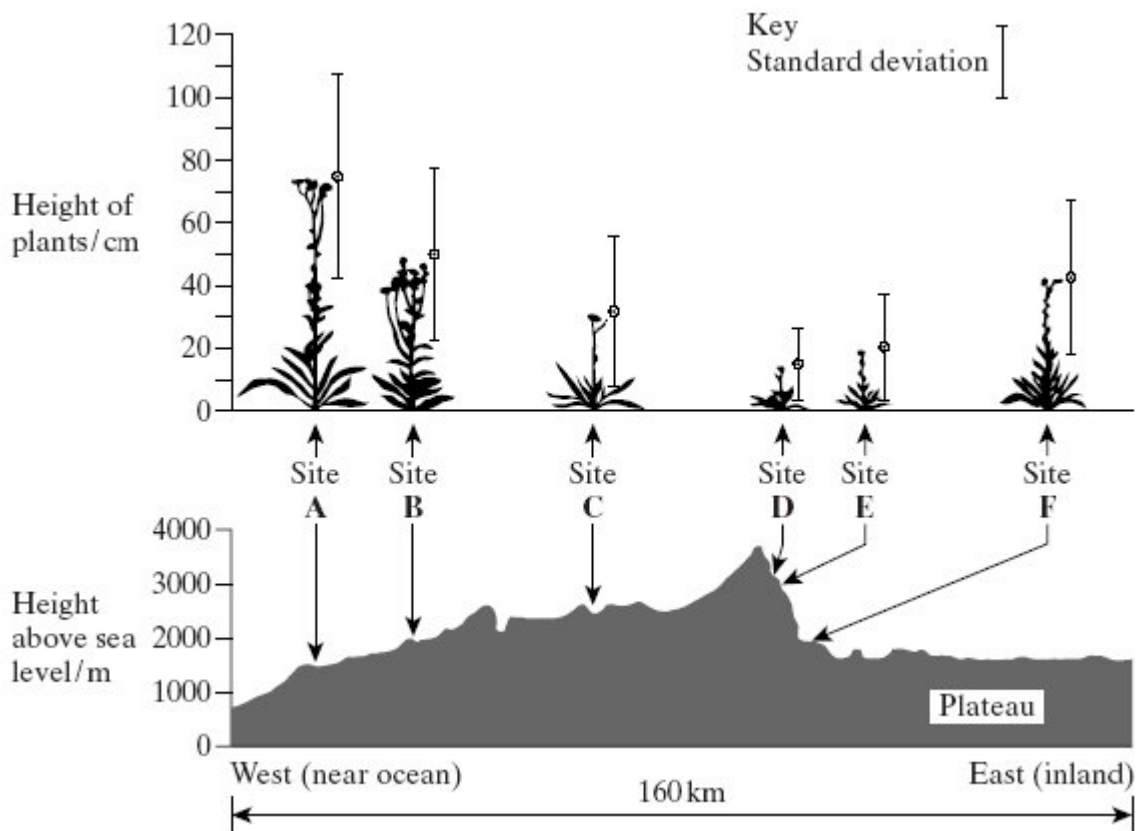
(2)

(Total 8 marks)

**Q15.** Climatic factors, such as temperature and rainfall, vary greatly over short distances across mountain ranges. In an investigation, populations of the plant, *Achillea lanulosa*, were sampled from several sites on a transect across a mountain range. At each sampling site, seeds were collected at random. Each batch of seeds was germinated and grown to maturity under the same experimental conditions.

The diagram shows

- a profile indicating the position and altitude of the sampling sites
- the mean height of mature plants grown from each sample of seeds
- the standard deviation of heights of the mature plants grown from each sample of seeds.



(a) (i) Give **one** limitation of using a line transect to collect these data.

.....  
 .....(1)

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- (ii) Suggest how plants should be chosen at each sampling site to avoid bias and to be representative.

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.....(2)

- (b) (i) What information does the bar representing standard deviation give about the plants in a sample?

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.....(1)

- (ii) Describe what the results show about the variation of the height of the plants in relation to altitude.

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(2)

- S** (iii) There was a significant difference between the mean heights of the plants grown from seeds taken from sites **A** and **D**. Describe the evidence from the information given which shows that this is likely to be due to genetic differences between the two populations.

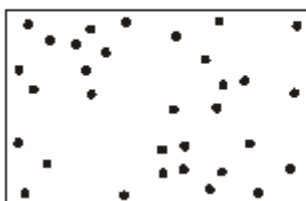
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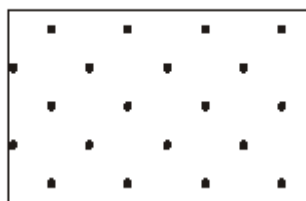
(Total 7 marks)

**Q16.** The diagrams show three types of plant distribution.

**Random**



**Uniform**



**Clustered**



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- (a) Describe how you would use quadrats to determine whether a particular plant species has a clustered or a random distribution.

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(3)

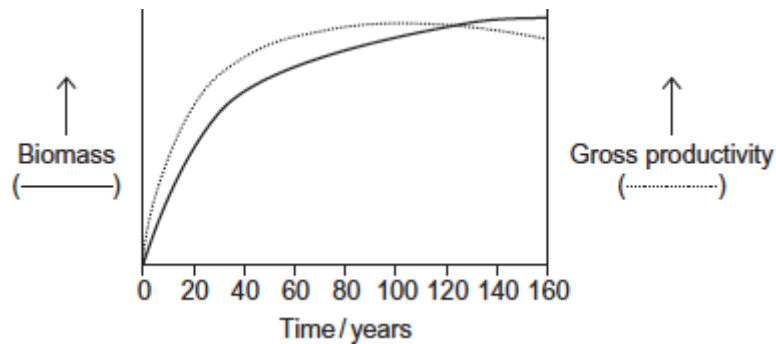
- (b) Some plants in a dry, hot desert have a uniform distribution and are widely spaced. Suggest how this type of distribution is an advantage to the plants.

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(2)

(Total 5 marks)

**Q17.** The graph shows how gross productivity and biomass in an area changed with time in the succession from bare soil to mature woodland.



- (a) (i) Suggest appropriate units for gross productivity.

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(1)

- (ii) Explain the decrease in gross productivity as the woodland matures.

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(2)

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- (b) Use your knowledge of succession to explain the increase in biomass during the first 20 years.

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..... (3)

- (c) Use the information in the graph and your knowledge of net productivity to explain why biomass shows little increase after 100 years.

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..... (2)

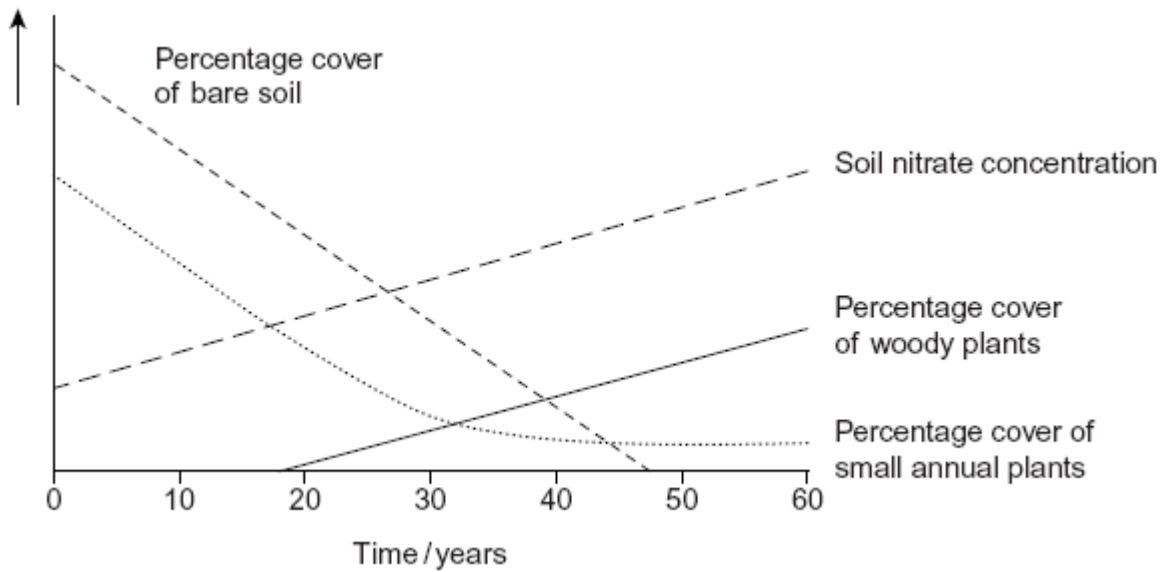
- (d) Suggest **one** reason for conserving woodlands.

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..... (1)

**(Total 9 marks)**



**Q18.** Ecologists investigated succession in some abandoned crop fields. The data that they collected are shown in the graph. The curves show the trends that occurred over a period of 60 years.



(a) Explain the change in soil nitrate concentration shown on the graph.

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 .....(2)

(b) The pioneer plants had different characteristics from the plants that colonised the fields after 50 years.

(i) The pioneer plants had seeds that germinate better when the temperature fluctuates.

Explain the advantage of this to these pioneer plants.

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(2)

(ii) Explain the advantage to a plant that colonises after 50 years of having a high rate of photosynthesis at low light intensities.

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 .....(1)

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- (c) Conservation of grassland habitats involves management of succession. Use the data in the graph to explain why.

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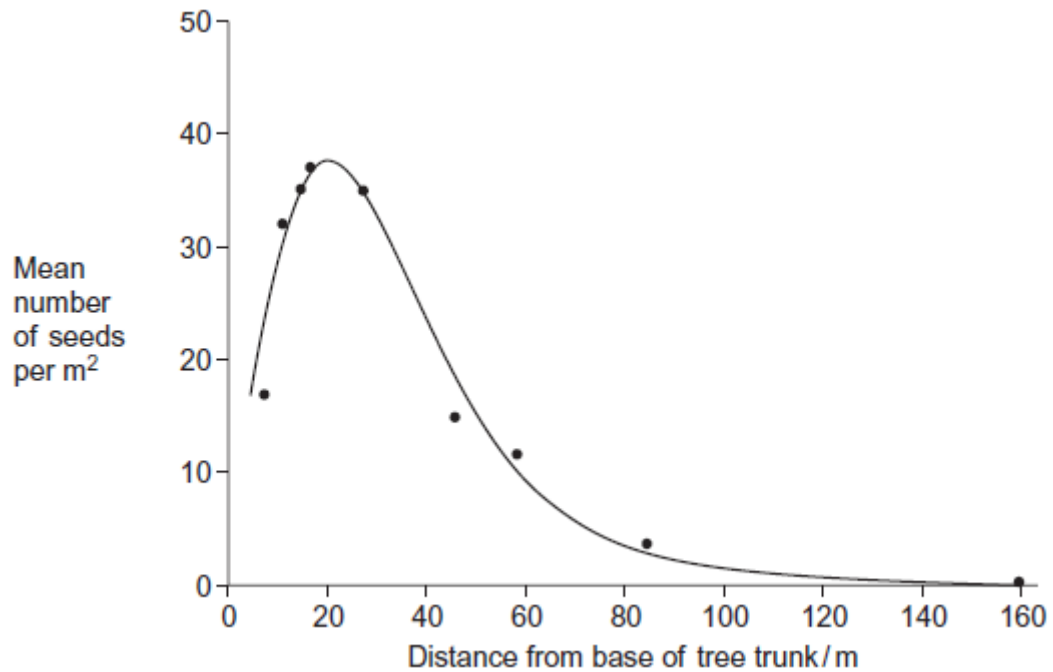
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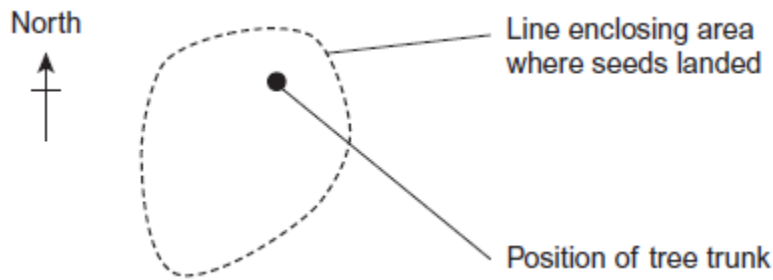
(2)  
(Total 7 marks)

**Q19.** A 75 m tall tree released very large numbers of small seeds. Ecologists used quadrats along a transect to measure the number of these seeds at different distances from the tree. Their results are shown on the graph.



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The seeds of this tree are dispersed by wind. The diagram shows the pattern of seed dispersal from this tree.



- (a) Describe how the ecologists could have used quadrats and a transect to obtain the data from which the graph was drawn.

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.....(2)

- (b) Look at the diagram showing the pattern of seed dispersal from this tree.

- (i) Suggest an explanation for the shape of the line enclosing the area where the seeds landed.

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.....(2)

- (ii) The line enclosing the area where the seeds landed would be different for trees of this species that were of a different height. Suggest why.

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(c) In an ecological succession, trees that are pioneer species often have smaller seeds than those that are part of a climax community.

(i) The species of tree in this investigation is adapted to colonising areas that have been cleared of vegetation. Use information given above to explain how.

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.....(2)

(ii) The seeds produced by this species of tree did **not** grow successfully in a climax community. Suggest why.

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.....(2)

**(Total 10 marks)**

**Q20.** (a) Explain what is meant by the ecological term community

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.....(1)

(b) Scientists investigated the distribution of three species of fish in a lake. They recorded the range of depths where each species was found. The table shows their results.

Species of fish	Range of depths /m
White bass	0 to 8.4
Walleye	6.8 to 10.0
Sauger	7.2 to 14.6

(i) Use information from the table to give the range of depths at which all three species of fish may be found living together.

Answer ..... m

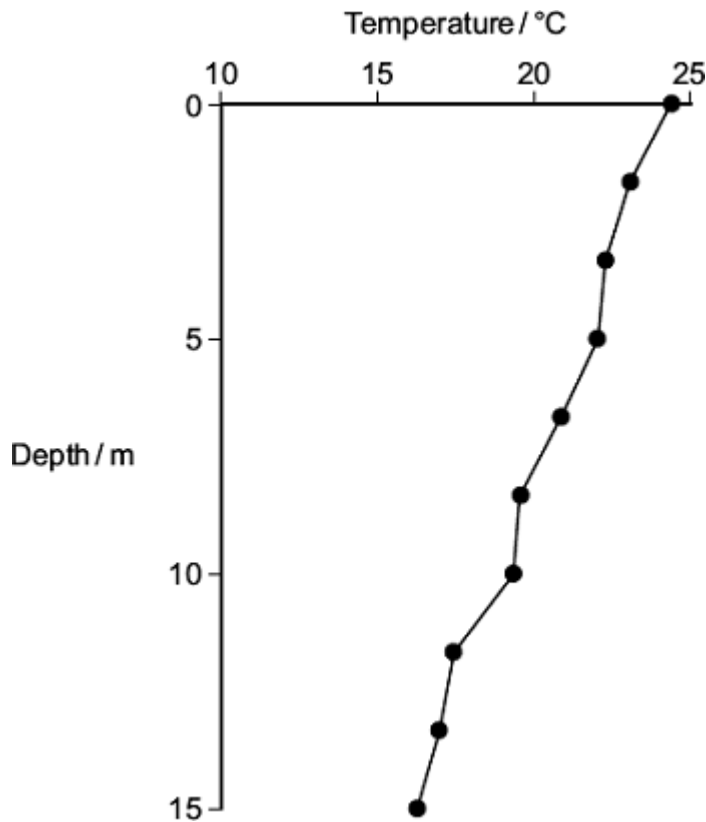
**(1)**

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- (ii) Suggest and explain **one** advantage to the fish of occupying different depths in the lake.

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- (c) The graph shows the relationship between the depth and the temperature of the water in the lake.



A student concluded that the temperature of the water in the lake determined the depth at which the species of fish were found. Use the table and the graph to evaluate this conclusion.

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(Total 7 marks)

**Q21.** Hydrilla (*Hydrilla verticillata*) is an aquatic plant which has become a major pest of waterways in parts of the USA. Hydrilla is not a native species of the USA. It was introduced into natural habitats from aquariums. In many freshwater habitats it has rapidly become the dominant plant species.

- (a) In many freshwater habitats Hydrilla has rapidly become the dominant plant species. Suggest **two** reasons why.

1.....  
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- (b) The spread of Hydrilla has had economic consequences for commercial activities and for the government's environmental agency. Suggest **two** economic consequences of the spread of Hydrilla.

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(2)

- (c) Scientists investigated the effect of the chemical fluridone as a method of controlling Hydrilla. The study was carried out using samples of Hydrilla grown under controlled laboratory conditions. Several samples of the plant were grown at different concentrations of fluridone. The results are shown in the following table.

	Days of treatment			
	0	20	40	60
Concentration of fluridone / $\mu\text{g dm}^{-3}$	Mean biomass of Hydrilla / g			
0.0	5.0	16.4	20.4	33.4
0.5	5.0	14.1	18.2	31.3
1.0	5.0	9.7	8.9	7.4
5.0	5.0	4.6	2.8	1.3
25.0	5.0	3.2	1.6	0.4

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- (i) The scientists obtained the biomass of each sample by heating it at 75 °C for 2 hours.  
They then weighed the sample, reheated it for 15 minutes and weighed it again.  
They continued this cycle of reheating and weighing until they found the sample had a constant mass.

Explain how this method helped to provide a reliable measurement of the biomass.

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(2)

- (ii) A scientist reviewed the results of this investigation. He suggested that fluridone should be used in the habitat at a concentration of 5.0  $\mu\text{g dm}^{-3}$  rather than at the other concentrations tested. Use the information provided and your knowledge of chemical control to explain why he made this suggestion.

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(4)

- (d) Scientists have also investigated the use of an integrated system to control Hydrilla. This involved using fluridone and a fungus as a biological control agent. They set up four different experiments.

- Experiment 1 – Hydrilla left untreated
- Experiment 2 – Hydrilla treated with the fungus
- Experiment 3 – Hydrilla treated with fluridone
- Experiment 4 – Hydrilla treated with both fluridone and the fungus.

The scientists determined the biomass of Hydrilla at the end of each experiment.

- (i) Experiment 1 acted as a control. Explain why the scientists carried out experiment 1.

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(1)

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- (ii) The scientists isolated the fungus from the tissue of Hydrilla growing in its country of origin. Suggest **two** possible advantages of using this fungus as the biological control agent.

1.....

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2.....

.....(2)

- (iii) The treatment in experiment **4** was the most effective. Use your knowledge of integrated pest control systems to suggest why the treatment in experiment **4** was the most effective.

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(2)  
(Total 15 marks)