Patterns of Inheritance

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.

Your answer ☐

[1]

2. A number of events occur for a new species to emerge in a population.

Which of the following statements correspond to events that are involved in the formation of a new species?

Statement 1: Gene mutation.
Statement 2: Selection pressure.
Statement 3: A change in the environment.

A. 1, 2 and 3
B. Only 1 and 2
C. Only 2 and 3
D. Only 1

Your answer ☐

[1]

3. Which of the rows, A to D, correctly describes how genetic variation is achieved during meiosis?

Row	Prophase 1	Metaphase 1	Metaphase 2	Anaphase 2
A	crossing over of sister chromatids	independent assortment of homologous chromosomes	independent assortment of chromatids	independent segregation of chromatids
B	crossing over of non-sister chromatids	independent segregation of chromatids	independent assortment of homologous chromosomes	independent segregation of chromosomes
C	crossing over of non-sister chromatids	independent assortment of homologous chromosomes	independent assortment of chromatids	independent segregation of chromatids
D	crossing over of sister chromatids	independent assortment of chromatids	independent assortment of homologous chromosomes	independent segregation of chromosomes

Your answer ☐

[1]

4. A pure-breeding long-wing red-eyed fly and a pure-breeding short-wing white-eyed fly were crossed. All the F1 offspring were long-wing and red-eyed. When members of the F1 generation were crossed the F2 generation included 27 flies with long wings and white eyes.

Which of the options, **A** to **D**, shows the observed results that most closely match the expected results for the number of long-wing red-eyed flies and short-wing red-eyed flies?

A. 92 long-wing red-eye and 31 short-wing red-eye
B. 27 long-wing red-eye and 29 short-wing red-eye
C. 86 long-wing red-eye and 11 short-wing red-eye
D. 27 long-wing red-eye and 88 short-wing red-eye

Your answer ☐

[1]

5. The haploid chromosome number in the koala, *Phascolarctos cinereus*, is 8.

Independent assortment of chromosomes in meiosis contributes to genetic variation in the gametes of the koala.

How many genetically different versions of koala gamete would it be possible for one individual to produce if independent assortment were the only source of genetic variation?

A 64
B 128
C 256
D 512

Your answer ☐

[1]

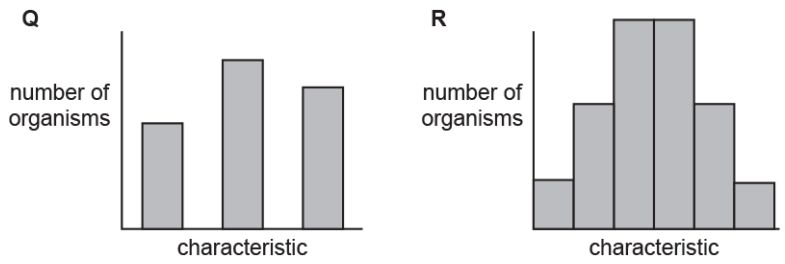
6. Which of the following statements about antibiotic resistance is correct?

A All antibiotics cause mutations in bacterial DNA.
B Antibiotic resistance in bacteria is evidence to support Darwin's theory of evolution by natural selection.
C The development of antibiotic resistance in bacteria is an example of genetic drift.
D The development of antibiotic resistance in bacteria is an example of stabilising selection.

Your answer ☐

[1]

7. The two histograms represent the frequency distribution for the two different types of variation.



Which of the statements, **A** to **D**, about characteristic **Q** is correct?

A controlled by many genes and unaffected by the environment
B controlled by one or two genes and unaffected by the environment
C controlled by many genes and influenced by the environment
D controlled by one or two genes and influenced by the environment

Your answer ☐

[1]

8. The adult wandering albatross, *Diomedea exulans*, has wingspans that range from 2.5 m to 3.5 m.

Which of the following describes the variation in wingspan of the wandering albatross?

A intraspecific and controlled only by genetic factors
B interspecific and controlled only by environmental factors
C intraspecific and controlled by both genetic and environmental factors
D interspecific and polygenic

Your answer ☐

[1]

9. Which of the following is **not** associated with the use of artificial selection in farm animals?

A health problems in more productive breeds
B inbreeding
C increased frequency of mutations
D reduced gene pool

Your answer ☐

[1]

10. The ability to roll one's tongue is under the control of a single gene. The gene has two alleles R and r.

People who can roll their tongues can have the genotypes RR or Rr. People who cannot roll their tongues have the genotype rr.

A survey by a student showed that 12% of the population in a single school cannot roll their tongues.

The student then used the Hardy-Weinberg principle to calculate the number of heterozygous individuals in the school.

Which of the following represents the percentage of heterozygous individuals at the student's school?

Use the equations: $p + q = 1$ and $p2 + 2pq + q2 = 1$

A 21.1%
B 22.7%
C 42.8%
D 45.3%

Your answer ☐ **[1]**

11. *Brassica rapa* is a plant that occurs in wild-type and dwarf varieties.

A student investigated the growth of *B. rapa*.

Seeds of both varieties were planted and the heights of stems were measured 20 days after planting.

The results are shown below.

Variety	Height after 20 days (cm)						
	Individual plants						Mean
	1	2	3	4	5	6	
Wild-type	90.7	94.5	87.4	82.7	92.0	91.5	89.8
Dwarf	6.5	8.0	7.4	7.8	8.3	7.8	7.8

Which of the following correctly explains the student's results?

A variation in height between varieties is continuous and polygenic
B variation in height between varieties is discontinuous and controlled by one or two genes
C variation in height within varieties is continuous and controlled only by one or two genes
D variation in height within varieties is discontinuous and polygenic

Your answer ☐ **[1]**

12. Scientists self-pollinated some pea plants that were heterozygous for the gene controlling height.

They expected a 3:1 ratio of tall plants to short plants in the offspring.

1046 plants grew in the next generation. 798 were tall and 248 were short.

Which of the following, **A** to **D**, is a statistical test that could be used to determine if these numbers are significantly different from a 3:1 ratio?

A chi-squared
B Spearman's rank
C standard deviation
D Student's t-test

Your answer ☐ **[1]**

13. Banana plants, *Musa* spp., first underwent artificial selection thousands of years ago. Early human populations discovered mutant banana plants that produced seedless, soft fruit. This mutation prevented pollen and seeds from developing.

Early human populations planted cuttings of these mutant plants. The bananas that are eaten today are descended from these cultivations.

Some scientists claim that banana crops will be extinct within a few years.

Use the information above to justify the scientists' claim.

---

[3]

14. Mitosis and meiosis are important in the life cycles of organisms.

Hydra is a small animal that lives in fresh water.

When conditions are not favourable, *Hydra* reproduces sexually. This often happens in the winter.

Cells in the body wall produce sperms and eggs by meiosis.

Large numbers of sperms are released into the water. These sperms can fertilise eggs from different individuals. Each egg forms a tough outer coat, and can lie dormant at the bottom of the water until conditions improve.

i. * Explain how sexual reproduction in *Hydra* leads to genetic variation in the offspring.

[6]

ii. Suggest why sexual reproduction in *Hydra* usually occurs in the winter.

[1]

15(a). In domesticated, farmed pigs, the following two traits have been studied:

The allele for curly tail, **T**, is dominant to the allele for straight tail, **t**.

The allele for pink skin (dermis), **D**, is dominant to the allele for black skin, **d**.

i. Draw a genetic diagram to show the results of crossing pigs that are heterozygous for both traits, tail and skin. Use the letters given above.

parental genotypes …… ……

gametes …… ……

F_1 offspring genotypes

---

offspring phenotypes

---

phenotype ratio

---

[5]

ii. Describe in words how this phenotypic ratio might be different if the two genes were autosomally linked.

---

[1]

(b). A pig farmer crossed one group of pigs, heterozygous for both traits, with another group homozygous recessive for both traits. The farmer expected to get roughly equal numbers of each of the four possible mixtures of tail and skin phenotype.
The results that actually occurred are shown in **Table 17.2.**

Phenotype	Observed, *O*	Expected, *E*			
curly pink	20	26			
curly black	30	26			
straight pink	21	26			
straight black	33	26			
straight black	33	26			

Table 17.2

i. The farmer thought from these results that the two genes might be autosomally linked.

Calculate x^2. (You may wish to use **Table 17.2** to write figures for steps in your calculation process.)

$$x^2 = \sum \frac{(O-E)^2}{E}$$

Answer…… **[3]**

ii. The farmer had concluded that the genes are linked.

Use your calculation and **Table 17.3** to justify whether the farmer's conclusion can be supported or not.

Degrees of freedom	Probability							
	0.95	**0.90**	**0.75**	**0.50**	**0.25**	**0.10**	**0.05**	**0.01**
1	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09

Table 17.3

---**[1]**

16(a). In pigeons, the male bird is homogametic (XX) and the female bird is heterogametic (XY).

Feather colour in pigeons is a sex-linked characteristic that is affected by one gene which has three alleles.

In female birds allele C^{r} produces ash red feathers, C^{br} produces brown feathers and C^{bl} produces blue feathers.

C^{r} is dominant to C^{br}, which is dominant to C^{bl}.

A pigeon breeder crossed an ash red male with a brown female. The two eggs hatched to produce one brown male and one blue female.

Use a genetic diagram to explain these results.

	Male	Female
Parental genotypes:		
Gametes:		
F1 generation genotype:		
phenotype:		

[4]

(b). Pigeons can live for 15 years in captivity. They are kept in small mixed flocks but tend to be monogamous (have one partner). Each season the female produces two eggs.

A student used a genetic diagram to show the breeder that over a number of generations the following ratio of offspring could be expected from the breeding pair.

1 ash red male : 1 brown male : 1 ash red female : 1 blue female

The breeder decided to test this prediction.

Over a number of breeding seasons records were kept of the offspring produced by the same pair of birds. Table 17.1 shows the results recorded by the breeder.

Year	Males		Females	
	Ash red	Brown	Ash red	Blue
1		1		1
2	1		1	
3		1		1
5**	1			1
6	1	1		
7	2			
8		1	1	
9		1		1
10	1			1
11	1		1	
total	7	5	3	5

** in year 4 there were two brown female chicks

Table 17.1

The chi-squared test can be used to assess the probability of achieving these observed results. The value of chi-squared is given by the formula:

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

i. Use Table 17.2 to calculate the value of chi-squared using the ratio predicted by the student as the expected results.

	Ash red male	Brown male	Ash red female	Blue female	Total
O	7	5	3	5	20
E	5	5	5	5	20
$(O-E)^2$					
$(O-E)^2$ / E					

Table 17.2

X^2 =.....

[2]

ii. The critical value of chi-squared for three degrees of freedom at a probability of 0.05 is 7.81.

What can you conclude about the observed results collected by the breeder in Table 17.1?

_____ **[1]**

iii. Explain why the observed results did not exactly match the predicted results.

_____

_____ **[1]**

(c). In year 4 the breeder noticed that the two chicks were brown feathered females. The student had not predicted that brown feathered females would be produced. The value of E for this category would be zero. Therefore the breeder had left this category out of the results table.

i. What effect would adding this unexpected result into the results table have on the value of chi-squared?

_____ **[1]**

ii. Assuming that the student had made an accurate prediction about the ratio of offspring, what might the breeder have concluded about the parents of the chicks in year 4?

_____ **[1]**

iii. Explain how you have reached this conclusion.

_____

_____

_____

_____

_____ **[2]**

17. The sweet pea plant has been used to study inheritance since the nineteenth century. The seeds of the sweet pea can vary in colour and shape.
The gene that controls colour has two alleles:

- **Y** is dominant and produces yellow seeds.
- **y** is recessive and produces green seeds.

The gene that controls shape has two alleles:

- **R** is dominant and produces round seeds.
- **r** is recessive and produces wrinkled seeds.

In the nineteenth century, Gregor Mendel crossed a pea plant that was heterozygous for both seed colour and shape with a pea plant that had green and wrinkled seeds.

i. List the gametes that would be produced by a sweet pea plant that was heterozygous for both seed colour and shape.

---

[1]

ii. List the genotypes of the offspring that were produced from Mendel's cross and state the corresponding phenotypes.

genotypes

---

phenotypes

---

[2]

18(a). Agammaglobulinemia and Vici syndrome are both genetic diseases.

Agammaglobulinemia results in a lack of mature B lymphocytes in a person's blood.

i. Suggest and explain one symptom of agammaglobulinemia.

---

[2]

ii. Fig. 4 shows the inheritance pattern of agammaglobulinemia in a family.

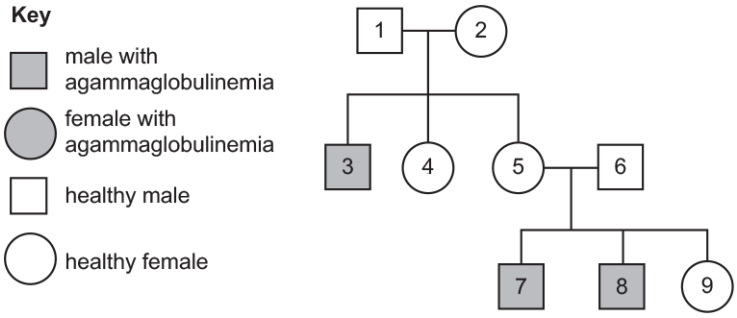


Fig. 4

What conclusions can you draw about the location and nature of the allele responsible for causing agammaglobulinemia? Explain your conclusions.

---

[4]

(b). Vici syndrome is a genetic disease that shows a recessive inheritance pattern. The allele responsible for Vici syndrome is found on chromosome 18.

i. Two carriers of Vici syndrome have six children.

Calculate how many of the six children you would expect to:

- have Vici syndrome
- be carriers of Vici syndrome.

Vici syndrome _____

Carriers _____

[1]

ii. A daughter of these parents and a male carrier of Vici syndrome have a child.

Calculate the probability of the child having Vici syndrome.

Answer = _____ **[1]**

19. The colour of onion bulbs is determined by two genes, **A/a** and **B/b**.

- **A** is a dominant allele and codes for the production of a red pigment.
- Onion bulbs that are homozygous for the recessive allele, **a**, produce no pigment and are white.
- **B** is a dominant allele that inhibits the expression of allele **A**.
- The recessive allele, **b**, allows the production of the red pigment.

A white onion plant was cross-pollinated with a red onion plant. All 15 offspring had the genotype **AaBb**.

i. Identify the following:

The genotype of the white onion plant .....

The genotype of the red onion plant .....

The phenotype of the offspring .....

[3]

ii. State the type of gene interaction shown by the genes **A/a** and **B/b**.

_____ **[1]**

iii. Suggest how allele **B** inhibits the expression of allele **A**.

_____

_____

_____

_____ **[2]**

20(a). The inheritance of some alleles depends on the sex of the individual.

In birds, sex is determined by a combination of **Z** and **W** chromosomes.

Male birds have two **Z** chromosomes and female birds have one **Z** chromosome and one **W** chromosome.

i. The chromosomes used to determine sex inheritance are given different letters in birds and mammals.

Identify one **other** way in which the sex determination in birds is different from sex determination in mammals.

_____

_____ **[1]**

ii. A pigeon is a bird. The colour of pigeon feathers is determined by a single gene on the **Z** chromosome.

The feather colour gene has three alleles.
$\mathbf{Z^A}$ = red
$\mathbf{Z^B}$ = blue
$\mathbf{Z^b}$ = brown

$\mathbf{Z^A}$ is dominant to $\mathbf{Z^B}$ and $\mathbf{Z^b}$
$\mathbf{Z^B}$ is dominant to $\mathbf{Z^b}$

The **W** chromosome contains no gene for feather colour.

A pigeon with the genotype $\mathbf{Z^A\ Z^b}$ was crossed with a pigeon with genotype $\mathbf{Z^BW}$.

Complete the answer lines below to show this genetic cross.

Parent genotypes: $\mathbf{Z^A\ Z^b}$ × $\mathbf{Z^BW}$

Parent phenotypes: _____ _____

Gametes: _____ _____

Offspring genotypes: _____

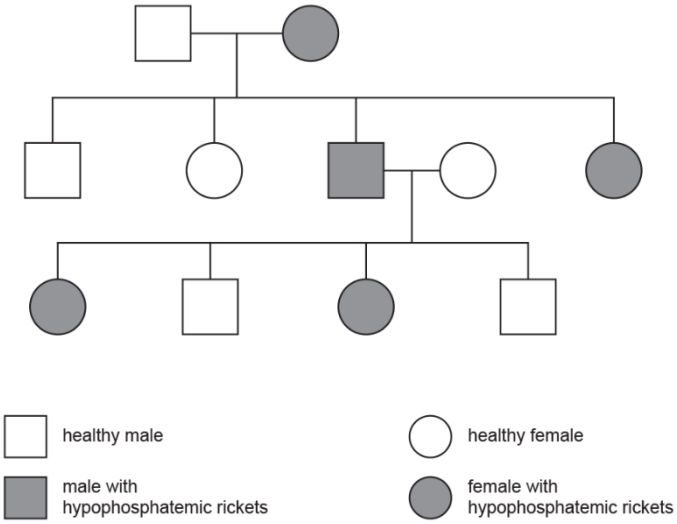
Offspring phenotypes: _____

_____

[4]

(b). Hypophosphatemic rickets is a sex-linked condition.

The diagram shows the occurrence of hypophosphatemic rickets in a single family.



What conclusions can be drawn about the inheritance of hypophosphatemic rickets?

Explain your answer.

_____

_____

_____

_____

_____ **[2]**

21. The sweet pea plant has been used to study inheritance since the nineteenth century. The seeds of the sweet pea can vary in colour and shape.
The gene that controls colour has two alleles:

- **Y** is dominant and produces yellow seeds.
- **y** is recessive and produces green seeds.

The gene that controls shape has two alleles:

- **R** is dominant and produces round seeds.
- **r** is recessive and produces wrinkled seeds.

When Mendel crossed two pea plants that were heterozygous for both seed colour and shape, the ratio of phenotypes in the offspring was:

- 9 yellow round
- 3 green round
- 3 yellow wrinkled
- 1 green wrinkled.

Some students tried to recreate this investigation using a modern variety of plant that showed the same phenotypic variation in seed colour and shape.

The students crossed two of the modern plants that were heterozygous for both seed colour and shape.
The results of this cross were:

- 58 yellow and round
- 31 green and round
- 21 yellow and wrinkled
- 2 green and wrinkled

The students used the chi-squared test to compare their data to the expected 9 : 3 : 3 : 1 ratio.

i. Use the chi-squared formula $\chi^2 = \sum \frac{(O-E)^2}{E}$ to calculate the x^2 value for these data.
You may use the table below for working out.

X^2= ---------- **[3]**

Table 17 shows a x^2 probability table.

Degrees of freedom	Probability (p)					
	0.95	**0.90**	**0.10**	**0.05**	**0.025**	**0.01**
1	0.00	0.02	2.71	3.84	5.02	6.64
2	0.10	0.21	4.61	5.99	7.38	9.21
3	0.35	0.58	6.25	7.82	9.35	11.34
4	0.71	1.06	7.78	9.49	11.14	13.28
5	1.15	1.61	9.24	11.07	12.83	15.09
6	1.64	2.20	10.64	12.59	14.45	16.81
7	2.17	2.83	12.02	14.07	16.01	18.48

Table 17

ii. After analysing the results, the students stated that the inheritance of the seed colour and shape in their investigation was different from that in Mendel's investigation.

Using Table 17, discuss whether the results of the investigation and the chi-squared test support the students' statement.

---

[3]

iii. A ratio that is different from the expected 9 : 3 : 3 : 1, in a cross such as this, can be the result of epistasis.

Suggest and explain one reason, **other** than epistasis, why the phenotype ratio might not be 9 : 3 : 3 : 1.

Suggestion

Explanation

---

[3]

22. Haemophilia in humans is a sex-linked disorder.

The recessive haemophilia allele is carried on the **X** chromosome.

Females who carry the recessive allele for haemophilia on one of their sex chromosomes do not show any symptoms.

A female who was a carrier of the haemophilia allele and a male who did not have the haemophilia allele had nine children. The expected ratio of phenotypes in the children of this couple would be 2 healthy females : 1 healthy male : 1 male with haemophilia.

i. A student performed a chi squared calculation on the phenotypes of the actual nine children.

Part of the calculation is shown in **Table 19.1**.

Phenotypes	**Observed number (O)**	**Expected number (E)**	**O–E**	**$(O–E)^2$**	**$\frac{(O–E)^2}{E}$**
Healthy female			0.5	0.25	0.056
Healthy male			0.75	0.56	0.249
Haemophilia male			–1.25	1.56	0.693
				χ^2 =	0.998

Table 19.1

Complete the table by filling in the columns for the observed and expected numbers.

[Answer on Table 19.1] **[2]**

ii. **Table 19.2** shows part of a statistical table for the chi squared test.

p%	**99**	**95**	**90**	**10**	**5.0**	**1.0**	**0.5**
v = **1**	.0001	.0039	.0158	2.706	3.841	6.635	7.879
2	.0201	0.103	0.211	4.605	5.991	9.210	10.60
3	0.115	0.352	0.584	6.251	7.815	11.34	12.84
4	0.297	0.711	1.064	7.779	9.488	13.28	14.86
5	0.554	1.145	1.610	9.236	11.07	15.09	16.75
6	0.872	1.635	2.204	10.64	12.59	16.81	18.55
7	1.239	2.167	2.833	12.02	14.07	18.48	20.28
8	1.646	2.733	3.490	13.36	15.51	20.09	21.95
9	2.088	3.325	4.168	14.68	16.92	21.67	23.59

Table 19.2

Identify the critical value for the chi squared test in part **(i)**.

Critical value = ... **[1]**

iii. The calculated value for χ^2 was below the critical value.

The student concluded that their expected ratio of 2 : 1 : 1 was incorrect and should be rejected.

Evaluate the student's conclusion.

---**[2]**

23. The apple tree, *Malus domestica*, is a species that humans have selectively bred.

Circumference and seed production, listed in Table 1.1, are two features of apple tree fruit that vary between individuals.

Complete Table 1.1 by writing the correct **word or phrase** in each box to describe the type of variation shown by each feature.

Feature	**Cause of feature**	**Number of genes involved**	**Type of graph used to present data**
Circumference (mm)			
Seed-containing / seedless			

Table 1.1

[3]

24.

i. It takes time for an effective vaccine to be prepared in quantity for a new strain of bacterium.

List two vulnerable groups of people for whom you would advise doctors to prescribe antibiotics although they are **not** yet showing symptoms of the new disease.

_____

_____ **[2]**

ii. Discuss the implications of the over-use of antibiotics when people do not show symptoms.

_____

_____

_____

_____

_____

_____

_____ **[4]**

25. * Read the following five statements.

Mutations preventing lactose intolerance have occurred in humans at various times in the prehistoric past, and in all human races.

The domestication of large lactating mammals like goats and cattle arose in Europe and parts of Africa 5 000 to 10 000 years ago.

The lowest levels of lactose intolerance are found in areas that European populations colonised, like North America.

The ability of agricultural populations to digest the milk, as well as the meat, of animals, is advantageous. It adds to their general nutrition.

Until recent times the Australian aborigines had been isolated on their island continent for around 50 000 years.

Suggest how the lactose intolerance phenotype came to be present in only 5% of a population like the Europeans, but came to be present in 97% of the Australian aborigines. Use the information given above and knowledge of Darwin's theory of evolution by natural selection.

[9]

26. Crude oil contains hydrocarbons.

Crude oil is often spilled from ships into the sea causing great damage to wildlife. The chemicals in crude oil are harmful to many species and do not break down quickly in the environment.

Some bacteria can break down the hydrocarbons in crude oil. These bacteria have been used by conservationists at sites where oil has been spilled.

Bacteria that are able to digest and metabolise the hydrocarbons in crude oil are more common in areas, such as around the coast of Alaska and the Gulf of Mexico, where oil spillages are common.

Suggest an explanation for this observation.

_____

_____

_____ **[1]**

27. The cheetah, *Acinonyx jubatus*, is a member of the cat family, Felidae.

Cheetahs display less intraspecific variation than other members of the family Felidae.

The population of cheetahs has been declining for the past 100 years and is estimated to be between 6000 and 7000.

Within the remaining cheetah population, intraspecific genetic diversity is very low.

One isolated population of cheetahs in Iran has fewer than 100 individuals.

i. State one way in which genetic diversity can be measured.

_____

_____ **[1]**

ii. It is thought that the modern cheetah population has low genetic diversity because the population, relatively recently, experienced a genetic bottleneck.
Explain why a genetic bottleneck can lead to low genetic diversity.

_____

_____

_____

_____

_____

_____ **[2]**

iii. Scientists are concerned about genetic drift in the remaining cheetah populations.
Explain why genetic drift is likely to be of particular concern in the population of 100 cheetahs in Iran.

_____

_____

---**[2]**

28(a). Charles Darwin visited the Galapagos Islands in the 1820s. The organisms living on the Galapagos Islands provided Darwin with evidence that helped him to develop his theory of evolution by natural selection.

Finches are small birds that are common on the Galapagos Islands.

The variation in the sizes of beak of the various Galapagos finch species provided evidence for evolution by natural selection.

Scientists recently studied the beak sizes of two species of Galapagos finch living on the same island, *Geospiza fuliginosa* and *Geospiza fortis*.

Beak size is an overall measurement that includes length, depth and width. The arbitrary units are relative to the average of all of the individual birds measured.

Some of the scientists' results are shown in **Fig. 20.1**.

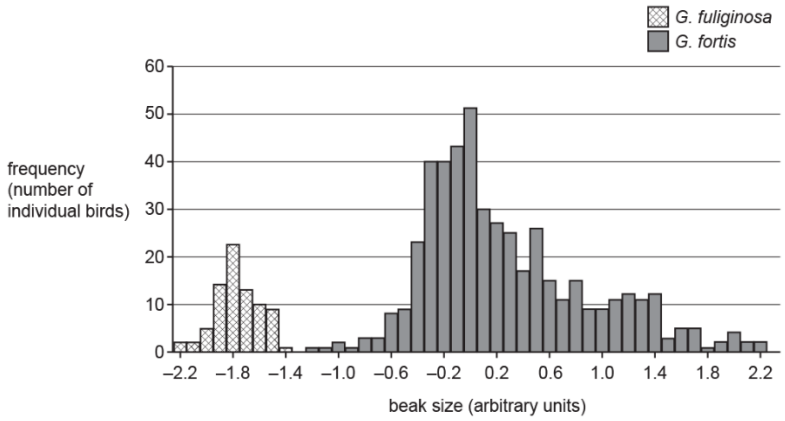


Fig. 20.1

i. Identify the modal beak size of *G. fuliginosa*.

Size = ... arbitrary units **[1]**

ii. Calculate the range of *G. fuliginosa* beak size as a proportion of the range of *G. fortis* beak size.

Give your answer to **2** significant figures.

Proportion = ... **[2]**

iii. The scientists concluded that the data showed evidence of disruptive selection in the population of *G. fortis*. In disruptive selection, extreme phenotypes are selected for and average phenotypes selected against.

Evaluate the conclusion that disruptive selection is occurring in *G. fortis*.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

(b). * In the 1970s, another group of scientists studied beak sizes in one species of finch on Daphne Island, one of the Galapagos Islands. The study lasted three years. The results are shown in **Fig. 20.2**.

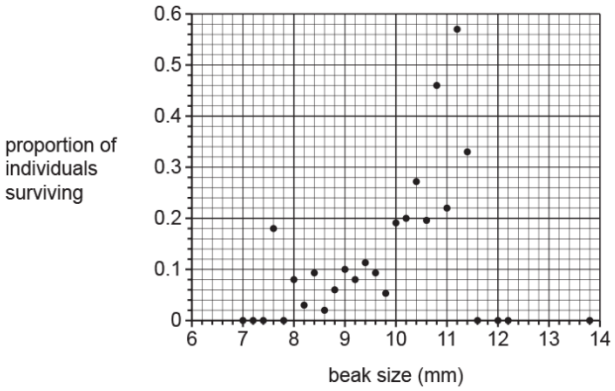


Fig. 20.2

The results suggested that stabilising selection was occurring within this population of finches.

With reference to **Fig. 20.2**, explain the effect of stabilising selection on beak size on Daphne Island.

_____

_____

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_____ **[6]**

29(a). The cheetah, *Acinonyx jubatus*, is a member of the cat family, Felidae.

Cheetahs display less intraspecific variation than other members of the family Felidae.

Fig. 20.1 shows the mean body length of a population of cheetahs from southern Africa.

The error bars on Fig. 20.1 show the standard deviation of mean body length.

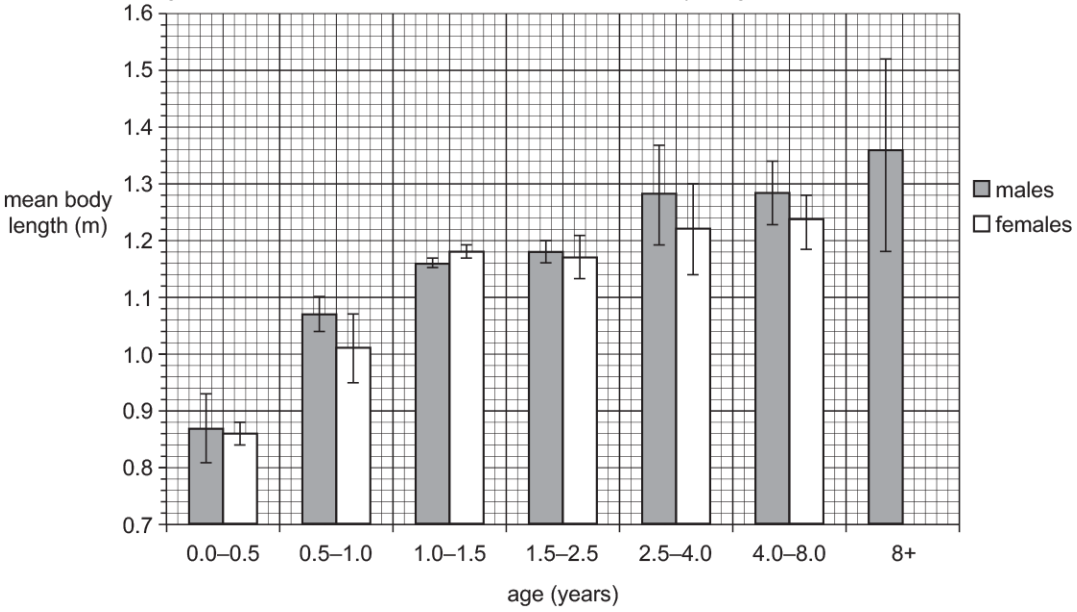


Fig. 20.1

i. At between 2.5 and 4 years old, the mean length of female cheetahs is less than that of males.

Calculate how much shorter than males female cheetahs are.

Show your working. Express your answer as a percentage to **two significant figures**.

Answer ..... % **[2]**

ii. Using only Fig. 20.1 and your answer to (i), what can be concluded about the **significance** of the difference between the length of male and female cheetahs aged between 2.5 and 4 years?

Explain your answer.

---

[2]

iii. A student looked at Fig. 20.1 and wrote:

"The longest male cheetah that was measured was 1.52 m long".

Explain whether the information in Fig. 20.1 supports the student's answer.

---**[1]**

iv. State the likely causes of variation in body length in cheetahs.

---**[2]**

(b). Madagascar is a large island off the coast of Africa that once formed part of the mainland.

The fossa, *Cryptoprocta ferox* is the top predator on Madagascar.

The fossa shares many physical similarities with cats but it is not a member of the family Felidae. It is related to the mongoose.

The mongoose is a much smaller mammal that lives on the African mainland.

Fig. 20.2 shows a fossa and a mongoose.

fossa  mongoose 

Fig. 20.2

i. The mongoose is a smaller mammal and also has proportionally longer fur. State **one** other difference, **visible in Fig. 20.2**, between a fossa and a mongoose.

---**[1]**

ii. When the island of Madagascar became separated from the African continent, there were no members of the cat family, Felidae, on the island.
Outline how a fossa could have evolved from a much smaller, mongoose-like ancestor.

---

[4]

iii. Islands, such as Madagascar, often have species that are different from those on the nearest land mass because they are reproductively isolated.
State **three** other conditions that must be present in order for speciation to occur.

1 ---

2 ---

3 ---

[3]

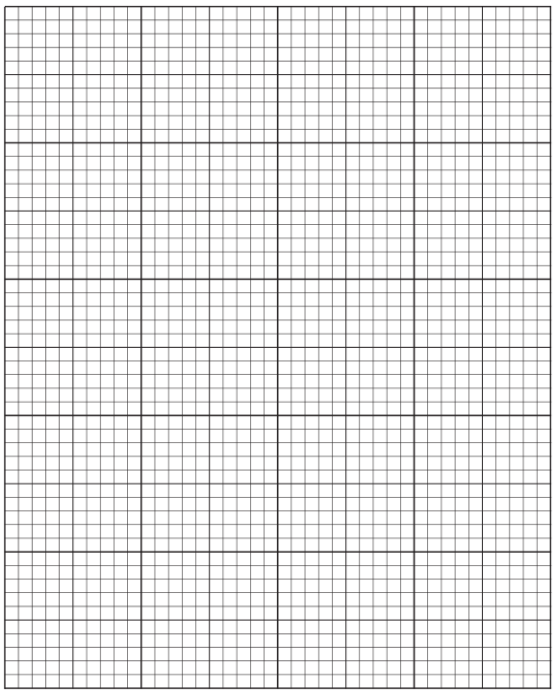
30. When studying variation, it is sometimes impractical to analyse DNA.

A student was investigating variation between a number of students in their school. They recorded the frequency of students that could and could not roll their tongue.

The results are shown in the table.

Phenotype	Frequency	
	Females	**Males**
Tongue-rolling	83	88
Non tongue-rolling	43	34

i. Represent the data in the table as a bar chart on the grid provided below.



[4]

ii. Since 1940, people have believed that the ability to roll the tongue is caused by a single gene with two alleles.

R is dominant and allows tongue-rolling.

r is recessive and does not allow tongue-rolling.

The genotype of students who can roll their tongue could be either RR or Rr.

In the results shown in the table opposite

- the total number of students who could roll their tongue = **171**
- the total number of students who could not roll their tongue = **77**.

The Hardy–Weinberg principle allows us to estimate the proportion of each genotype.

Use the Hardy–Weinberg principle to estimate the proportion of heterozygous individuals in the school survey in the table.

Use the equations:

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

$p + q = 1$

proportion = ... **[3]**

iii. The Hardy–Weinberg principle might not give an accurate estimate of the proportion of genotypes for the results of the student's investigation.

The population of students varies from year to year and so cannot be said to be stable.

State **two other** reasons why it might be inappropriate to use the Hardy–Weinberg principle to estimate allele frequencies for the results in the table.

1 _____

_____

2 _____

_____

[2]

31. One subspecies of tiger is the Bengal tiger. One in 10 000 Bengal tiger births results in a white Bengal tiger.

White Bengal tigers (as shown below and in Fig. 3.1b **on the insert**) have black stripes but lack orange fur.

Fig. 3.1b

The allele that causes white fur is recessive and is a result of a mutation to a gene called SLC45A2.

According to the Hardy-Weinberg principle, the following equations can be used to estimate allele frequency within a population:

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

$$p + q = 1$$

Use the Hardy-Weinberg equations to calculate the percentage of Bengal tigers that are heterozygous for the SLC45A2 gene.

Give your answer to **one** significant figure.

Show your working.

Answer:

…… %

[3]

32. Finches are small birds that are common on the Galapagos Islands.

The variation in the sizes of beak of the various Galapagos finch species provided evidence for evolution by natural selection.

Scientists recently studied the beak sizes of two species of Galapagos finch living on the same island, Geospiza fuliginosa and Geospiza fortis.

In disruptive selection, extreme phenotypes are selected for and average phenotypes selected against. The *G. fortis* all live in the same location. If disruptive selection is occurring in the *G. fortis* population, it is possible that speciation might occur.

i. Name the type of speciation that occurs when two populations live in the same location.

_____ **[1]**

ii. Suggest how *G. fortis* with large beaks could become reproductively isolated from *G. fortis* with small beaks despite living in the same location.

_____

_____ **[1]**

iii. Comparing anatomy between species such as beak size in finches can be used to provide evidence to support the theory of evolution by natural selection.

Describe how DNA can be used to provide evidence to support the theory of evolution by natural selection.

_____

_____

_____

_____

_____ **[2]**

33(a). Charles Darwin was aware of the role that some farmers have in altering the course of evolution. He had observed that farmers could breed animals and plants so that certain characteristics become more exaggerated.

i. Name the type of selection used by farmers to breed exaggerated features in animal or plant species.

_____ **[1]**

ii. Name **one** example of a plant that has been bred by farmers to show exaggerated features and describe the feature that has been exaggerated.

_____

_____ **[1]**

(b).

Timber wolf

Bloodhound

Dachshund

Fig. 21

Fig. 21 shows a wolf (*Canis lupus*) and two breeds of dog.

All dog breeds belong to the same species (*Canis lupus familiaris*) that evolved from wolves.

Darwin made the following statement in his book *The origin of species*:

‘Man selects only for his own good; Nature only for that of the being which she tends.’

This has been paraphrased as:

‘Man selects for looks; nature selects for survival.’

Discuss this statement using examples of dog breeds such as those shown in Fig. 21.

[4]

(c). The Kennel Club is an organisation that protects and promotes the health and welfare of dogs. It also publishes descriptions to define each breed.

Explain why such an organisation is necessary.

[3]

34. Lungs are the specialised gas exchange surfaces in mammals. Dogs are mammals.

A disease called canine pulmonary fibrosis (CPF) can affect lung function in dogs. CPF can reduce the tidal volume of a dog's lungs.

i. The West Highland Terrier develops CPF more often than other breeds of dog.

The lung function of a West Highland Terrier was tested. At rest, its ventilation rate was 1.44 dm^3 min^{-1} and its breathing rate was 24 breaths min^{-1}.

Calculate the tidal volume of the West Highland Terrier in cm^3.

Tidal volume = ... cm^3 **[1]**

ii. Explain how the high occurrence of CPF in West Highland Terriers could have been a result of artificial selection.

---

[1]

iii. Explain how DNA sequencing could help scientists understand how the West Highland Terrier's genes affect its probability of developing CPF.

---

[2]

iv. Another disease that affects dogs is caused by parvovirus. Dogs can be vaccinated against parvovirus at six weeks of age.

Suggest what the parvovirus vaccine is likely to contain.

---

[1]

v. Dogs need a booster vaccination against parvovirus when they are one year old.

Explain why a booster vaccination is needed.

---

[1]

35. * 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]