1 Wheat is an important food crop in many European countries. Developments in farming allowed the yield of wheat produced by farms in the UK to increase rapidly in the second half of the 20th century.

Fig. 4.1 shows the increase in the yield of wheat from 1947 to 1992. The graph also shows the increase that is thought to be as a result of the development of new varieties through selective breeding.

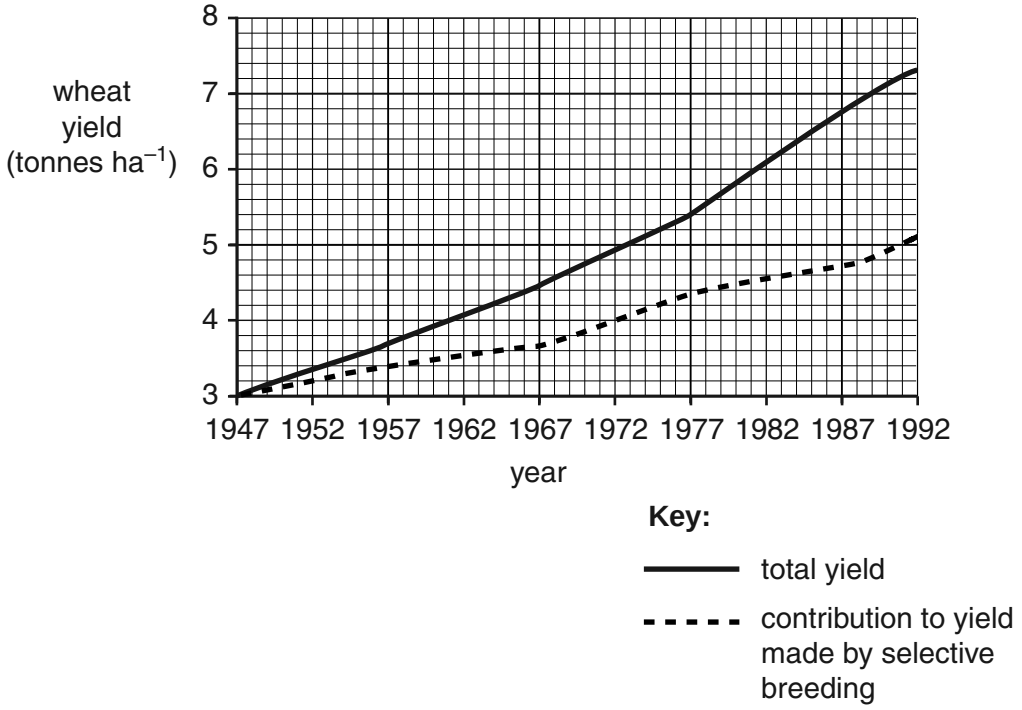

Fig. 4.1

(a) Use the graph to calculate the mean annual increase in total wheat yield between 1947 and 1992. Give your answer to **three decimal places**.

Show your working and include units with your answer.

Answer = ...

Units ..... **[3]**

(b) Explain how the selective breeding that led to this increased yield could have been done.

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..... **[4]**

(c) State **two** developments, other than selective breeding, that could account for the total increase in wheat yield per hectare.

1 .....

2 .....
[2]

[Total: 9]

2 This question looks at two ways of using mathematical concepts in Biology.

(a) When a new road system was constructed, it split a population of a rare snail species into three smaller populations, **A**, **B** and **C**. As a result, each of these populations became reproductively isolated.

The Hardy-Weinberg principle was used to calculate the relative frequencies, p and q, of a dominant and a recessive allele in each population.

Table 4.1 shows the values of p and q, and the estimated sizes of these three populations.

Snail population	Estimated population size	Immediately after road building		10 years after road building	
		p (frequency of dominant allele)	q (frequency of recessive allele)	p (frequency of dominant allele)	q (frequency of recessive allele)
A	1000	0.50	0.50	0.52	0.48
B	100	0.49	0.51	0.63	0.37
C	10	0.40	0.60	0.20	0.80

Table 4.1

(i) Name the type of isolating mechanism that prevents interbreeding between these three snail populations.

..... **[1]**

(ii) The habitat of these snail populations did not change over the ten years.

State the term used to describe the **random** changes in allele frequency in a small population.

..... **[1]**

(iii) Explain which of the populations, **A**, **B** or **C**, experienced most genetic change.

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..... **[2]**

(b) The inheritance of different alleles in fruit flies, *Drosophila* spp., has been studied extensively in the laboratory.

Two genes that affect the appearance of *Drosophila* are:

R / r red / pink eyes
Y / y yellow / ebony body

Flies known to be heterozygous at both of these loci were crossed with homozygous pink-eyed ebony flies.

Based on the hypothesis that the two genes assort independently, the offspring expected from this cross would be four different phenotypes in a ratio of 1:1:1:1.
The results obtained, however, are shown in Table 4.2.

Phenotype	Expected number	Observed number
Red eye, yellow body	360	6
Pink eye, yellow body	360	701
Red eye, ebony body	360	729
Pink eye, ebony body	360	4

Table 4.2

The chi-squared (χ^2) test can be used to assess whether the results in Table 4.2 are significantly different from the expected results.

The equation for working out the value of χ^2 is given below.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where Σ = 'sum of …'
O = observed value
E = expected value

(i) Calculate the value of χ^2 **to the nearest whole number** for the genetic cross results shown in Table 4.2.

Complete the table below and determine the value of χ^2.

Phenotype of fly	**O – E**	**$(O - E)^2$**	**$\frac{(O - E)^2}{E}$**
Red eye, yellow body	–354	125 316	348
Pink eye, yellow body	341	116 281	323
Red eye, ebony body			
Pink eye, ebony body			

χ^2 = ... **[3]**

(ii) Statistical tables show that, for this data set, if χ^2 has a value of 11.35, the observed results would only be produced by chance in 1% of trials.

Use this information and the value for χ^2 that you have calculated in **(i)** to explain whether the original hypothesis should be accepted or rejected.

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..... **[1]**

(iii) The difference in the observed numbers from the cross compared with the expected numbers has **not** occurred by chance. Suggest a genetic explanation for this difference.

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..... **[3]**

[Total: 11]

3 A breed of cattle, known as Chillingham cattle, is thought to resemble the wild cattle from which modern domestic breeds have been produced.

Fig. 7.1 shows one of the Chillingham cows and Fig. 7.2 shows a modern cow.

Fig. 7.1 Chillingham cow

Fig. 7.2 modern cow

(a) (i) Suggest **one** feature of the Chillingham cow that is likely to have changed during selective breeding to increase productivity.

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..... **[1]**

(ii) Describe how modern cattle have been produced from less productive wild cattle ancestors.

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..... **[4]**

(b) Many people in the UK consume large amounts of milk and beef.

Over-consumption of milk and beef can lead to an unbalanced diet and malnutrition.

(i) Define the term *balanced diet.*

.....

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..... **[2]**

(ii) Milk and beef both contain triglyceride molecules.

Fig. 7.3 represents a triglyceride molecule.

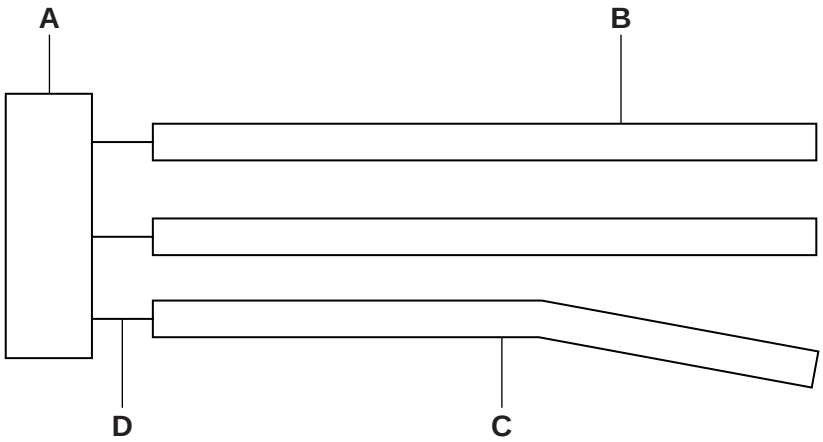

Fig. 7.3

Identify **A**, **C** and **D** on Fig. 7.3.

A .....

C .....

D .....

[3]

(iii) Suggest and explain why over-consumption of milk and beef can lead to malnutrition.

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..... **[3]**

(c) In the past, beef was preserved by adding salt.

Explain how salting preserves food.

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..... **[3]**

[Total: 16]

4 **(a)** Fig. 6.1 shows a number of examples of inheritance.

A	An *Antirrhinum* plant with red flowers is crossed with one that has white flowers. All the offspring have pink flowers.
B	A haemophiliac man has children with a woman who is not a haemophiliac. Their daughters all carry the allele for the disease, but their sons do not have the disease.
C	Two *Salvia* plants with purple flowers are crossed. The offspring are produced in the ratio 9 purple-flowered : 3 pink-flowered : 4 white-flowered.
D	A short-haired black mouse crossed with a long-haired brown mouse produces all short-haired black offspring. Mating one of these offspring with the long-haired parent produces mice in the ratio of 1 short-haired black : 1 long-haired black : 1 short-haired brown : 1 long-haired brown.
E	Two snails with plain shells produce 34 offspring with plain shells and 12 with striped shells.

Fig. 6.1

Complete the table below, by matching each of the examples **A** to **E** to the correct explanation of their pattern of inheritance.

Explanation	Letter of example
One gene with two alleles. The alleles show codominance.	
One gene with two alleles located on an autosome (gene not sex linked). One allele is dominant and the other is recessive.	
Two genes for two different characteristics on two different chromosomes.	
A sex linked gene with a dominant and a recessive allele.	
Epistasis, where two genes interact to affect one phenotypic character.	

[5]

(b) The Hardy-Weinberg principle, represented by the equations below, can be used to estimate the frequency of alleles in a population.

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

Albino rabbits have white fur as these individuals are unable to produce the pigment melanin. The ability to produce melanin is controlled by a gene with a dominant allele (B), resulting in brown fur, and a recessive allele (b), resulting in an albino.

Of the 60 rabbits in a pet shop, 45 are brown.

(i) A student decided to use the Hardy-Weinberg principle to estimate the frequencies of the alleles in this group of rabbits.

Using the Hardy-Weinberg equations, calculate the frequency of the dominant allele in this group.

Show your working.

Frequency of the dominant allele = ... **[3]**

(ii) Give **two** reasons why it was not appropriate to use the Hardy-Weinberg principle to estimate the frequencies of alleles in this group of rabbits in the pet shop.

1 .....

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2 .....

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[2]

[Total: 10]

5 Domestic chickens have been bred for many years to increase the number of eggs laid by the females. It is useful to be able to identify the young female chicks on the day after they hatch, as only the females need to be kept for laying eggs.

Unlike mammals, where the sex chromosomes are known as X and Y, in chickens the sex chromosomes are known as Z and W.

- Male chickens have two Z chromosomes (ZZ).
- Female chickens have one Z chromosome and one W chromosome (ZW).

(a) Some genes for feather colour and pattern in chickens are carried on the Z chromosome but not on the W chromosome. One such example is the gene for striped feathers (barring).

State the name given to this type of inheritance.

..... **[1]**

(b) Inheritance of the barring pattern can be used to identify female chicks when they are one day old.

The phenotypes associated with the two alleles of the barring gene are shown in Table 1.1.

Allele	Adult phenotype	Day-old chick phenotype
dominant **B**	black feathers striped with white bars (barred)	black body with a white spot on head
recessive **b**	black feathers (non-barred)	black body and head

Table 1.1

(i) State the **adult phenotypes and sex** of the following individuals:

Z^BZ^b .....

Z^BW .....

Z^bW .....

[3]

(ii) A cross was carried out between a barred female and a non-barred male.

Complete the genetic diagram to show the parental genotypes, their gametes and the F1 genotypes. State the phenotypes of the offspring as **day-old chicks**.

Parent phenotypes	**Barred female**	**Non-barred male**
Parent genotypes	.....	.....
Gametes	.....	.....
F1 genotypes	.....	.....
F1 day-old chick phenotypes		

male .....

.....

female .....

..... **[5]**

(c) The autosomal gene **I / i** shows epistasis over **all** other genes affecting feather colour in chickens.

Individuals carrying the dominant allele **I** have white feathers.

Chickens that are not white have the genotype **ii**.

(i) State the precise term used to describe the genotype **ii**.

..... **[1]**

(ii) Predict the colour(s) of the offspring of a cross between a male homozygous barred chicken and a white female chicken with the genotype **II**.

..... **[1]**

[Total: 11]