Exampro A-level Biology

Inheritance

Name:

Class:

Author:

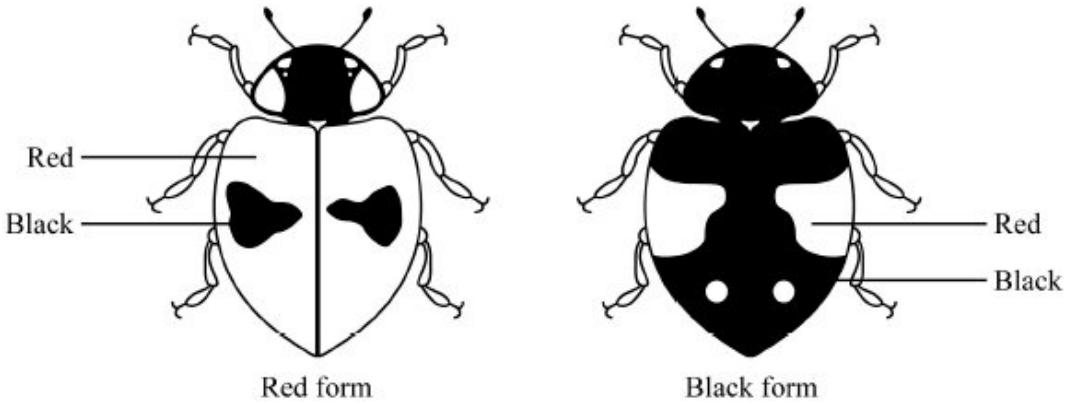
Date:

Time: 158

Marks: 137

Comments:

Q1. The two-spot ladybird is a small beetle. It has a red form and a black form. These two forms are shown in the diagram.



Colour is controlled by a single gene with two alleles. The allele for black, **B**, is dominant to the allele for red, **b**.

Scientists working in Germany compared the number of red and black ladybirds over a ten-year period. They collected random samples of ladybirds from birch trees.

(a) (i) It was important that ladybirds in the samples were collected at random. Explain why.

.....

.....

(1)

(ii) Suggest **one** method by which the scientists could collect a random sample of ladybirds from the trees.

.....

.....

(1)

Some of the results from the investigation are shown in the table.

Year	Season	Frequency of b allele
1933	Autumn	0.70
1934	Spring	0.82
1934	Autumn	0.59
1935	Spring	0.76
1935	Autumn	0.57
1936	Spring	0.78

(b) Use the Hardy-Weinberg expression to estimate the percentages of red ladybirds and black lady birds in the Autumn 1933 ladybird population.
Show your working.

Answer ..... red ladybirds

..... black ladybirds

(2)

(c) (i) The evidence from the table shows that the black ladybirds were at a disadvantage and survived less well over winter. Explain this evidence.

.....

.....

.....

.....

(2)

(ii) The scientists found that black ladybirds heated up more quickly and became active at lower temperatures than red ladybirds. How might this explain the poorer survival of black ladybirds over winter?

.....

.....

.....

.....

(2)
(Total 8 marks)

Q2. The polecat, shown in the drawing, is a wild British mammal. At one time it was very rare. It is now more common and its range is increasing. Scientists carried out a survey of the distribution and status of polecats in Britain during the 1990s.

The first problem that the scientists had was that they needed to distinguish between wild polecats and escaped ferrets. Ferrets are domesticated polecats. They investigated skulls from polecats and ferrets.

They used dial callipers to take skull measurements. They took each measurement six times on six different skulls. They used their measurements to calculate a percentage measurement error using the formula:

$$\text{Percentage measurement error} = \frac{100(1+0.25n)\sigma}{x}$$

where n = number of measurements
σ = standard deviation
x = mean

(a) (i) Use the information from this question to explain the difference between accuracy and reliability.

.....

.....

.....

.....

(2)

(ii) Unreliable measurements will produce a large percentage measurement error. Use the formula to explain why.

.....

.....

.....

.....

(2)

Table 1 shows some of the skull measurements obtained by the scientists.

Table 1

Animal	Sex	Number of skulls measured	Mean skull breadth/mm		Cranial volume/cm^3	
			mean	standard deviation	mean	standard deviation
Polecat	Male	90	16.38	1.34	10.15	0.92
Ferret	Male	114	15.56	0.84	8.96	0.93
Polecat	Female	44	15.52	1.04	8.34	0.68
Ferret	Female	47	14.42	0.78	7.03	0.55

(b) (i) Describe **one** way in which you could show whether there was a correlation between mean skull breadth and mean cranial volume.

.....

.....

.....

.....

(2)

(ii) The scientists found that there was an advantage in taking measurements of skull breadth rather than cranial volume when measuring skull size. Suggest this advantage.

.....

.....

(1)

(iii) Is skull breadth a reliable way of determining whether a particular skull came from a polecat of from a ferret? Explain the evidence from **Table 1** that supports your answer.

.....

.....

.....

.....

.....

.....

(3)

(c) In the report that the scientists wrote, they referred to an earlier scientific paper about "Some characteristics of the skulls and skins of the European polecat, the Asiatic polecat and the domestic ferret"
Describe **two** ways in which this earlier paper might have helped the scientists to carry out their work and produce a reliable report.

.....

.....

.....

.....

(2)

In this survey, the scientists collected the bodies of the dead polecats from roads where they had been killed by passing vehicles. They analysed the stomachs to see what the polecats had eaten. **Table 2** shows the results.

Table 2

Prey	Total number of polecats examined = 83			
	Mass/g	**Mass as percentage of all prey**	**Number of stomachs in which prey item found**	**Percentage of all stomachs in which prey item found**
Rabbit	1063.80	85.4	60	72.3
Rat	22.18	1.8	2	2.4
Other mammals	43.54	3.5	9	10.8
Pigeons	29.45	2.4	3	3.6
Other birds	7.68	0.6	5	5.6
Frogs and toads	56.98	4.6	7	8.4
Fish	0.12	0.01	1	1.2
Earthworms	21.97	1.8	2	2.4
Total	**1245.72**		**89**	

(d) The table shows that a total of 83 stomachs were analysed. Explain why the total for the number of stomachs in which the prey item was found was more than 83.

.....

.....

(1)

(e) Some farmers regard polecats as pests and claim that they kill poultry and game birds. Use the data to suggest how you would explain to these farmers that they should tolerate polecats on their land.

.....

.....

.....

.....

(2)
(Total 15 marks)

Q3. (a) (i) Explain what is meant by a **recessive** allele.

.....

.....

.....

(1)

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

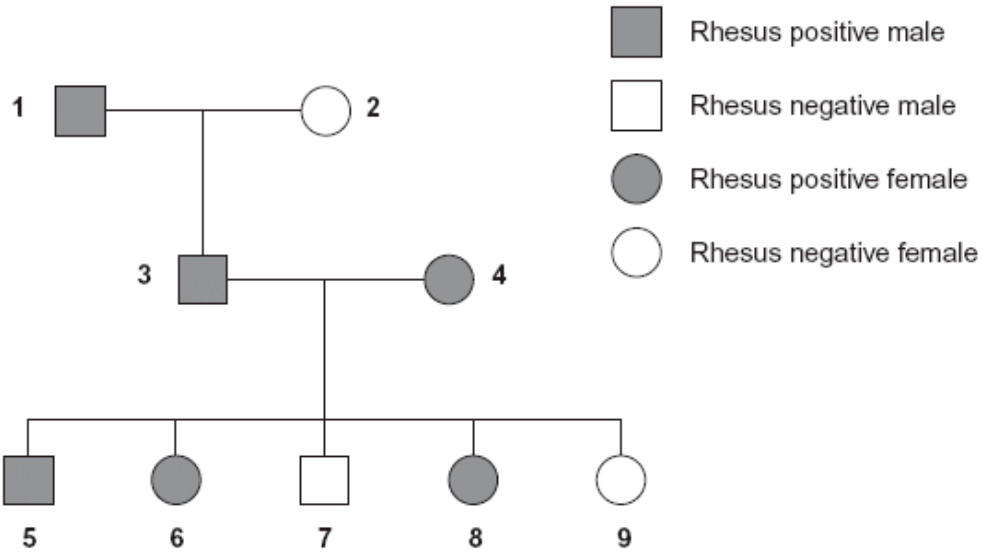
.....

.....

.....

(1)

(b) The Rhesus blood group is genetically controlled. The gene for the Rhesus blood group has two alleles. The allele for Rhesus positive, **R**, is dominant to that for Rhesus negative, **r**. The diagram shows the inheritance of the Rhesus blood group in one family.



(i) Explain **one** piece of evidence from the diagram which shows that the allele for Rhesus positive is dominant.

.....

.....

.....

.....

.....

(2)

(ii) Explain **one** piece of evidence from the diagram which shows that the gene is **not** on the X chromosome.

.....

.....

.....

.....

.....

(2)

(c) Sixteen percent of the population of Europe is Rhesus negative. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene.

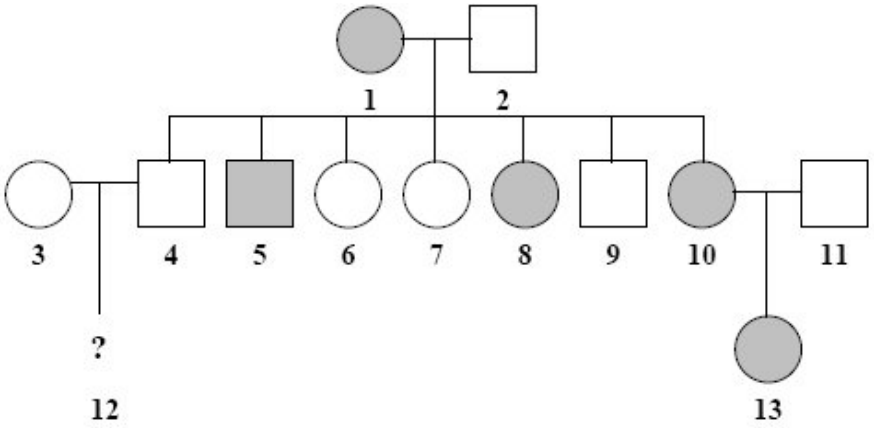
Show your working.

Answer .....

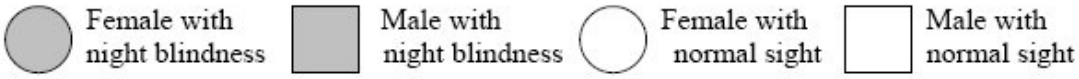
(3)
(Total 9 marks)

Q4. People with night blindness have difficulty seeing in dim light. The allele for night blindness, **N**, is dominant to the allele for normal vision, **n**. These alleles are *not* carried on the sex chromosomes.

The diagram shows part of a family tree showing the inheritance of night blindness



Key



(a) Individual **12** is a boy. What is his phenotype?

.....

(1)

(b) What is the genotype of individual **1**? Explain the evidence for your answer.

Genotype .....

Evidence.....

.....

.....

(2)

(c) What is the probability that the next child born to individuals **10** and **11** will be a girl with night blindness? Show your working.

Answer.....

(2)

(Total 5 marks)

Q5. There is evidence that the first photosynthetic organisms were primitive water-dwelling bacteria. The very first of these lived near the surface of the water in lakes and contained a purple pigment that absorbed light most strongly in the green region of the spectrum. Later, other bacteria evolved that lived on the top of sediment at the bottom of the lakes (**Figure 1**). Gene mutations had enabled these bacteria to synthesise chlorophyll instead of the purple pigment present in the bacteria living near to the surface. Chlorophyll absorbs light most strongly in the blue and red regions of the spectrum (**Figure 2**).

Figure 1

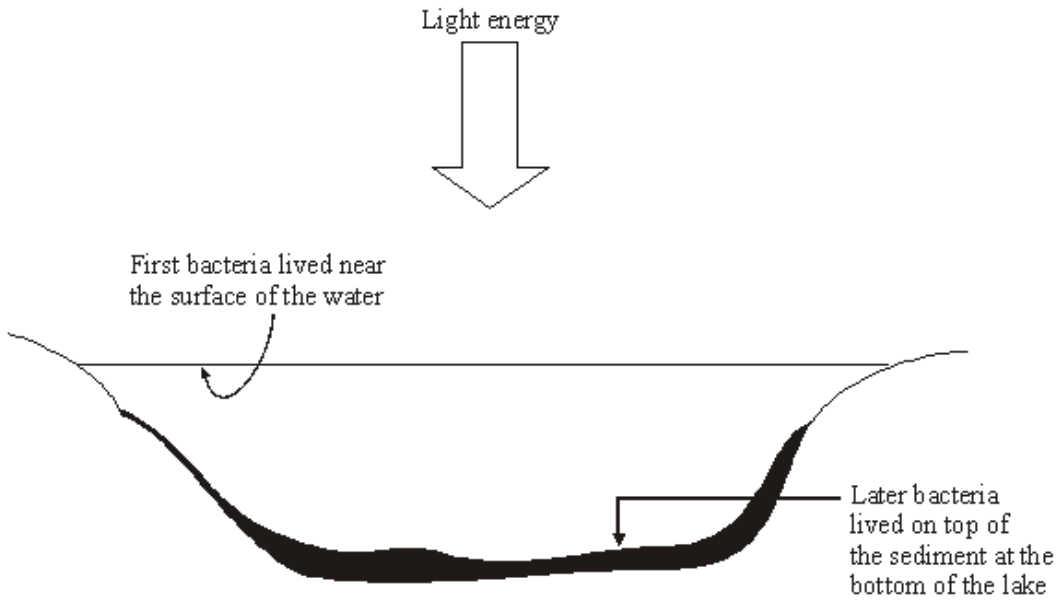
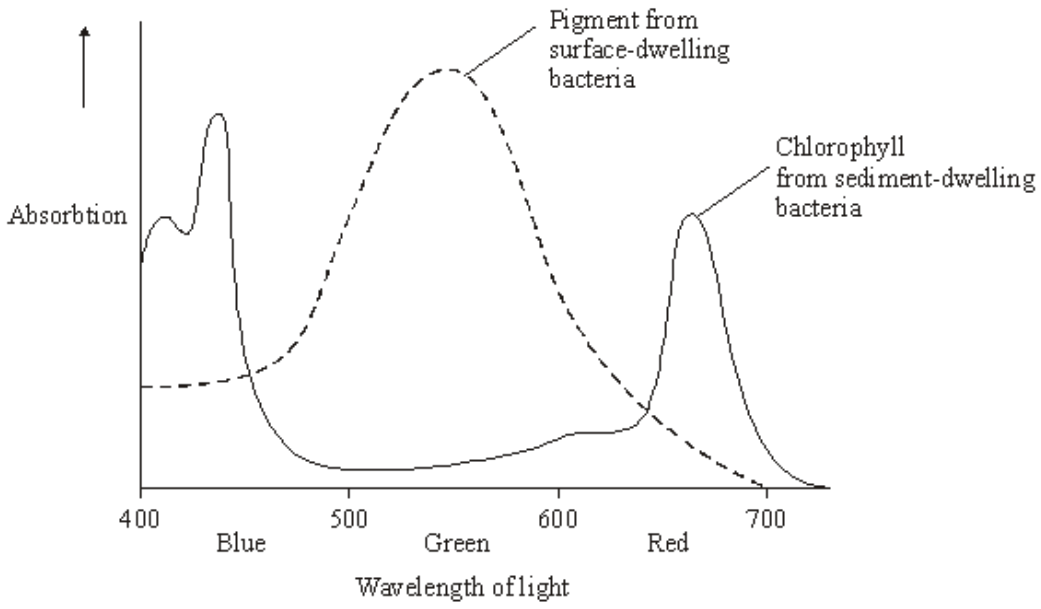


Figure 2



(a) Describe how light energy absorbed by chlorophyll molecules is used to synthesise ATP.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(5)

(b) Use **Figure 2** to explain how natural selection would favour the evolution of sediment-dwelling bacteria containing a different photosynthetic pigment from those living near the surface of the water.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)
(Total 11 marks)

Q6. Colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, X^b, is recessive to the allele for normal colour vision, X^B . The gene controlling the presence of a white streak in the hair is not sex linked, with the allele for the presence of a white streak, **H**, being dominant to the allele for the absence of a white streak, **h**.

(a) Explain why colour blindness is more common in men than in women.

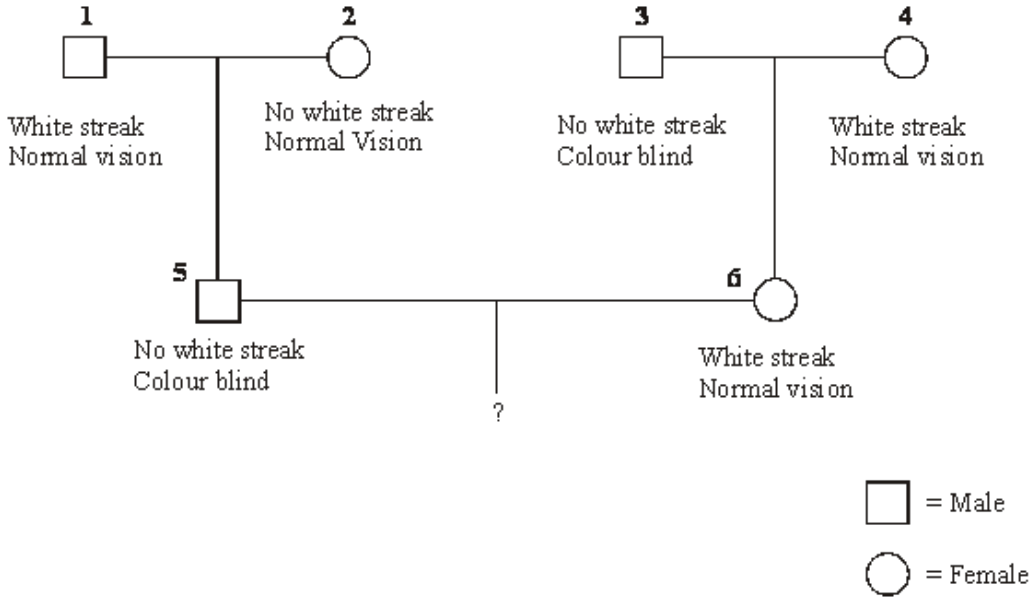
.....

.....

.....

(2)

(b) The diagram shows a family tree in which some of the individuals have colour blindness or have a white streak present in the hair.



(i) What are the genotypes of individuals **5** and **6**?

Individual **5**

.....

Individual **6**

.....

(2)

(ii) Give the possible genotypes of the gametes produced by

individual **5**;

.....

individual **6**.

.....

(1)

(iii) What is the probability that the first child of individuals **5** and **6** will be a colour blind boy with a white streak in his hair? Show your working.

Answer .....

(2)

(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 $\mathbf{W^R}$.

Rats have three possible genotypes:

$\mathbf{W^RW^R}$ resistant to warfarin
$\mathbf{W^RW^S}$ resistant to warfarin
$\mathbf{W^SW^S}$ susceptible (not resistant) to warfarin.

In addition, rats with the genotype $\mathbf{W^RW^R}$ 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 $\mathbf{W^SW^S}$, 176 had the genotype $\mathbf{W^RW^S}$ and 56 had the genotype $\mathbf{W^RW^R}$.

(i) Use these figures to calculate the actual frequency of the allele $\mathbf{W^R}$ in this population. Show your working.

Answer .....

(2)

(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.

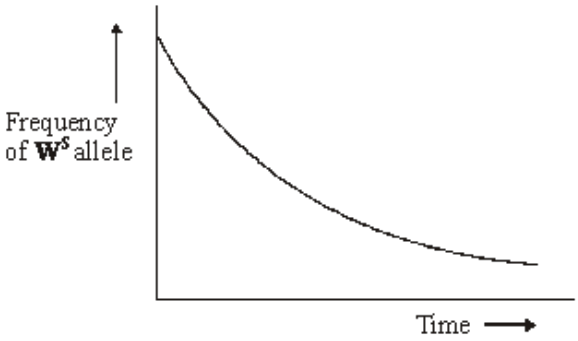
Answer ..... %

(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)

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



.....

.....

.....

.....

.....

.....

.....

.....

(4)

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

1 ….....

.....

2 ….....

.....

(2)
(Total 15 marks)

Q8. The fruit fly is a useful organism for studying genetic crosses. Female fruit flies are approximately 2.5 mm long. Males are smaller and possess a distinct black patch on their bodies. Females lay up to 400 eggs which develop into adults in 7 to 14 days. Fruit flies will survive and breed in small flasks containing a simple nutrient medium consisting mainly of sugars.

(a) Use this information to explain **two** reasons why the fruit fly is a useful organism for studying genetic crosses.

1.....

.....

2.....

.....

(2)

(b) Male fruit flies have the sex chromosomes XY and the females have XX. In the fruit fly, a gene for eye colour is carried on the X chromosome. The allele for red eyes, **R**, is dominant to the allele for white eyes, **r**. The genetic diagram shows a cross between two fruit flies.

(i) Complete the genetic diagram for this cross.

Phenotypes of parents	red-eyed female		white-eyed male
Genotype of parents	.....	×	.....
Gametes	.....and.....		.....and.....
Phenotypes of offspring	red-eyed females	and	red-eyed males
Genotype of offspring	.....		.....

(3)

(ii) The number of red-eyed females and red-eyed males in the offspring was counted. The observed ratio of red-eyed females to red-eyed males was similar to, but not the same as, the expected ratio. Suggest **one** reason why observed ratios are often **not** the same as expected ratios.

.....

.....

.....

(1)

(c) Male fruit flies are more likely than female fruit flies to show a phenotype produced by a recessive allele carried on the X chromosome. Explain why.

.....

.....

.....

.....

.....

(2)

(Total 8 marks)

Q9. A breeder crossed a black male cat with a black female cat on a number of occasions. The female cat produced 8 black kittens and 4 white kittens.

(a) (i) Explain the evidence that the allele for white fur is recessive.

.....

.....

(1)

(ii) Predict the likely ratio of colours of kittens born to a cross between **this** black male and a white female.

.....

(1)

(b) The gene controlling coat colour has three alleles. The allele **B** gives black fur, the allele **b** gives chocolate fur and the allele $\mathbf{b}^{i}$ gives cinnamon fur.

- Allele **B** is dominant to both allele **b** and $\mathbf{b}^{i}$.
- Allele **b** is dominant to allele $\mathbf{b}^{i}$.

(i) Complete the table to show the phenotypes of cats with each of the genotypes shown.

Genotype	Phenotype
$\mathbf{Bb}^{i}$	
$\mathbf{bb}^{i}$	
Bb	

(1)

(ii) A chocolate male was crossed several times with a black female.

They produced

- 11 black kittens
- 2 chocolate kittens
- 5 cinnamon kittens.

Using the symbols in part (b), complete the genetic diagram to show the results of this cross.

Parental phenotypes	Chocolate male	Black female	
Parental genotypes	.....	.....	
Gametes	.....	.....	
Offspring genotypes	.....	.....	.....
Offspring phenotypes	Black	Chocolate	Cinnamon

(3)

(iii) The breeder had expected equal numbers of chocolate and cinnamon kittens from the cross between the chocolate male and black female. Explain why the actual numbers were different from those expected.

.....

.....

.....

(1)

(iv) The breeder wanted to produce a population of cats that would all have chocolate fur. Is this possible? Explain your answer.

.....

.....

.....

.....

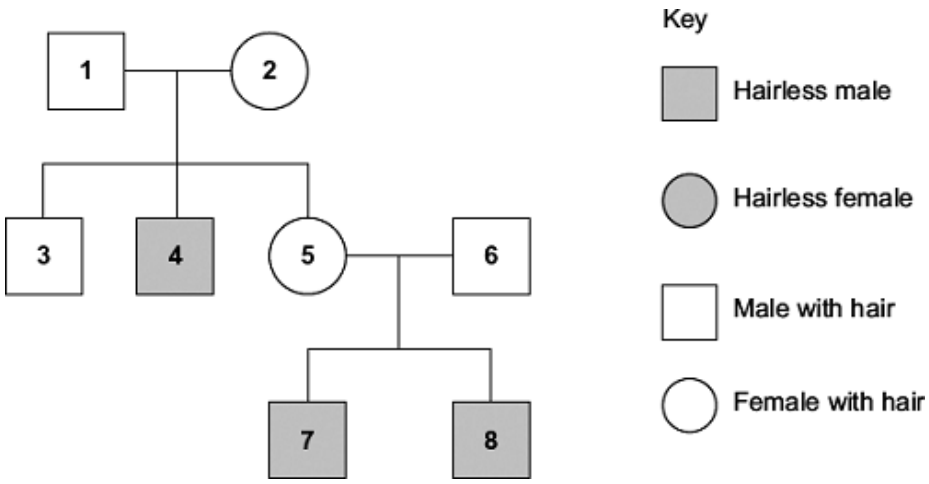
.....

(2)

(Total 9 marks)

Q10. A single gene controls the presence of hair on the skin of cattle. The gene is carried on the X chromosome. Its dominant allele causes hair to be present on the skin and its recessive allele causes hairlessness.

The diagram shows the pattern of inheritance of these alleles in a group of cattle.



(a) Use evidence from the diagram to explain

(i) that hairlessness is caused by a recessive allele

.....

.....

.....

.....

.....

(2)

(ii) that hairlessness is caused by a gene on the X chromosome.

.....

.....

(1)

(b) What is the probability of the next calf born to animals **5** and **6** being hairless? Complete the genetic diagram to show how you arrived at your answer.

Phenotypes of parents	Female with hair	Male with hair
Genotypes of parents	.....	.....
Gametes	.....	.....

Genotypes of offspring .....

Phenotypes of offspring .....

Probability of next calf being hairless .....

(4)

(Total 7 marks)

Q11. In birds, **males are XX** and **females are XY**.

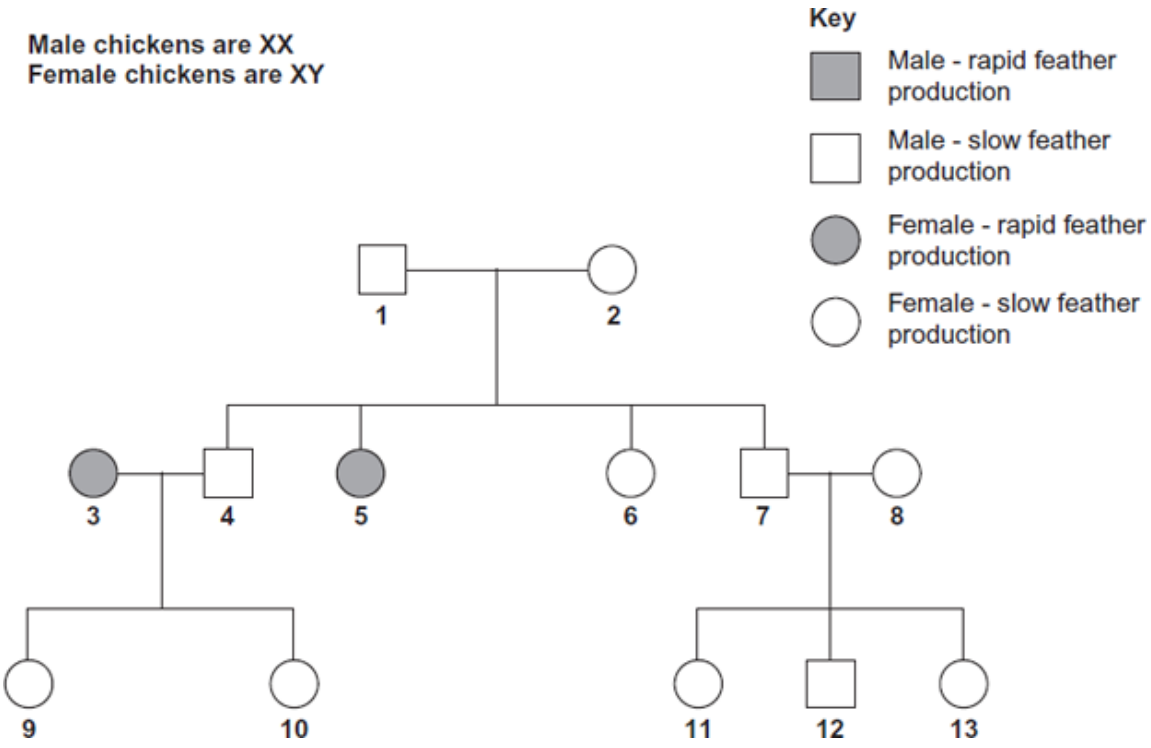
(a) Use this information to explain why recessive, sex-linked characteristics are more common in female birds than in male birds.

.....

.....

(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.

.....

.....

.....

.....

(2)

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

Chicken 5 .....

Chicken 7 .....

(2)

(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 $\mathbf{C^B}$ codes for black feathers and the allele $\mathbf{C^W}$ 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)

Q12. Malaria is a disease caused by a parasite. Scientists investigated the effect of malaria on competition between two species of *Anolis* lizard on a small Caribbean island. They sampled both populations by collecting lizards from a large number of sites on the island.

(a) (i) Explain the importance of collecting lizards from a large number of sites.

.....

.....

.....

(1)

(ii) Describe **one** method the scientists could have used to ensure that the sites were chosen without bias.

.....

.....

.....

.....

.....

(2)

(iii) The population number of both species of lizard varied at different times of the year. Suggest **two** reasons why.

1.....

.....

2.....

.....

(2)

The scientists investigated the percentage of lizards of both species that were infected with malaria at different sites on the island. They collected samples of both lizards at intervals of 3 months for 1 year. They also recorded the elevation (height above sea level) of each site. Some of their results are shown in the table.

Site	**Elevation of collection site / metres**	**Total number of *A. gingivinus* collected in one year**	**Percentage of *A. gingivinus* infected with malaria**	**Total number of *A. wattsi* collected in one year**	**Percentage of *A. wattsi* infected with malaria**
1	10	13	0	0	0
2	80	30	0	0	0
3	120	35	23	3	0
4	200	40	30	7	0
5	300	52	46	12	0
6	315	35	31	13	1
7	370	155	37	79	2
8	414	124	44	68	4

(b) When analysing their results, the scientists used the percentage of lizards infected at each site, rather than the number of lizards infected. Explain why.

.....

.....

.....

.....

.....

(2)

(c) A preliminary study suggested that malarial infections were more common at higher elevations. Use the information provided to evaluate this suggestion.

.....

.....

.....

.....

.....

(2)

(d) (i) As a result of this investigation, the scientists concluded that the presence of malaria provided a competitive advantage to *A. wattsi.* Use the information provided to explain how they reached this conclusion.

.....

.....

.....

.....

.....

(2)

(ii) The malarial parasite of *Anolis* lizards destroys both red and white blood cells.Suggest how an increase in the percentage of *A. gingivinus* infected with malaria could result in *A.wattsi* having a competitive advantage.

.....

.....

.....

.....

.....

(2)

(iii) The scientists carried out a statistical test to determine whether the correlation between the number of *A. wattsi* collected and the percentage of *A. gingivinus* infected was significant. They obtained a value for P of < 0.01.

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

.....

.....

.....

.....

.....

(2)
(Total 15 marks)

Q13. Cows suffer from heat stress when the environmental temperature is too high. Heat stress occurs when their core body temperature rises above 39.4 °C. The table shows how environmental temperature affects the food intake, water intake and milk production of cows in a fixed period of time.

Environmental temperature / °C	Food intake / kg	Water intake / dm^3	Milk production / dm^3
20	18.2	81.8	27.0
25	17.7	88.6	25.0
30	17.0	95.0	22.9
35	16.7	144.1	18.0

(a) Calculate the percentage decrease in milk production between the temperatures of 30 °C and 35 °C. Show your working.

Answer ..... %

(2)

(b) Suggest how each of the following responses helps to maintain core body temperature.

(i) The change in water intake as environmental temperature increases.

.....

.....

.....

(1)

(ii) The change in food intake as environmental temperature decreases.

.....

.....

.....

.....

.....

(2)

(c) Explain the change in milk production as environmental temperature increases.

.....

.....

.....

(1)

(d) The rectal temperatures of cows are recorded to monitor heat stress. This is a better measurement of core body temperature than measuring the temperature of the skin. Explain why.

.....

.....

.....

.....

.....

(2)

(e) Selective breeding can be used to produce cows with desirable features. This involves mating cows with bulls. Suggest how a bull is selected to increase the probability of producing cows with a high milk yield.

.....

.....

.....

(1)

Milk contains lactose. Human babies produce the enzyme lactase, which digests lactose. Many human adults do not produce lactase and are lactose intolerant.

People who are lactose intolerant can become very ill if they drink milk or eat dairy products, such as butter and cheese.

(f) Scientists have recorded the percentage of adults who are lactose intolerant in different countries. Explain the advantage of using percentages in this type of study.

.....

.....

.....

.....

.....

(2)

(g) The scientists found that the percentage of people who can tolerate lactose is much higher in populations that drink a lot of milk and eat a lot of dairy products.

Use your knowledge of natural selection to explain this finding.

.....

.....

.....

.....

.....

.....

.....

.....

(Extra space) .....

.....

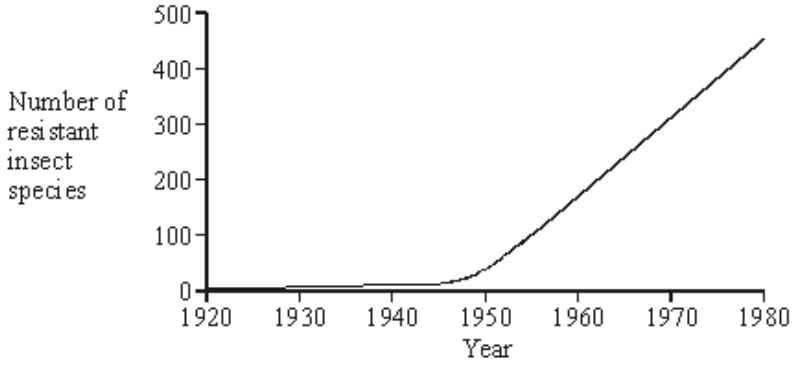
.....

.....

(4)

(Total 15 marks)

Q14. The graph shows the number of species of insects reported to be resistant to at least one insecticide between 1920 and 1980.



(i) Suggest **one** reason why there was a rapid rise in resistant species after 1950.

.....

.....

(1)

S (ii) Explain how an insect population can become resistant to an insecticide.

.....

.....

.....

.....

.....

.....

(3)
(Total 4 marks)