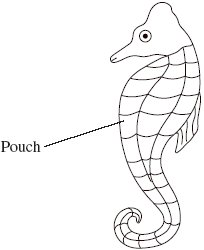
**Q1.**          The diagram shows a seahorse. A seahorse is a fish. Mating in seahorses begins with courtship behaviour. After this, the female transfers her unfertilised eggs to the male’s pouch. Most male fish fertilise eggs that have been released into the sea. However, a male seahorse fertilises the eggs while they are inside his pouch. The fertilised eggs stay in the pouch where they develop into young seahorses.



(a)     Give **two** ways in which courtship behaviour increases the probability of successful mating.

1 ...................................................................................................................

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2 ...................................................................................................................

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**(2)**

(b)     Give **one** way in which reproduction in seahorses increases the probability of

(i)      fertilisation

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**(1)**

(ii)     survival of young seahorses.

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**(1)**

  Scientists investigated the effect of total body length on the selection of a mate in one Australian species of seahorse. The scientists used head length as a measure of total body length.

(c)     (i)      Use the diagram to suggest why the scientists measured head length rather than total body length.

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**(1)**

(ii)     Suggest why the scientists were able to use head length as a measure of total body length.

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**(1)**

The scientists measured the head lengths of the female and male of a number of pairs.  
The results are shown in the graph.



(d)     The scientists concluded that total body length affects the selection of a mate.  
Explain how the results support this conclusion.

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**(1)**

(e)     A female with a head length of 50 mm selected a mate. Explain how you could use the graph to predict the total head length of the mate selected.

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**(2)**

(f)      Scientists studied two species of North American seahorse. They thought that these two species are closely related. Describe how comparisons of biological molecules in these two species could be used to find out if they are closely related.

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**(6)**

**(Total 15 marks)**

**Q2.**          Detritivorous insects feed on the dead remains of plants. Some students estimated the numbers of detritivorous insects at two different sites in an ecosystem. They also obtained data about the net primary production of the sites to see if this influenced the numbers of insects present. Net primary production is a measure of plant biomass formed per year. The results are shown in the table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Site** | **Number of insects per m2** | **Net primary production / g m–2 y–1** |
|  | **A** | 316 | 1440 |
|  | **B** | 90 | 550 |

(a)     Explain how the students could use the mark-release-recapture technique to estimate the numbers of insects.

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**(4)**

(b)     The students used the chi-squared (χ2) test to test the hypothesis that there was no significant difference between the numbers of insects per square metre at sites **A** and **B**. The value they obtained was 125.8. They checked this value in χ2 tables.

(i)      How many degrees of freedom should they check against?

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**(1)**

(ii)     What level of probability is normally used to judge whether a difference is statistically significant?

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**(1)**

(iii)     The value of χ2 for the 0.001 level of probability for this number of degrees of freedom is 10.8. What does the value obtained by the students suggest about the difference in numbers of the insects per square metre between the two sites?

Explain your answer.

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**(2)**

(c)     (i)      Explain why the net primary production of an area does not represent the total amount of plant biomass formed per year by photosynthesis.

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**(2)**

(ii)     Suggest how the difference in net primary production of sites **A** and **B** might explain the difference in the number of insects between the sites.

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**(1)**

**(Total 11 marks)**

**Q3.**             A medical officer investigated the effectiveness of five different types of influenza vaccine. A total of 1350 people agreed to be vaccinated. The medical officer divided these into five groups. The number who suffered from influenza in the following year was recorded. The results are shown in the table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Number of people vaccinated** | | | |
| **Type of influenza vaccine** | **Suffered from influenza** | **Did not suffer from influenza** | **Total** | **Proportion suffering from influenza** |
| I | 43 | 237 | 280 | 0.15 |
| II | 52 | 198 | 250 | 0.21 |
| III | 25 | 245 | 270 | 0.09 |
| IV |  |  | 260 | 0.18 |
| V | 57 | 233 | 290 | 0.20 |

(a)     Complete the spaces in the table for the people vaccinated with type IV vaccine.

**(1)**

(b)     The medical officer used a statistical test to assess the effectiveness of the five different vaccines.

(i)      What would be the null hypothesis?

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**(1)**

(ii)     The statistical test gave a probability of less than 0.05. What conclusion can be drawn from this?

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**(1)**

(c)     It was suggested that the raw data showed that the type III vaccine was the most effective. Give **two** reasons why this conclusion may not be reliable.

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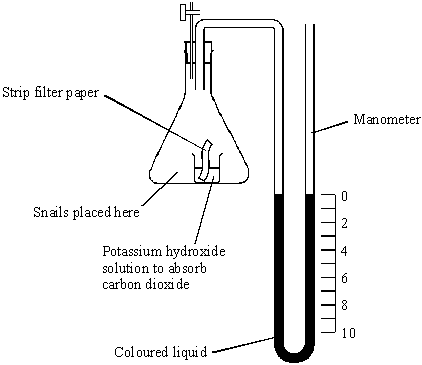
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**(2)**

**(Total 5 marks)**

**Q4.**          **S**       The diagram shows apparatus used to measure the oxygen uptake of snails that live on the seashore. The apparatus was kept at a constant temperature.



(a)     (i)      Explain the purpose of the strip of filter paper in the potassium hydroxide solution.

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**(1)**

(ii)     The level of liquid in the right-hand side of the manometer went down during the experiment. Explain why.

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**(2)**

(iii)     What measurements are needed to calculate the rate of oxygen uptake by the snails in mm3 g–1 h–1?

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**(3)**

(b)     Two experiments were carried out using the apparatus shown in the diagram.

1     The oxygen uptake of batches of 10 seashore snails kept in moist air was measured at temperatures between 5 °C and 35 °C.

2     Experiment 1 was repeated but with batches of 10 seashore snails covered by aerated seawater.

The experiments were repeated several times and means and standard deviations calculated. The results are shown in the table. The values given are means plus or minus one standard deviation.

|  |  |  |
| --- | --- | --- |
| **Temperature / °C** | **Oxygen uptake of snails kept in moist air / mm3 g–1 h–1** | **Oxygen uptake of snails kept in seawater / mm3 g–1 h–1** |
| 5 | 35 ± 2 | 28 ± 8 |
| 10 | 34 ± 6 | 32 ± 3 |
| 15 | 36 ± 3 | 35 ± 3 |
| 20 | 86 ± 8 | 52 ± 10 |
| 25 | 141 ± 13 | 96 ± 15 |
| 30 | 132 ± 14 | 108 ± 9 |
| 35 | 120 ± 16 | 79 ± 21 |

(i)      Describe **one** similarity and **one** difference between the pattern of mean oxygen uptake of the snails kept in moist air and those covered by seawater.

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**(2)**

(ii)     Explain why valid conclusions cannot be drawn about the trends in oxygen uptake at temperatures of 25 °C and above.

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**(2)**

**(Total 10 marks)**

**Q5.**The inheritance of body colour in fruit flies was investigated. Two fruit flies with grey bodies were crossed. Of the offspring, 152 had grey bodies and 48 had black bodies.

(a)     Using suitable symbols, give the genotypes of the parents. Explain your answer.

Genotypes .....................................................................................................

Explanation ....................................................................................................

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**(2)**

(b)     Explain why a statistical test should be applied to the data obtained in this investigation.

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**(2)**

(c)     A species of insect, only found on a remote island, has a characteristic controlled by a pair of codominant alleles, **CM** and **CN**.

(i)      What is meant by *codominant*?

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**(1)**

(ii)     There were 500 insects in the total population. In this population, 300 insects had the genotype **CM CM**, 150 had the genotype **CM CN** and 50 had the genotype **CN CN**. Calculate the actual frequency of the allele **CN** by using these figures. Show your working.

Answer ........................................

**(2)**

(iii)    Use your answer to (ii) and the Hardy-Weinberg equation to calculate the number of insects that would be **expected** to have the genotype **CN CN**.

Answer ........................................

**(3)**

**(Total 10 marks)**

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**Q6.**         Some students investigated the effect of light intensity in the environment on the size of leaves of nettles. They measured leaves on sixty plants in each of two sites. The results are summarised in the table.

|  |  |  |
| --- | --- | --- |
| **Dimensions of leaves / mm** | **Site with high light intensity** | **Site with low light intensity** |
| Length of longest leaf | 113 | 116 |
| Length of shortest leaf | 41 | 42 |
| Mean length | 86 | 92 |
| Mean maximum width | 68 | 74 |

|  |  |  |
| --- | --- | --- |
| Standard deviation of lengths | 11 | 16 |
| Standard deviation of maximum widths | 7 | 11 |

(a)     Each leaf to be measured was selected in the following way.

•        The top left hand corner of a quadrat frame was placed at coordinates given by a random number table; the nettle plant nearest the centre of the quadrat was selected,

•        The sixth leaf from the tip of the plant was selected.

Explain the importance of

(i)      the method of selecting the nettle plant;

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**(2)**

(ii)     measuring the sixth leaf.

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**(2)**

(b)      Use the data about the length of leaves in the two sites to explain why standard deviation is more useful than range as a measure of variation within a population.

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**(4)**

(c)     The area of a nettle leaf can be estimated using the formula

area   =   length × maximum width × 0.5

Calculate the ratio of the mean area of the leaves from the site with low intensity to the mean area of the leaves from the site with high light intensity. Show your working.

Answer .....................................

**(2)**

**(Total 10 marks)**

**Q7.**          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 cm2 quadrat, placed one metre above the ground on each of three walls.  
A 2 test was applied to the results.

(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 2 test?

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**(1)**

(d)     A 2 value of 15.5 was calculated from these results. This 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 protoctists. 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)**

**Q8.**(a)     Meiosis results in cells that have the haploid number of chromosomes and show genetic variation. Explain how.

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**(6)**

(b)     In mice, two genes affecting coat colour are on different chromosomes.  
One gene controls whether there is any black pigment in the hairs. The dominant allele of this gene, **B**, results in black fur. The recessive allele, **b**, results in white fur. The second gene controls banding of the fur. The dominant allele, **A**, causes a yellow band to develop on each hair. The resulting coat colour is called agouti. The recessive allele, **a**, results in hairs with no bands on them. This gene has no effect on mice with white fur; white mice do not develop bands, even if they have the **A** allele.

Breeders performed many crosses in which agouti mice were crossed with white mice, homozygous for both genes. They expected agouti, black and white mice in the offspring in a 1 : 1 : 2 ratio.

(i)      Complete the genetic diagram to show how this ratio of phenotypes would be produced.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Parental phenotypes | Agouti | White |

Parental genotypes

Gamete genotypes

Offspring genotypes

Offspring phenotypes

**(4)**

(ii)     The actual numbers of offspring with each phenotype were

|  |  |  |
| --- | --- | --- |
|  | Agouti | 34 |
|  | Black | 35 |
|  | White | 51 |

The *x*2 test can be used to test the hypothesis that there is no significant difference between these results and the expected 1 : 1 : 2 ratio. Complete the table to calculate the value of *x*2 for these results.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Colour of offspring** | **Observed (O)** | **Expected (E)** | **(O - E)** | **(O - E)2** |  |
|  | Agouti | 34 |  |  |  |  |
|  | Black | 35 |  |  |  |  |
|  | White | 51 |  |  |  |  |
|  |  | | | Σ= | | |

**(2)**

(iii)    The table shows values for *x*2 at different levels of probability and for different degrees of freedom.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Degrees of freedom** | **Probability, p** | | | | |
|  | **0.2** | **0.1** | **0.05** | **0.02** | **0.01** |
|  | 1 | 1.64 | 2.71 | 3.84 | 5.41 | 6.64 |
|  | 2 | 3.22 | 4.61 | 5.99 | 7.82 | 9.21 |
|  | 3 | 4.64 | 6.25 | 7.82 | 9.84 | 11.35 |
|  | 4 | 5.99 | 7.78 | 9.49 | 11.67 | 13.28 |
|  | 5 | 7.29 | 9.24 | 11.07 | 13.39 | 15.09 |

What should the breeders conclude about the significance of their results?  
Explain your answer.

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**(3)**

**(Total 15 marks)**

**Q9.**Species richness and an index of diversity can be used to measure biodiversity within a community.

(a)     What is the difference between these two measures of biodiversity?

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**(1)**

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

•        The canopy traps were set among the leaves of the trees 16–27 m above ground level.

•        The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. The table below summarises their results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Species of butterfly** | **Mean number of butterflies** | | **P value** |
|  | **In canopy** | **In understorey** |
|  | *Prepona laertes* | 15 | 0 | < 0.001 |
|  | *Archaeoprepona demophon* | 14 | 37 | < 0.001 |
|  | *Zaretis itys* | 25 | 11 | > 0.05 |
|  | *Memphis arachne* | 89 | 23 | < 0.001 |
|  | *Memphis offa* | 21 | 3 | < 0.001 |
|  | *Memphis xenocles* | 32 | 8 | < 0.001 |

(b)     The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

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**(1)**

(c)     By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

*d* = 

where *N* is the total number of organisms of all species and *n* is the total number of organisms of each species.

Answer = ...................................

**(3)**

(d)     The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in the table.

Explain what the results of these statistical tests show.

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**(3)**

**(Total 8 marks)**

**Q10.**The ‘placebo effect’ describes the improvement in patients’ symptoms due to psychological effects. Scientists investigated the placebo effect in patients with asthma. They divided a large number of asthma patients into three groups, **1**, **2** and **3**.

•        Group 1 inhaled a spray containing albuterol every day. Albuterol is a drug used to treat asthma.

•        Group 2 inhaled a placebo spray every day. This was identical to the spray given to  
group 1 but it did not contain albuterol.

•        Group 3 did not receive any spray treatment.

(a)     Describe one way the scientists could have allocated the patients to each group.

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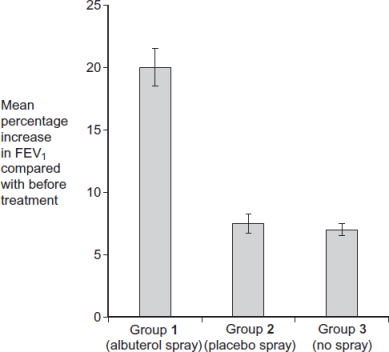
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**(2)**

The scientists measured the forced expiratory volume (FEV1 ) of each patient at regular intervals. The forced expiratory volume (FEV1 ) is the volume of air forced out of the lungs in the first second when breathing out. The scientists recorded each patient’s FEV1  before treatment started and after 60 days of treatment. They then calculated the mean increase in FEV1  for each group. Their results are shown in the graph. The bars show the standard deviation.



Patient group

(b)     What do the standard deviation bars suggest about the difference in the mean increase in FEV1  between Group **1** and the other groups? Explain your answer.

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**(2)**

(c)     What do the data suggest about the ‘placebo effect’ in this investigation? Explain your answer.

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**(2)**

(d)     On each occasion that a patient’s FEV1  was measured, a doctor repeated the measurement several times. Explain why.

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**(2)**

(e)     All the patients continued with their normal treatment for asthma. The normal treatment was the same for all patients and its effects were short-lived. The patients were told to stop this treatment 24 hours before FEV1  measurements were taken.

(i)      Suggest why all the patients were allowed to continue with their normal asthma treatment in this investigation.

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**(1)**

(ii)     Suggest why the patients were told to stop their normal asthma treatment 24 hours before their FEV1  measurements were taken.

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**(2)**

(f)     After 60 days, the patients in each group were asked to give themselves an *Improvement* Score from 0-10 to show how much they felt their symptoms had improved. This was done before their FEV1  was measured. The scientists calculated the mean *Improvement* Score for each group.

(i)      The scientists concluded that the data obtained for the Improvement Scores were less reliable than the data obtained measuring FEV1 . Suggest why they concluded this.

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**(2)**

(ii)     Group 3 reported the lowest mean *Improvement* Score. Suggest **one** explanation for this.

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**(2)**

**(Total 15 marks)**

**Q11.**          Scientists investigated the species of insects found in a wood and in a nearby wheat field. The scientists collected insects by placing traps at sites chosen at random both in the wood and in the wheat field.

The table shows the data collected in the wood and in the wheat field.

|  |  |  |
| --- | --- | --- |
| **Species of insect** | **Number of organisms of each species** | |
| **Wood** | **Wheat field** |
| Bird-cherry oat aphid | 0 | 216 |
| Beech aphid | 563 | 0 |
| Large white butterfly | 20 | 0 |
| Lacewing | 12 | 3 |
| 7-spot ladybird | 36 | 0 |
| 2-spot ladybird | 9 | 1 |
| Total number of organisms of all species | 640 | 220 |

(a)     The scientists collected insects at sites chosen at random. Explain the importance of the sites being chosen at random.

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**(1)**

(b)     (i)      Use the formula



to calculate the index of diversity for the insects caught in the wood, where

*d* = index of diversity*N* = total number of organisms of all species*n* = total number of organisms of each species

Show your working.

                               Answer ...................................................................

**(2)**

(ii)     Without carrying out any further calculations, estimate whether the index of diversity for the wheat field would be higher or lower than the index of diversity for the wood.

Explain how you arrived at your answer.

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**(2)**

(c)     A journalist concluded that this investigation showed that farming reduces species diversity.  
Evaluate this conclusion.

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**(2)**

(d)     Farmers were offered grants by the government to plant hedges around their fields.  
Explain the effect planting hedges could have on the index of diversity for animals.

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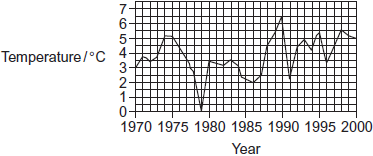
**(2)**

**(Total 9 marks)**

**Q12.**During the last 50 years, there have been changes in the climate of the UK. One of the main changes is temperature. The data in the following resources all relate to southern England.

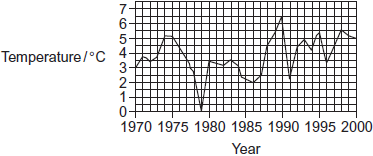
**Figure 1** shows the mean temperatures for January and February combined.

**Figure 1**



**Figure 2** shows the mean temperatures for March.

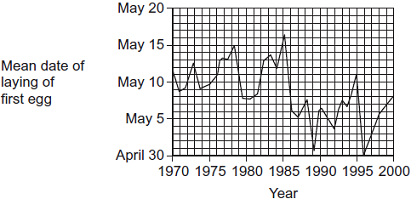
**Figure 2**



Birds, such as chaffinches, have been recorded as breeding earlier. Chaffinches build nests. When the nest is complete, the female lays eggs until she has produced a full clutch of 4 to 6 eggs. After the eggs hatch, the parent birds feed the young on insects.

**Figure 3** shows the mean date on which chaffinches laid their first egg.

**Figure 3**

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The data from which this graph was drawn were collected by volunteers. They used standard record cards. The volunteers used one record card for each nest they found. Each card was used to record

•        the geographical location

•        the habitat in which the nest site was situated

•        the date of each visit to the nest by the volunteer

•        the number of eggs present in the nest at each visit.

Visits were made to the nests at least once every 5 days.

(a)     Do the data in **Figure 1** and **Figure 2** support the idea that there has been a rise in the mean temperatures in southern England between 1970 and 2000? Explain your answer.

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**(2)**

(b)     Describe briefly how you would use a statistical test to find whether there is a significant correlation between mean March temperature and the date when chaffinches laid their first egg.

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**(3)**

(c)     In chaffinches, the date of laying the first egg is determined by a number of factors. These include day length and temperature. What is the advantage to the bird of egglaying being determined by

(i)      daylength

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**(2)**

(ii)     temperature?

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**(2)**

(d)     Scientists found that there was a correlation between mean annual temperature and the date when chaffinches laid the first egg. Can you conclude that higher temperatures cause earlier laying of the first egg?  
Explain your answer.

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**(2)**

(e)     How does the way in which the data were collected affect the conclusions which can be drawn from **Figure 3**?

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**(2)**

**(Total 13 marks)**

**Q13.**          Sea otters were close to extinction at the start of the 20th century. Following a ban on hunting sea otters, the sizes of their populations began to increase. Scientists studied the frequencies of two alleles of a gene in one population of sea otters. The dominant allele, **T**, codes for an enzyme. The other allele, **t**, is recessive and does not produce a functional enzyme.

In a population of sea otters, the allele frequency for the recessive allele, **t**, was found to be 0.2.

(a)     (i)      Use the Hardy-Weinberg equation to calculate the percentage of homozygous recessive sea otters in this population. Show your working.

Answer ..................................... %

**(2)**

(ii)     What does the Hardy-Weinberg principle predict about the frequency of the **t** allele after another 10 generations?

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**(1)**

(b)     Several years later, scientists repeated their study on this population. They found that the frequency of the recessive allele had decreased.

(i)      A statistical test showed that the difference between the two frequencies of the **t** allele was significant at the P = 0.05 level.

Use the terms **probability** and **chance** to help explain what this means.

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**(2)**

(ii)     What type of natural selection appears to have occurred in this population of sea otters? Explain how this type of selection led to a decrease in the frequency of the recessive allele.

Type of selection ................................................................................

Explanation .........................................................................................

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**(2)**

**(Total 7 marks)**

**Q14.**Scientists investigated the control of blood glucose concentration in mice. They kept a group of normal mice without food for 48 hours. After 48 hours, the blood glucose concentrations of the mice were the same as at the start of the experiment.

(a)     Explain how the normal mice prevented their blood glucose concentration falling when they had **not** eaten for 48 hours.

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**[Extra space]** ................................................................................................

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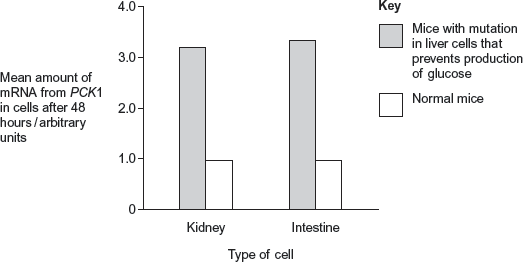
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**(3)**

The scientists then investigated mice with a mutation that prevents their liver cells making glucose. They kept a group of these mice without food for 48 hours. After 48 hours, the mean blood glucose concentrations of the mutant mice and the normal mice were the same.

The scientists investigated how blood glucose concentration is controlled in these mutant mice. An enzyme required for synthesis of glucose is coded for by a gene called *PCK*1. The scientists measured the mean amount of mRNA produced from this gene in cells from the kidneys and intestines of normal mice and mutant mice. They did this with mice that had previously been without food for 48 hours.

The scientists’ results are shown in the graph.



(b)     Use information from the graph to suggest how blood glucose concentration is controlled in the mutant mice, compared with the normal mice.

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**[Extra space]** ................................................................................................

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**(3)**

(c)     The scientists performed statistical tests on the data shown in the graph, to see whether the differences in the amount of mRNA in cells from normal and mutant mice were significant. Both the probability values they obtained were p<0.01.

Explain what this means about the differences in the amounts of mRNA produced.

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**[Extra space]** ................................................................................................

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**(2)**

**(Total 8 marks)**

**M1.**          (a)     Recognition of same species;

Stimulates release of gametes;

Recognition of mate / opposite gender;

Indication of sexual maturity / fertility;

**2 max**

(b)     (i)      Internal fertilisation / fertilisation occurs in pouch / limited area;

***Q*** *The term fertilisation is not required in the answer but must be implied.*

**1**

(ii)     Protection from predators (developing in pouch);

**1**

(c)     (i)      Less stress caused to seahorse / quicker / more accurate method / body is curved / head is linear;

***Q*** *Do not accept “easier” unless qualified.*

**1**

(ii)     Head length proportional to body length / or described;

**1**

(d)     Positive correlation between head / body lengths of male and female / female and male with similar head / body lengths pair together;

**1**

(e)     Use line of best fit;

And extrapolate / extend line as required;

**2**

(f)      (Compare) DNA;

Sequence of bases / nucleotides;

Compare same / named protein;

Sequence of amino acids / primary structure;

Immunological evidence – not a mark

Inject (seahorse) protein / serum into animal;

(Obtain) antibodies / serum;

Add protein / serum / plasma from other (seahorse) species;

Amount of precipitate indicates relationship;

***Q*** *The marks awarded for reference to DNA and sequence of bases / nucleotides must be in a different context to DNA hybridisation.*

**6 max**

**[15]**

**M2.**          (a)     collect a sample (of insects in each area) and mark unobtrusively / in a way not harmful to insects;  
release and allow time to re-integrate with rest of population / eq.;  
collect second sample and count number marked;  
number in population estimated by:





**4**

(b)     (i)      1;

**1**

(ii)     (p =) 0.05 / 5%;

*(ignore 95%)*

**1**

(iii)     value for χ2 exceeds critical value / 125.8 > 10.8 ;  
Results unlikely to be due to chance / have a biological cause;  
P < 0.1% / < 5% ;

**2 max**

(c)     (i)      biomass respired / GPP – respiration = NPP;  
biomass lost as CO2;

**2**

(ii)     more food for insects;

**1**

**[11]**

**M3.**          (a)     47 213;

**1**

(b)     (i)      there is no difference in the proportion / number of influenza cases  
between the 5 vaccines;

*(reject vaccinated versus no vaccinated)*

**1**

(ii)     significant difference in proportion / number of cases of influenza  
between the vaccines / the null hypothesis should be rejected;

**1**

(c)     sample size small;  
possible differences in exposure to infection;  
exposure to different strains / mutants;  
possible differences in existing immunity;  
possible differences in sex / age;  
possible differences in socio-economic status;

**2 max**

**[5]**

**M4.**          (a)     (i)      to increase surface area (for carbon dioxide absorption);

**1**

(ii)     oxygen is used / carbon dioxide emitted is absorbed;   
so decrease in volume / pressure;

**2**

(iii)     change of level of (manometer) liquid over time;  
bore of tube;  
mass of snails;  
time interval;

**3 max**

(b)     (i)      *valid* *similarity taking into account SD e.g. between 5 and 15 °C*both show little effect of temperature / intakes similar  
between 5 and 15 °C;

**1**

*valid difference taking into account SD above 15 °C e.g.*rise at 20 °C and above is less when snails kept in sea water;

**1**

(ii)     standard deviations high;  
means unreliable;

*(accept 25 °C being out of normal range for snail /   
not enough temperature readings for 1 mark)*

**2**

**[10]**

**M5.**(a)     Gg / suitable equivalent;

Grey : black about 3: 1;

*[Note: Can be in table / diagram]*

**2**

(b)     To determine the probability;

*[Accept: Likelihood]*

Of the results being due to chance;

*[Accept: Coincidence]*

**2**

(c)     (i)      both alleles will be expressed (in the phenotype);

**1**

(ii)     0.25 / 25%; = 2 marks  
CN = 250 / 1000; = 1 mark

**2**

(iii)    *P2* = (0.25)2 / 0.0625 / square of calculated figure for CN; = 2 marks

*p2 +2pq + q2* = 1.0; = 1 mark

= 31.25 / 31;

*[Accept: Derived from either p2 or q2]*

**3**

**[10]**

**M6.**          (a)     (i)      *Selecting the nettle plant*:  
Random number table avoids bias in placing of quadrat;  
‘Nearest centre’ avoids bias in choosing plant to measure;

*1 mark for “method avoids bias”*

**2**

(ii)     *Measuring the sixth leaf:*

To allow valid comparison / so as not to introduce another variable;

Reduces / avoids influence of growth / age / light / shading;

**2**

(b)     Definition of range + SD / effect of outliers on range + SD;

Ranges are similar in both areas;

Suggests that variation within populations is similar;

SD smaller in area of high light intensity;

Shows that area of high light intensity is a more uniform population;

**4**

(c)     1.164 / 1.16 / 1.2 , however derived = 2 marks  
0.83 – 0.86 / 1.1, however derived = 1 mark

*Evidence of correct use of both sets of figures, but inappropriate answer = 1 mark*

**2**

**[10]**

**M7.**          (a)     there is no difference between the number of lichens growing on the walls (facing different directions);

**1**

(b)     36, 36, 36;

**1**

(c)     2;

**1**

(d)     p less than 0.05 so reject the null hypothesis;  
the difference is not due to chance / significant difference;  
the direction the wall faces does have an effect on the population of lichens;

**3 max**

(e)     algae photosynthesise / produce organic molecules / named;  
fungus anchors the lichen / absorbs water which is available to the algae / prevents dehydration of alga / absorbs mineral ions / phosphates / nitrates;

**2**

**[8]**

**M8.**(a)     1.      Homologous chromosomes pair up / bivalents form;

2.      Crossing over / chiasmata form;

3.      Produces new combination of **alleles;**

4.      Chromosomes separate;

5.      At random;

6.      Produces varying combinations of chromosomes / genes / alleles (*not twice*) ;

7.      Chromatids separated at meiosis II / later;

*Independent assortment / random segregation = marking points 4 and 5*

**6 max**

(b)     (i)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Parental phenotypes | Agouti | White |  |
|  | Parental genotypes | BbAa | bbaa | ; |
|  | Gamete genotypes | BA     Ba     bA     ba | ba | ; |
|  | Offspring genotypes | BbAa     Bbaa | bbAa     bbaa | ; |
|  | Offspring phenotype | Agouti     Black | White     White | ; |

*Phenotypes must match genotypes*

*Allow marking points 2 and 3 if correctly derived from wrong parental genotypes*

**4**

(ii)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | ***Colour of offspring*** | ***Observed (O)*** | ***Expected (E)*** | ***(O-E)*** | ***(O-E)2*** |  |
|  | Agouti | 34 | 30 | 4 | 16 | 0.53 |
|  | Black | 35 | 30 | 5 | 25 | 0.83 |
|  | White | 51 | 60 | 9 | 81 | 1.35 |
|  |  | | | | ***Σ*= 2.71 or 2.72** | |
|  |  | | | | ;;       2 | |

*(χ2 correct = 2 marks)*

*((O-E)2 all correct = 1 mark)*

p = 0.05;

2 degrees of freedom;

Differences due to chance / no significant difference as χ2 less than / to left of critical value OR Not due to chance / difference is significant as χ2 greater than to right of critical value;

*(as appropriate for candidates χ2)*

**3**

**[15]**

**M9.**(a)     Species richness measures only number of (different) species / does not measure number of individuals.

**1**

(b)     Trees vary in height.

**1**

(c)     1.      Index for canopy is 3.73;

2.      Index for understorey is 3.30;

3.      Index in canopy is 1.13 times bigger;

*If either or both indices incorrect, allow correct calculation from student’s values.*

**3**

(d)     1.      For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;

2.      For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;

3.      Because P < 0.001 which is highly significant / is much lower than 5%.

**3**

**[8]**

**M10.**(a)     1.      Random;

*Random number generator = 2 marks*

2.      Method e.g. number generator / number out of a hat;

*Same age = 2 marks*

***OR***

3.      Matched / all the same;

4.      For e.g. age / sex;

**2 max**

(b)     1.      (Differences) are real / significant / not due to chance;

*It = the difference*

2.      (As) bars / SDs do not overlap;

*2. Accept: ‘standard errors do not overlap’ as told ‘standard deviation’ in the question stem*

**2**

(c)     1.      No / slight (placebo) effect;

2.      Group **2** and **3** results are similar / the same / SDs / bars overlap;

*2. Accept: other descriptions of Groups* ***2*** *and* ***3***

*2. Accept: that Groups* ***2*** *and* ***3*** *are not significantly different*

**2**

(d)     1.      (Allows) anomalies to be identified / ignored / effect of anomalies to be reduced / effect of variation in data to be minimised / concordant results;

*Accept: ‘outliers’ instead of anomalies*

*1. Reject: idea of not recording anomalies / preventing anomalies from occurring*

*1. Accept: ‘cancels out anomalies’ as bottom line response*

2.      (Makes) average / mean (more) reliable;

*2.* ***Q*** *Neutral: makes the average / mean more accurate*

*2. Ignore: ‘more reliable’ alone*

**2**

(e)     (i)      1.      Unethical / unfair not to treat patients;

2.      Dangerous / could cause an asthma attack;

**1 max**

(ii)     1.      Ensures normal treatment does not affect results / improvements are only due to the spray;

2.      (As) normal treatment is short-lived / effective for less than 24 hours / (24h) is long enough for normal treatment to wear off;

**2**

(f)     (i)      1.      (Improvement scores) are qualitative / subjective / rely on own judgement / different patients may assess symptoms differently;

*Accept: converse arguments for measuring FEV1 e.g. quantitative / objective patients cannot lie*

2.      Some patients may lie / exaggerate / want to please doctors;

*1. Neutral: empirical evidence*

**2**

(ii)     1.      Not blind / patients knew they were not receiving treatment / patients did not receive treatment;

2.      (So) more likely to underestimate / give lower scores / did not expect to improve / less improvement;

**2**

**[15]**

**M11.**          (a)     Removes bias;

**1**

(b)     (i)     1.      1.28 / 1.29 / 1.285 / 1.3

*1. Ignore more than 3dp*

2.      Answer incorrect but shows clear understanding of Σ

*2. Σ = 318250. Allow mark if denominator written out. Incorrect denominator but evidence of understanding gains mark*

**2**

(ii)     Diversity index would be lower (NO MARK)

*Assume wheat field if site unspecified*

1.      Fewer species / Beech aphid / Large white butterfly / 7-spot ladybird absent / only three species / species diversity lower / mostly one species / mostly bird-cherry aphid;

*1. Allow species richness in context of few species*

2.      Fewer plant species;

*2. Allow one type of food source if clearly plant*

**2**

(c)     For:

1.      Data support the claim / evidence supports claim;

*1. Ignore reference to correlation / causation*

Against:

2.      Only wheat field / only comparing with wood / one type of habitat / only insects considered;

**2 max**

(d)     1.      Greater variety of plants;

2.      Another habitat / more habitats / places to live / niches / another food source / more food types;

*2. Answers referring to ‘more food’ should not be credited. Allow  reference to either animal or plant as foods*

**2**

**[9]**

**M12.**(a)     Shows trend of mean temperature rise;  
Higher temperatures more frequent since 1984 (in January and February);  
Considerable variation in temperature from year to year;  
Which may be due to chance;

*No mark for yes or no Do not penalise candidates who state there is no trend*

**2 max**

(b)     Construct null nypothesis;  
Use Spearman rank (and calculate test statistic);  
Look up in table (to find critical value of P = 0.05 / 5 %);  
Use figure (in table) to accept or reject null hypothesis;

**3 max**

(c)     (i)      (Particular daylength) always occurs at same time of year / valid example;  
Birds do not start laying eggs when period of warm weather occurs early in year;  
Synchronises breeding behaviour;  
Sufficient foraging time for food collection for young;

**2 max**

(ii)     Birds able to respond to changing climate;  
Food availability (mainly) determined by temperature;  
As insect / invertebrate development temperature-dependent;

**2 max**

(d)     A correlation does not indicate a causal relationship;  
As may be due to another factor / named factor;

**2**

(e)     Visits could be up to 5 days apart;  
Date of egg-laying may be inaccurate by 5+ days;

**2**

**[13]**

**M13.**          (a)     (i)      Two marks for correct answer of 4;;

One mark for calculation involving 0.2 × 0.2 or 0.04;

**2**

(ii)     0.2 / the frequency remains the same;

*Reject if wrong frequency is quoted*

**1**

(b)     (i)      1.      There is a probability of 5% / 0.05;

2.      That difference in frequencies / difference in results are due to chance;

*Accept 95% probability changes in frequencies not different as a result of chance*

**2**

(ii)     1.      Directional;

2.      The recessive allele confers disadvantage / the dominant allele confers advantage / more likely to survive / reproduce;

*Assume "it" to refer to the recessive allele*

*2. References to selection do not gain credit as the term is in the question. Allow reference to phenotype / enzyme functionality (instead of allele) when describing advantage / disadvantage.*

**2**

**[7]**

**M14.**(a)     1.      Release of glucagon;

2.      Leads to formation of glucose in liver (cells);

*Reject: glucagon breaks down glycogen, or any other biological molecule*

3.      From non-carbohydrates / amino acids / fatty acids.

*Accept: gluconeogenesis / references to glycogen as source of glucose*

**3**

(b)     1.      Mutant mice (mRNA suggests) make a lot of (the) enzyme;

*Accept: PCK1 made (for enzyme made)*

2.      Mutant mice use kidney / intestine (cells) to make glucose;

*Accept: use other organ (than liver)*

3.      Normal mice do this much less / normal mice use liver cells.

**3**

(c)     1.      Differences significant;

*Reject: references to results being significant once*

2.      Probability of difference being due to chance less than 0.01 / 1% / 1 in 100 / probability of difference not being due to chance more than 0.99 / 99% / 99 in 100.

*Ignore: references to 0.05 / 5% / 5 in 100*

**2**

**[8]**

**E1.**          (a)     Most candidates had little difficulty obtaining at least one mark often for stating that courtship behavior enables recognition of the same species. Over a third of candidates gained a second mark. These candidates often linked courtship behaviour to sexual maturity or to the release of gametes. Most candidates failing to gain two marks often provided only one suggestion or there was a lack of clarity in their answers.

(b)     (i)      Almost two thirds of candidates gained this mark. Most candidates used the information in the stem of the question to explain that fusion between gametes would be more likely within a limited area.

(ii)     Less than half the candidates obtained this mark by indicating that developing within the pouch protected young seahorses from predators.

(c)     (i)      Most candidates gained this mark often by stating that the curved tail made it difficult to obtain an accurate measurement of body length.

(ii)     This proved slightly more difficult with a number of candidates providing the same answer as in (c)(i). Nevertheless, over 60% of candidates did obtain the mark by suggesting that body length is proportional to head length.

(d)     The vast majority of candidates obtained this mark by describing the trend of seahorses with similar head/body lengths pairing together.

(e)     This was generally well answered with most candidates obtaining the first marking point by referring to drawing a line of best fit. Over 50% of candidates gained the second mark by explaining how extrapolation of the graph could be used to predict the total head length of selected mate.

(f)      This question proved an excellent discriminator. The vast majority of candidates described how DNA hybridisation could be used to find out if the two species of seahorses are closely related. Not surprisingly, the quality of the descriptions of DNA hybridisation varied considerably and a variety of alternative methods were credited. Most candidates gained a couple of marks for naming the technique and for the principle of mixing the DNA strands of the two species. Many candidates also appreciated that a higher temperature would be required to separate hybrid strands from closely related species. A maximum of four marks was available for a full description of DNA hybridisation.

Other methods described included; comparing DNA base sequences, comparing amino acid sequences and immunological studies. There was considerable confusion between the first two methods with many candidates referring to ‘amino acid sequences of DNA’. Few candidates appreciated that the same or a named protein should be studied when comparing amino acid sequences. Descriptions of immunological investigations were relatively infrequent and apart from some notable exceptions, were generally of poor quality displaying little understanding of even the basic principles. Nevertheless, over a third of candidates obtained four or more marks for this question with many providing outstanding detailed descriptions of the various methods involved.

**E2.**          (a)     Most candidates knew the mark-release-recapture technique, and were able to describe the various steps. However, they did not always explain the reasons behind the steps. For example, they did not always explain that the released insects should be left for a suitable period of time to allow them to re-integrate with the rest of the population.

(b)     (i)      Nearly all candidates knew that there would be only one degree of freedom.

(ii)     Most candidates knew that the 0.05 level of probability is that most commonly used in biological analysis to judge statistical significance.

(iii)     Responses to this section were generally disappointing. Most candidates were unable to reason that, because the value for χ2 is greater than the critical value, then there is a probability of less than one in one thousand that the results are due to chance. They were uncertain as to whether the difference in values of χ2 implied that the differences in results are due to chance or due to some biological cause. They wrote about rejecting a null hypothesis which had not been stated and also merely that ‘the results are statistically significant’. Candidates should be aware of the logic that, if *χ*2 is greater than the critical value, there is only a probability of (usually one in twenty) that the results are due to chance as the basis for rejecting any null hypothesis and accepting the experimental hypothesis.

(c)     (i)      A number of candidates realised that some of the biomass produced in photosynthesis would be respired by the plant, but very few actually explained that biomass is lost in the form of carbon dioxide. Most of those who involved respiration in their answers suggested that energy is lost, which is true, but loss of energy does not account for the difference in biomass between gross primary production and net primary production.

(ii)     Nearly all knew that a higher net primary production would lead to more dead plants and so more food for the detritivorous insects.

**E3.**          Whilst a full range of marks was seen on this question, five marks were very rarely awarded. Most candidates’ powers of expression were not up to the task of explaining what they meant in part (b). Most candidates scored between one and three marks.

(a)     The majority of candidates obtained this mark.

(b)     Relatively few obtained the mark in part (i). Most candidates misunderstood the basic purpose of the study and wrote about vaccination (versus no vaccination) having no effect on the number of influenza cases. Many merely turned the stem of the question around and stated ‘there is no difference in effectiveness of the vaccines’. More candidates scored a mark in part (ii) by writing about the rejection of the null hypothesis.

(c)     This discriminated quite well. Good candidates usually obtained two marks, average candidates often failed to gain one mark for vague references along the lines of ‘it not being a fair test’, and weak candidates gave answers such as ‘there were a different number of people in each group’.

**E4.**          (a)     In part (a)(i), a majority of candidates answered in terms of pH. Only the best candidates made any reference to increasing surface area for carbon dioxide absorption. In part (a)(ii), the majority of candidates realised that the snails took in oxygen, but only the better candidates made reasonable reference to changes in pressure or volume. In part (a)(iii) most of the candidates realised that the mass of the snails and time should be measured but comparatively few referred to the bore of the tube or to the distance moved by the manometer liquid.

(b)     Very few of the candidates analysed the data and therefore most did not realise that there was no significant increase in oxygen consumption between 5 °C and 15 °C,and no significant difference between the oxygen uptake of the two sets of snails between 5 °C and 15 °C. Most of the candidates were content with generalised statements such as 'The snails kept in air took in more oxygen than the snails kept in seawater'. In part (ii), only a handful of candidates realised that with large standard deviations, means would be unreliable.

**E5.**Whilst it was pleasing to see a few excellent candidates achieving full marks with this question, it was more common to see low-scoring answers. Most candidates still struggle with numerical and statistical treatment of data and its application to biological situations.

(a)     Most candidates gave an appropriate genotype and recognised the approximate 3:1 ratio in the offspring as the evidence for such. A number incorrectly used different letters for the dominant and recessive alleles or assumed the characteristic to be sex-linked.

(b)     Statistical tests are used to test the *probability* of results being due to *chance*. Whilst the concept of chance was well demonstrated, the probability of this being the case was seldom identified.

(c)     Well-prepared candidates were familiar with a definition of *codominant*. Answers were then clear and concise − both alleles would be expressed in the phenotype of a heterozygote. Where this was not the case, weak explanations, such as ‘neither is dominant’, often failed to make the point.

The clue to the calculations was in the wording of the questions. Part (iii) required use of the Hardy-Weinberg equation. This was not requested in part (ii) and attempting to do so was an inappropriate strategy. All that was required was an addition of all alleles present (1000) against which the *actual* frequency of the particular allele could then be established (0.25 or 25%). Many candidates failed to recognise the significance of calculating the *actual* frequency (250 in 1000).

For most candidates, their remaining credit was restricted to identification of the Hardy- Weinberg equation. Those that were able recognised that their actual frequency would be *q*, (but would work equally as *p*) from which *q*2 could be determined and applied to determine the expected number with the genotype in the population (500). It was interesting to note that candidates who performed well with the mathematical nature of this question were not always successful with questions testing biological understanding.

**E6.**          Several parts of this question elicited responses that displayed a basic understanding of principles, but which lacked real detail and depth of understanding

(a)     In (i) many candidates understood that the importance of removing bias in sampling, but most only referred specifically to the random placing of quadrats and made no mention of the systematic sampling of the nettle plants within the quadrats. In (ii) Too many candidates did not get beyond saying “to make it a fair test“. Good candidates, however, wrote about the need to control as many variables as possible and that plants at different heights could be different sizes simply because of age or could be subject to different shading effects.

(b)     Part (b) was another instance of candidates failing to take note of the requirements of the question and producing a response to similar, but more general, questions that have been asked in the past. This question required candidates to use the data to explain the preference for standard deviation over range when comparing variation in two populations. Those candidates who did take note of the requirement had no problem in pointing out that, although the ranges were similar, suggesting similar populations, the standard deviations were different, suggesting a different degree of variation about the mean.

(c)     Most candidates could calculate the actual areas, using the formula supplied, producing the answers of 3404 mm2 (low light intensity) and 2924 mm2 (high light intensity). Too many, however, simply wrote the ratio as 3404 : 2924 or just reduced it to 851 : 731 by dividing by 4. They should appreciate that the actual ratio of 1.16 : 1 immediately conveys the information of a 16% larger leaf area in the site with low light intensity, whereas the unresolved ratios do not do this.

**E7.**          It was pleasing to see so many good answers to a statistics question with many clearly understanding the basic principles.

(a)     Most could give a good working null hypothesis. Those that did not usually stated a hypothesis instead.

(b)     Most could give the expected values.

(c)     Most candidates gave the correct number of degrees of freedom as 2.

(d)     The chi-squared value was well explained. Many candidates were able to relate the information to the difference not being due to chance and being significant, so that the null hypothesis could be rejected.

(e)     Many realised that the algae photosynthesised and would therefore supply the fungus with carbohydrates. Few could give the role of the fungus in this relationship; for example, supplying water, minerals or giving anchorage.

**E8.**(a)     Many candidates produced stock answers to the question ‘describe how meiosis takes place’. By not concentrating on the key features, candidates are likely to produce responses that address those features in insufficient detail. Good candidates, however, were more selective and produced focused responses which described how crossing over between the non-sister chromatids of bivalents produced new combinations of alleles and how random segregation of homologous chromosomes reduced the chromosome number and produced different combinations of chromosomes. They usually also went on to describe the role of meiosis II in splitting the chromatids. A common omission from otherwise good answers was to fail to explain how the processes of crossing over and random segregation introduce variation.

(b)     (i)      Good candidates made use of all the information supplied and were able to deduce that to produce black offspring the white parents must be aabb not AAbb and the agouti mice must be Aa not AA; to produce white offspring the agouti parents must be Bb, not BB. The good candidates then laid out the cross correctly and were able to show the correct ratio of genotypes. Some failed to gain a mark by not clearly showing which genotype produced which phenotype. Candidates who did not make use of all of the information, frequently began from wrong parental genotypes, and often ended with the wrong ratio. Oddly, they did not then attempt to correct this.

(ii)     Most candidates were able to calculate χ2 correctly, although many made a basic arithmetic error in calculating (O − E) for the white mice. These candidates correctly calculated E as 60, but then in subtracting 51 from 60 produced the answer 11.

(iii)    Most candidates correctly stated that there would be two degrees of freedom. They were then able to correctly relate **their** calculated value of χ2 to the critical value at a probability level of p = 0.05 and, from this, to correctly infer whether or not the results were, or were not, significantly different from the expected ratio.

**E10.**(a)     60% of students scored full marks and the first route on the mark scheme was the most popular. Students scoring one mark typically mentioned ‘random’. However, some responses conveyed a failure to read the question stem carefully enough. Consequently, they answered a different question from the one asked and produced answers such as ‘reduces bias’, ‘use a double blind trial’, ‘ensure there is the same number of patients in each group’ and ‘do not tell patients which treatment they are receiving’.

(b)     It was disappointing that 60% of students were unfamiliar with the use of standard deviation and scored zero. Only a quarter of students stated that the bars did not overlap and related this to the difference in results between Group **1** and the other groups as being significant, or not due to chance. Weaker responses that did make reference to the standard deviation bars usually went no further than to state that the bar for Group **1** was larger than that of the other groups.

(c)     Three-quarters of students were aware that there was no evidence of a placebo effect, or that this effect was slight. However, the ability to link this to data shown in the graph proved to be a good discriminator.

(d)     Two-thirds of students gained one mark for the idea that anomalies could be identified. However, some thought that repeats prevented anomalies from occurring or being recorded. It was only the best responses that referred to allowing a more reliable mean to be calculated. Taking additional readings does not necessarily allow results to be closer to the true value. Hence, references to ‘a more accurate mean’ were not credited. Weaker responses often referred to ‘the results’ being more reliable or more accurate, without further qualification.

(e)     (i)      Just over half of students gained this mark. Students who failed to score typically repeated information given in the question stem. The most typical response seen was ‘so that the normal treatment was the same for all patients’.

(ii)     Almost all students scored at least one mark. This was usually for appreciating that the normal treatment would not affect the results. Weaker responses usually relied on vague, stock *How Science Works* phrases, e.g. ‘so a comparison can be made’, ‘it would give less reliable results’ and ‘to make it a fair test’. There was also evidence that a minority of students failed to read the question carefully enough. Their responses referred to albuterol as, the normal treatment or FEV as the experimental drug.

(f)     (i)      80% of students scored at least one mark. This was usually for stating that improvement scores are subjective or qualitative. Only 10% of students went further and suggested that some patients might lie, exaggerate or want to please doctors. Again, weaker responses typically repeated information given in the question stem, e.g. ‘the improvement score is how much the patients felt their symptoms had improved so it less reliable’.

(ii)     Almost all students scored at least one mark. This was usually for the idea that patients knew they were not receiving any treatment. However, two-thirds of students were able to complete the story by linking this to patients being more likely to give lower improvement scores.

**E11.**          (a)     This question was generally answered well, with the better students able to explain the importance of random collection in the context of the investigation rather than simply turning out the phrase ‘avoiding bias’.

(b)     (i)       Most students understood the summation process even though they made mistakes in another part of the calculation. A significant number of answers went up to 5 or 6 decimal places which, although not penalised, should be avoided. The mathematical requirements of the specification do state the ‘use of an appropriate number of significant figures’. A significant number of students use the space available as rough working rather than for setting out the logic by which they arrived at the answer. A tangled mass of numbers did not always allow the examiners to credit incorrect responses for an understanding of underlying principles.

(ii)     Most students made reasonable attempts at this section. Most correct references were to the reduction in species number and to the predominance of the bird-cherry aphid. Incorrect references were made to totals of all organisms and totals of all species. Weaker students assumed that the fewer organisms in total, the lower the biodiversity. Some wrote, incorrectly, about genetic diversity.

(c)      Instead of evaluating the conclusion given, a significant number of students wrote their own conclusions about the effects of farming on the environment and the mechanisms by which these were brought about. Answers were often vague and did not refer to the data provided.

(d)     Generally answered well; almost all students offered responses, often with good explanations relating to increasing variety of habitats and food sources.

**E12.**(a)     Candidates recognised that temperatures were generally higher and also suggested that the temperature fluctuated. This question was usually marked at the correct level. It was less common for candidates to identify that the trend in the data may have been due to chance.

(b)     This was well understood with the vast majority scoring two or more marks. It was marked at the correct level by most centres. Most commonly the null hypothesis was absent in responses. Many accounts provided extensive unnecessary detail about calculating the test statistic. This was often incorrectly given credit.

(c)     (i)      Only a very small number of candidates established valid links between egg-laying and daylength. Very few candidates realised that daylength was related to a particular time of year. Too many answers which did not correspond to points on the marking guidelines were credited by centres. Credit was also often incorrectly given for synchronising egg-laying rather than breeding behaviour.

(ii)     Candidates had more success with the relationship of egg-laying and temperature. They established links with availability of food and an increase in insect numbers. Many candidates, however, discussed body temperature and survival of young and this was incorrectly credited by some centres. Others answered in terms of temperature affecting egg hatching.

(d)     This was well answered by the vast majority and marked at the correct level.

(e)     Many candidates were able to use the data supplied to suggest that the date of egg-laying would be imprecise. Many answers were linked to the collection of data by volunteers, candidates considering that as a consequence the data were unreliable and the conclusions that could be drawn were debatable. Again answers not meeting the requirements of those in the marking guidelines, such as ‘don’t know when the eggs were laid’, were credited.

**E13.**          (a)     About 50% of candidates gained both of the marks available for part (i), but of the rest there was considerable evidence of confusion. Nearly all wrote out the equation p2 + 2pq + q2 = 1, when finding 0.22 was all that was needed in this case. Many also did not know whether the allele frequency of 0.2 was the value for *q* or for *q*2. Most candidates responded correctly to part (ii), but a number continued to provide irrelevant detail about the conditions required for the Hardy-Weinberg principle to be valid.

(b)     Few candidates gained both the marks available for part (i), as they did not show the necessary understanding of the difference between chance and probability. The answer given by many to part (ii), stabilising selection, suggested that they had not read the stem of this part of the question carefully enough. Those candidates who missed marks in their explanations usually did so because they wrote generally about selection rather than explaining the effect of this allele on survival and reproductive success and the consequent decrease in its frequency.

**E14.**(a)     About a third of students correctly explained how glucagon would be involved in regulation of blood glucose concentrations in the mice and obtained 3 marks. Some students failed to mention what glucagon does, or where it acts. There were some students who got very confused between glucagon and glycogen and others who wrote about glucagon either acting on glycogen to break it down, or had glucagon broken down into glucose. This question showed weaknesses in use of language and terminology by many students.

(b)     This was marked by a very large number of students who wrote about large amounts of mRNA but did not link this to large amounts of the enzyme PCK1. These answers were simply describing the results shown in the graph, not giving a suggestion about how the process is controlled. The examiners required students to show understanding that large amounts of mRNA would (probably) mean large amounts of the enzyme. It should be noted that quite a large number of students wrote about mRNA breaking down glycogen (as an enzyme), or being broken down into glucose. Many students did write about the role of the enzyme in kidney and intestinal cells in producing glucose. However, many of these did not compare this with what happens in the normal mice referred to in the question. Some weak answers simply involved attempts to use rote-learned material about control of blood glucose concentration with no reference to the information in the question.

(c)     This again had students writing about the results / data being significant, rather than the difference in the amounts of mRNA, as given in the stem. Quite a few ignored the ‘less than’ symbol, or read it as ‘more than’. Others ignored the 0.01 and wrote entirely about less than 5%, which did not gain credit.