Patterns of Inheritance

Model Answers 1

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Genetics, evolution and ecosystems
Topic	Patterns of inheritance
Booklet	Model Answers 1

Time allowed: **49 minutes**

Score: **/36**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

Selection pressure can affect homozygous individuals. The effect can be investigated using a model gene pool.

A large gene pool is necessary to ensure that

A genetic drift can occur if frequency is higher.

B homozygous individuals are present in high frequency.

C the effect of chance variations in gene frequencies are minimised.

D Hardy–Weinberg equilibrium is achieved.

[1]

Small gene pools and inbreeding lead to genetic drift and homozygosity. Large gene pools have the genetic variety for populations to adap

Four different eye pigments in the fruit fly, *Drosophila melanogaster,* are made from the amino acid tryptophan. A simplified metabolic pathway of pigment production is shown in Fig. 2.1.

Three different gene loci control the pathway. Each locus has two alleles. These alleles are **V** or **v**, **C** or **c** and **B** or **b**, as shown in Fig. 2.1.

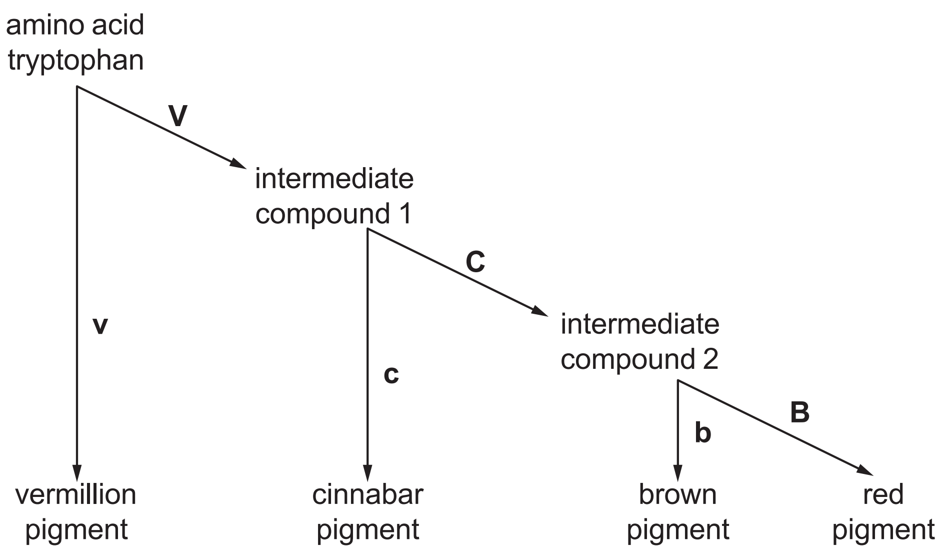


Fig. 2.1

(a) (i) Using the information in Fig. 2.1, deduce the phenotypes of flies with the following genotypes:

[3]

genotype	*phenotype*
VvCcBb	red
vvCCBB	vermillion
VvccBB	cinnabar

(ii) State the term that is applied to this type of gene interaction. **[1]**

- Epistasis is when the presence of one gene affects the expression of another

(iii) Explain how the products **coded for** by the genes interact to give the different pigments.

- This is a multi-step pathway **[3]**
- Where the product of one reaction becomes the substrate of the next reaction
- The products of the genes are enzymes which catalyse each step of the pathway
- The dominant allele gives rise to an active or functional enzyme
- The recessive allele gives rise to an enzyme that does not catalyse the reaction

(b) A mutation in another gene at another locus in *Drosophila* gives rise to white-eyed flies. The red eye allele of this gene (**R**) is known to be dominant to the white eye allele (**r**).

A student crossed a red-eyed fly with a white-eyed fly, expecting to get an F1 generation of red-eyed flies. In fact, the results were as shown in Table 2.1.

Table 2.1

phenotype of fly	number of offspring
red-eyed female	27
red-eyed male	0
white-eyed female	0
white-eyed male	23

(i) The student first suggested that the reason for there being red-eyed and white-eyed flies in the offspring was that the red-eyed parent was heterozygous.

Explain why this **cannot** be the correct explanation for the results shown in Table 2.1.

[2]

- If the red eyed parent was heterozygotes there would be no difference between males and females
- Red eyed males and white eyed females would occur
- the colours of eyes would be evening distributed throughout males and females in a 3:1 ratio of red eyes to white eyes.

If a condition is sex linked then it is carried on the X chromosome. This affects males and females differently because males have only one X chromosome, so whichever allele is present it will be expressed in the phenotype and the ratio of males phenotypes will be different to females.

(ii) In *Drosophila*, the males are the heterogametic sex, possessing two different sex chromosomes, X and Y.

Draw a genetic diagram to show how the results shown in Table 2.1 could have been produced.

[3]

Parental genotypes ....XrXr............ ....XRY............

Gametes ....Xr............ ....XR and Y............

F_1 genotypes ....XRXr............ ....XrY............

(iii) The chi-squared (χ^2) test can be used to analyse the results in Table 2.1.

The expected ratio of red-eyed females to white-eyed males is 1:1.

Use Table 2.2 to calculate a value for chi-squared (χ^2).

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} \qquad df = n - 1$$

Key to symbols:
Σ = 'sum of …'
df = degrees of freedom
n = number of classes
O = observed value
E = expected value

Table 2.2

phenotype of fly	O	E	O – E	$(O - E)^2$	$\frac{(O-E)^2}{E}$
red-eyed female	27	25	2	4	0.16
white-eyed male	23	25	-2	4	0.16

Use your calculated value of χ^2 and the table of probabilities shown in Table 2.3 to test the significance of the difference between the observed and expected results.

State your conclusion in the space below. **[4]**

Table 2.3

degrees of freedom	probability, p			
	0.90	0.50	0.10	0.05
1	0.02	0.45	2.71	3.84
2	0.21	1.39	4.61	5.99

Conclusion

- X^2 is 0.32
- There is no significant difference (at the 95% confidence level)

Statistically significant is the likelihood that a relationship between two or more variables is caused by something other than chance.

[Total: 16]

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.

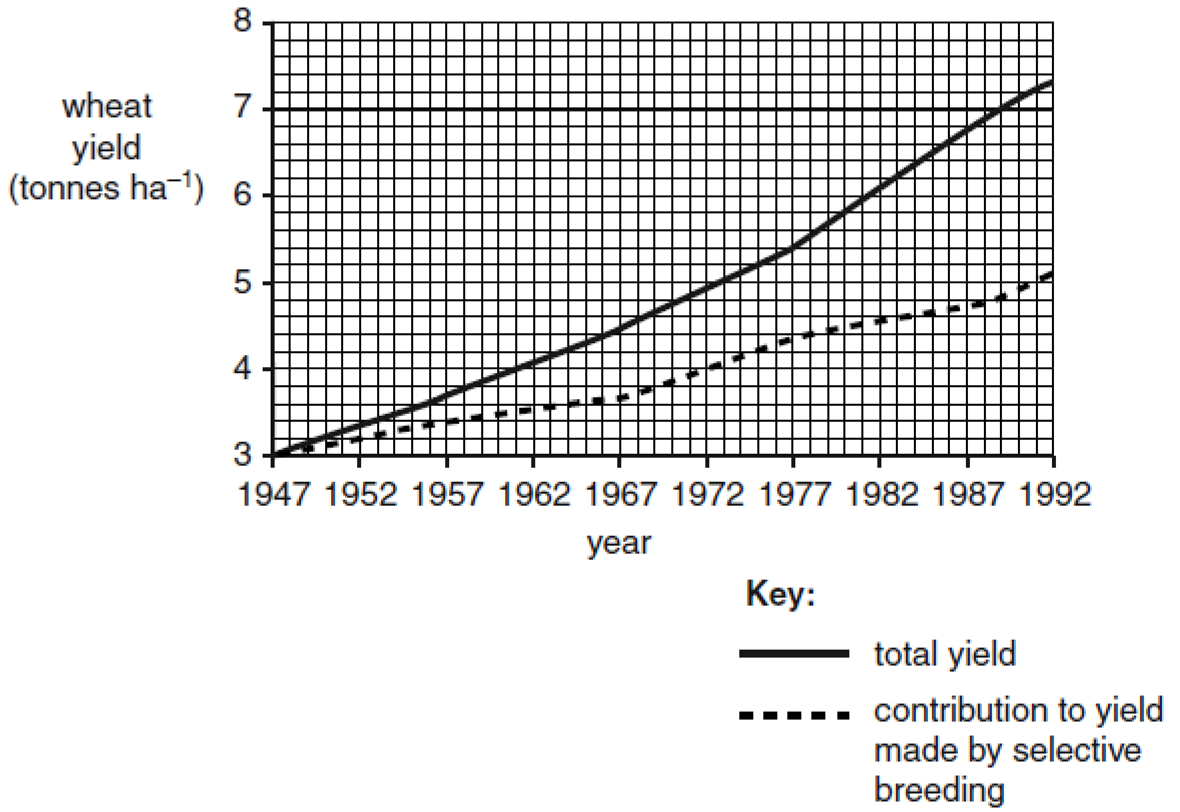
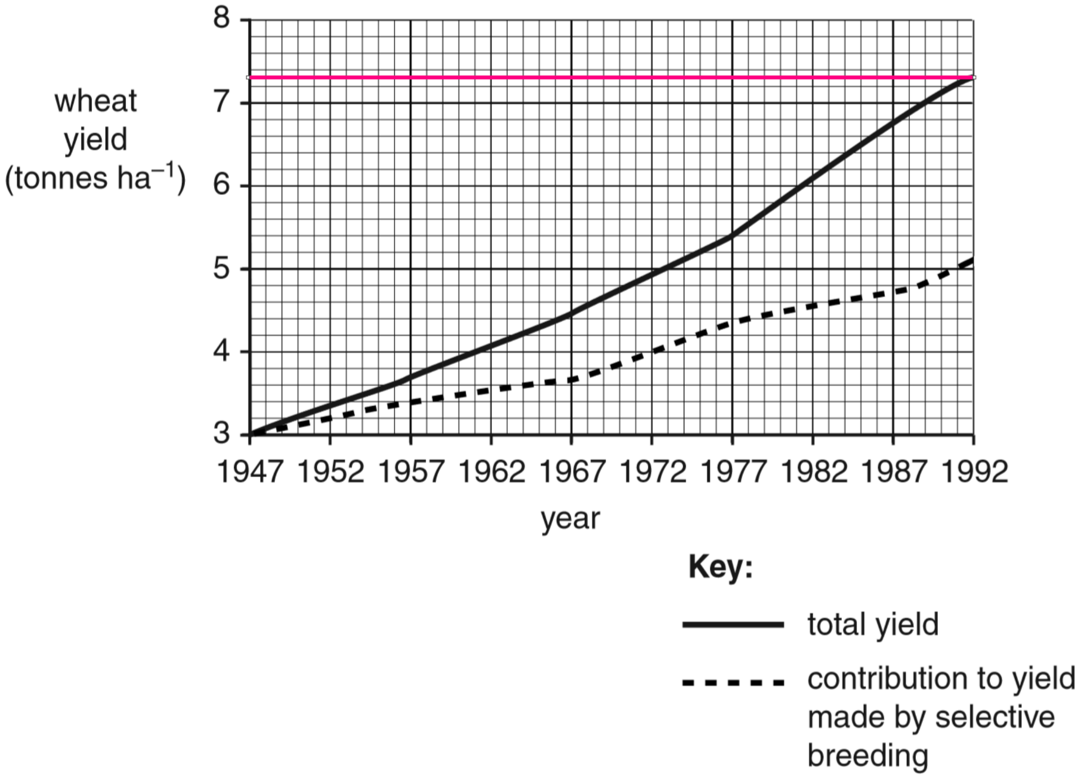


Fig. 4.1

(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. **[3]**



Goes from 3.0 tonnes in 1947 to 7.3 tonnes in 1992

= 4.3 tonnes in 45 years

So per year is 4.3/45

- = 0.096
- tonnes ha-1 y-1

(b) Explain how the selective breeding that led to this increased yield could have been done. **[4]**

- crossbreed high-yielding wheat plants
- measure the yield
- crossbreed best offspring
- over generations
- prevent self-pollination

***Note**: selective breeding requires the selection of characteristics that are beneficial for humans. The individuals who demonstrate these characteristics are bred together. Their offspring are assessed and those that demonstrate these characteristics the best will then be crossbred. This continues over many generations and over time the characteristics will become more present in the population.*

(b) State **two** developments, other than selective breeding, that could account for the total increase in wheat yield per hectare. **[2]**

- use of fertiliser
- use of pesticide
- improved technology

[Total: 9]

(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.

[5]

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

A is an example of co-dominance, as both alleles are equally dominant (red is dominant and white is dominant) and therefore are both expressed in the phenotype (pink flowers are a mix of red and white).

B is haemophilia, which is caused by a recessive allele at a gene locus on the X chromosome. As women have two X chromosomes, they can inherit one recessive and one dominant version of the gene, and hence be carriers. Whereas men (XY), only have one X chromosome; so if they inherit a recessive allele they have the disease. Genes associated with the sex chromosomes are said to be sex-linked.

C shows a ratio of offspring to be 9:3:4; this is an example of a ratio shown between two genes that interact with one another (epistasis).

D is an example of dihybrid inheritance, as we are looking at the inheritance of two different genes (one for fur length and one for fur colour). A ratio of 1:1:1:1 is an expected ratio, suggesting that there is no gene interaction.

E is an example of monohybrid inheritance, as we are only looking at one gene (shell patterning). There is no indication that this is linked to the snails' gender. When two heterozygotes are crossed we expect a 3:1 ratio of dominant phenotype: recessive; this is what we see here, with the plain pattern being dominant over striped.

(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. **[3]**

Subtract the number of brown rabbits (45) from the total population (60) to find the number of albino rabbits.

60 – 45 = 15

Therefore the proportion of albino rabbits (bb) in the population is this value over the total number. This is equivalent to q^2 in the first given Hardy-Weinberg equation.

$q^2 = 15 / 60 = 0.25$

From this, we can then work out the value of q, by square rooting. This refers to the frequency of the recessive b allele within the population:

$q = \sqrt{0.25} = 0.5$

The frequency of the dominant allele in this population can be found by calculating p. We can use the second given Hardy-Weinberg equation to calculate this (1- q):

1 – 0.5 = 0.5

Therefore p = **0.5**

Exam tip: *make show you clearly show your working here, step by step*

(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.

[2]

There are several assumptions that the Hardy- Weinberg equations take, for these equations to apply to populations. There are several of these that will not be happening within a population in a pet shop:

- In the pet shop, the population is **not sufficiently large enough** to justify using the principle.
- The Hardy-Weinberg Principle is designed for **random mating in populations** which is not occurring within the pet shop.
- Equally not all members of the population are **breeding**
- The non- brown rabbits may be colours other than white (i.e. there may be more than two alleles for this gene in the population)

[Total: 10]