Patterns of Inheritance

Model Answers 2

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Genetics, evolution and ecosystems
Topic	Patterns of inheritance
Booklet	Model Answers 2

Time allowed: **43 minutes**

Score: **/32**

Percentage: **/100**

Grade Boundaries:

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

Question 1

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]**

- This type of inheritance is sex linked or non-autosomal

Usually, males are XY and sex linked genes are carried on the X chromosome. There is a pair of sex chromosomes in humans (X and Y) leaving 22 more pairs called autosomes hence the other term for sex linked conditions which is non-autosomal

(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: **[3]**

Z^BZ^b .... barred male

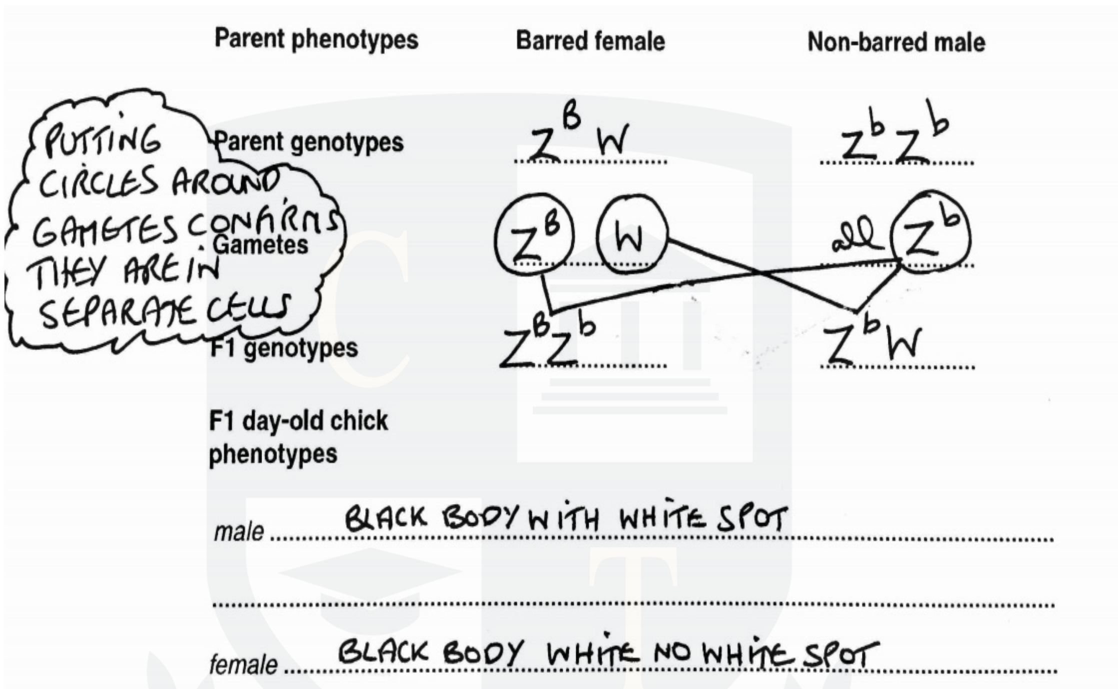
Z^BW .... barred female

Z^bW .... non barred female

Note the question refers to the adult phenotype and sex

(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**. **[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]**

- Homozygous recessive

(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]**

- All white

[Total: 11]

Question 2

A long-term breeding experiment to investigate the **genetic** basis of tame (friendly) behaviour was carried out in a population of silver foxes. The foxes were bred each year and the resulting young foxes assessed each month between the ages of 1 and 8 months to see how tame they were.

Table 6.1 shows how the foxes were put into categories according to their tameness.

Table 6.1

tameness class	description of behaviour towards humans
3	Not tame – these foxes run away from humans or bite when handled.
2	Neutral – these foxes allow handling by humans but show no emotionally friendly response.
1	Tame – these foxes are friendly to humans. They wag their tails and whine for attention.
elite	Very tame – these foxes are eager for human contact. They whimper to attract attention and sniff and lick humans.

The tamest 5% of the male foxes and the tamest 20% of the female foxes in each generation were used for breeding to produce the next generation. This was repeated for over forty generations.

(a) **(i)** State the name given to the process in which only a certain percentage of adult foxes were chosen by humans to breed in each generation.

[1]

- Artificial selection or selective breeding are both processes where humans decide which organisms to breed

The problem faced with selective breeding programmes is **inbreeding**, that is mating between closely related members of the same species. It leads to a small gene pool and lack of genetic diversity, the population is at risk of **genetic drift** and is less able to tolerate change. The chance of recessive alleles being homozygous is greater so they will be expressed in the phenotype more often. A weak immune system is a common example of inbreeding.

(ii) Suggest why 20% of the female foxes were used for breeding but only 5% of the male foxes.

[2]

- Males can mate several times to father many offspring
- Whereas females can only give birth to a few offspring
- More females than males are needed to maintain numbers in each generation
- Larger numbers of females are needed to try to increase the size of the gene pool
- A larger gene pool reduces the problem of inbreeding

(b) Table 6.2 shows the number of foxes in the elite tameness class during the long-term experiment.

Table 6.2

number of generations	foxes in elite class (%)
10	18
20	35
35	75

Discuss what the results shown in Table 6.2 suggest about the **causes of the variation** in tameness behaviour in silver foxes.

[3]

- The results suggest that the cause of variation in tameness is genetic
- Originally the allele must have arisen by mutation
- As the number of generations passes, the percentage of foxes in the elite class increases
- This increase is the result of selective breeding
- Selective breeding increases the frequency of the allele for tameness

Allele frequencies are the proportions of an allele circulating in the gametes of a population. They will always add up to one as they are fractions of the same gene, which has two versions or alleles. In Hardy Weinberg the frequency of the recessive allele is represented by q and the frequency of the recessive allele by p.

(c) As tameness increased in the silver fox population over the years, it was noticed that other phenotypic traits also became more common.

Table 6.3 compares the frequency of these traits in a control group of silver foxes that had not been used in this long-term breeding experiment and in the tame population of foxes.

Table 6.3

phenotypic trait	animals showing trait (per 100 000)		percentage increase in trait
	control population	tame population	
white patch of fur on head	710	12400	1646
floppy ears	170	230	35
short tail	2	140	6900
curly tail	830	9400	1033

Students were asked to suggest a variety of genetic hypotheses to explain why these traits become more common in tame foxes. Their suggestions were:

linkage **epistasis** **inbreeding** **genetic drift**

Select **one** hypothesis from the list and explain how it could account for the data in Table 6.3.

[2]

Linkage

- When genes are on the same chromosome they are said to be linked, so the characteristics for tameness must be on the same chromosome
- Genes on the same chromosome are inherited together

or

Epistasis

- When the product of one gene affects the expression of another
- Via an enzyme pathway

A gene codes for a protein, in this case an enzyme. The product of the enzyme reaction is then converted to a different product by another enzyme in a multi-step pathway

Or

Inbreeding

- When selecting for certain desirable characteristics there may be recessive alleles which are not expressed
- These are unintentionally selected for along with the chosen characteristics
- There is more chance of the recessive alleles being homozygous as the gene pool is small ie closely related

Or

Genetic drift

- Applies to a small population so any change in allele frequencies has a more profound effect
- There is a random chance that the alleles will be passed on

(d) Similar changes in tameness, colour and body shape are believed to have occurred in the 11 000 year period during which the grey wolf species, *Canis lupus*, evolved into the domesticated dog species, *Canis familiaris*.

Suggest how different types of isolating mechanism allowed dogs to evolve separately to wolves.

[3]

- Isolating mechanisms such as geographical
- Wolves avoid human contact whereas dogs are confined by humans
- Behavioural isolation
- Mating or courtship rituals are different or scents / pheromones fail to be recognised
- Mechanical isolation
- Large wolves cannot mate with small dogs or their genitalia are incompatible
- Gamete incompatibility
- Wolves and dogs may have different numbers of chromosomes
- Breeding time may be different or restricted to certain seasons

Speciation occurs over many generations when members of the same population become geographically separated by a barrier such as a stretch of sea. This is known as **allopatric speciation**, it can only occur however if the selection pressures on the two isolated populations are different and the better adapted survive. **Sympatric speciation** is really what we are discussing in this question. Members of the same population still occupy the same habitat but they develop into different species when for example, they feed on different plants that grow at different times of year or they depend upon them to lay their eggs or pollen/nectar is available at different seasons.

(e) Interbreeding between members of the wolf species and some dogs has been reported. However, there are some large breeds of dogs that cannot breed successfully with small dog breeds.

Use this information and your own knowledge to explain the problems of classifying wolves and different dog breeds according to:

- the biological species concept
  and
- the phylogenetic species concept.

[4]

- Members of the same species can interbreed to produce fertile offspring
- If they were separate species then they would not be able to interbreed as the question suggests
- Some large species of dog cannot interbreed with smaller dogs so they should be different species
- Phylogeny compares the genetic differences between organisms, this will be small between wolves and dogs
- The evolutionary relationship between wolves and dogs suggests they shared a recent common ancestor
- Phylogeny uses DNA profiling, DNA sequencing and proteomics to measure how closely related they are

On face value this question seems a bit vague and you have every right to feel a bit intimidated. Read the question though and there are two marks there already. Some dogs can't interbreed (so they should be different species) and some wolves and dogs can (so they should be the same species). Add to this the definition of species (biological concept) and there are 3 marks already.

Phylogeny isn't as hard as it sounds. If you looked at 3 DNA profiles from 3 species and compared the distance, width and number of bands, the ones with more in common are more closely related and shared a more recent common ancestor. That's their evolutionary relationship and that……is phylogeny. Easy.

[Total:15]

Question 3

For centuries, artificial selection has been used to improve the quality of crop plants used for human consumption.

Explain, with reference to selective breeding, why it is important to maintain viable wild populations of crop plant species.

[6]

- Wild populations provide genetic variation
- They act as a bank of genes
- They are a source of useful alleles
- They can be bred with varieties of crops
- There may be requirements in the future which are unknown
- They could be useful in a changing climate
- They could help to prevent inbreeding depression
- They could help to increase or at least maintain the size of the gene pool
- They could help to promote hybrid vigour

Inbreeding means reproduction between closely related individuals, this increases the chance of rare recessive alleles combining to be expressed in the phenotype, known as homozygosity. Inbreeding depression does not mean species become depressed but they show lack of vigour. In animals this is often a weak immune system. Key to this question is the size of the gene pool and adaptation to change.