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Draw a cross through the box (☒) if you have NOT written in this booklet

NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Biology 2024

91157 Demonstrate understanding of genetic variation and change

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of genetic variation and change.	Demonstrate in-depth understanding of genetic variation and change.	Demonstrate comprehensive understanding of genetic variation and change.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (////). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 09

QUESTION ONE: Cats

Some domestic cats exhibit a complete dominance pattern in coat colour. The allele for black fur (B) is dominant over the allele for brown fur (b). The gene for tail length is not linked and is located on a different chromosome from the coat colour gene. The allele for long tails (L) is dominant to the allele for short tails (l).

A cat that is homozygous for both black fur and long tail is crossed with a cat that is homozygous for both brown fur and short tail.

Domestic cats.

(a) Specify the genotype of individuals in the F1 generation produced by this cross.

BbLl

(b) Use the Punnett square below to show:

- the F1 gametes resulting from the cross **and**
- the possible genotypes within the F2 generation of cats.

F1 gametes	BL	Bl	bL	bl
BL	BBLL	BBLl	BbLL	BbLl
Bl	BBLl	BBll	BbLl	Bbll
bL	BbLL	BbLl	bbLL	bbLl
bl	BbLl	Bbll	bbLl	bbll

(c) Give the expected phenotype ratio resulting from this cross, indicating the phenotype each value represents.

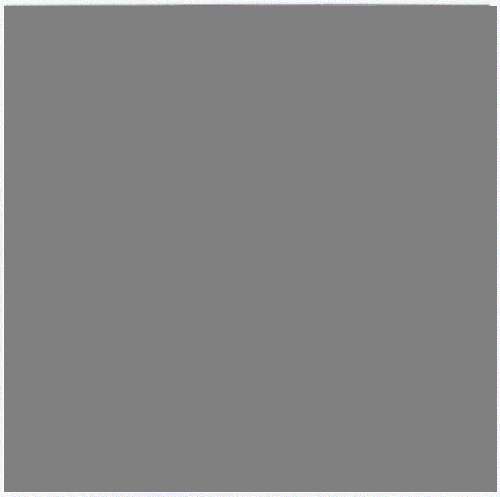
9 black fur long tail : 3 black fur short tail : 3 brown fur long tail : 1 brown fur short tail.

Some cats have fur colour that is an example of co-dominance AND sex linkage. In cats with orange fur, phaeomelanin (orange pigment) completely replaces eumelanin (black or brown pigment). This gene is located on the X chromosome. The orange fur allele is (F) and is co-dominant with non-orange (f). Males can typically only be orange or non-orange (black, brown, etc.).

Sex determination in cats is the same as humans.

Female cats can have orange fur, fur without any orange (black, brown, etc.), or have tortoiseshell fur (see image on the right), in which some parts of the fur are orange and others are non-orange.

Some cat diseases are known to be sex-linked as well. Male cats have been found to be more susceptible to recessive, sex-linked diseases than female cats.



Female black tortoiseshell.

(d) Evaluate the inheritance patterns of cats to include complete dominance, co-dominance, and sex-linkage.

In your answer, refer to the examples above and include a discussion of:

- the two patterns of dominance
- why only female cats can have tortoiseshell fur colour
- the similarities and differences of recessive and dominant sex-linked genes.

Co-dominance ~~incomplete dominance~~ is when both alleles are expressed in the phynotype. Complete dominance is when the dominant allele masks the recessive allele and for the recessive allele to be expressed you must have two. female cats are XX this means that ~~for a~~ the x chromosomes are always going to have a orange fur because it is on

the x chromosome. this means that females can also inherit a f recessive to have the co-dominance affect during crossing over when the maternal and paternal chromosome are switched if the chaimsa were to occour where the F orange fur allele is located then the female cat could get a f recessive. Sex-linkage reduces genetic variation because this means that not all cats are able to inherit that allele. the male can only be orange or brown because ~~in order for the~~ the F orange allele masks the recessive or the male could get two recessive.

QUESTION TWO: Takahē

The flightless takahē (*Porphyrio hochstetteri*) has special cultural, spiritual, and traditional significance to Ngāi Tahu, the iwi from New Zealand's South Island. Ngāi Tahu value takahē as a taonga (treasure), and they continue to act as kaitiaki (guardians) of the takahē, working alongside the Department of Conservation / Te Papa Atawhai (DOC).

Takahē in a protected colony.

Genetic analyses and fossil records show that takahē were restricted to isolated areas in the north-western South Island at the height of the last ice age, approximately 29 000–19 000 years ago. As the climate warmed, takahē shifted their distribution, migrating to eastern and southern regions. The takahē in the north-west South Island became locally extinct. Pressures from hunting, introduced predators, habitat destruction, and competition for food led to their decline and an extreme genetic bottleneck.

After being presumed extinct for nearly 50 years, the takahē was famously rediscovered in 1948. The rediscovery of the takahē led to New Zealand's longest-running, endangered species programme. For more than 70 years, measures to protect and increase numbers of takahē have included predator control, captive breeding, and island translocations (moving small populations of birds to offshore islands).

Ongoing genetic analyses have found that introduced island populations of takahē have significantly lower levels of genetic variation than the main Fiordland population. The island population also has significantly different gene frequencies, with some alleles becoming fixed (with no variability in the gene pools) on the island sanctuaries.

Discuss the decline in genetic diversity in the takahē, with reference to the information provided.

In your answer, include discussion of:

- the terms **population bottleneck**, **founder effect**, and **genetic drift**
- how the genetic diversity of the gene pools of the takahē have been impacted by these processes
- why the reduced genetic diversity from island translocation is a problem for the takahē population and how this may be improved in the future.

population bottle neck is when due to ~~chance event~~ unforseen circumstances some of the population dies causing the rest of the population to have a different allele frequency. the founder effect is ~~wt~~ due to chance events the ?. allele frequency is how much of that allele there is, in a population. genetic drift is when a section of the population migrates to a new area. when the climate warmed this meant that the takahē migrated the remaing takahē experienced bottle neck effect and because where they lived was 'unlivable' they died. the takahē that migrated were found and had little genetic variation to increase the variation humans translocated the takahē to breed with takahē with different alleles. however the takahē still had little genetic variation this is not good because if an environmental factor were to occur the takahē may not survive because of the minimal alleles. if gene flow were to happen which would be if new takahē came to the new place with different alleles and breeded with them. or a mutation caused by a mutagen could create genetic variation. because takahē has fixed alleles this means that it would be dificult to have genetic variation without a mutation.

QUESTION THREE: Lethal alleles

In 1907, Erwin Baur carried out research on the snapdragon plant, *Antirrhinum majus,* and studied the condition known as 'aurea', in which some plants produced golden leaves instead of green leaves. In this plant, the golden-leaf allele (G) is dominant to the green-leaf allele (g). When crossed with its own type (aurea × aurea), Baur observed a 2:1 phenotype ratio of golden:green-leafed plants, instead of the expected 3:1 ratio in the offspring.

By carrying out a number of test crosses, Baur concluded that all of the surviving golden-leafed plants were heterozygous. Homozygous dominant (GG) aurea plants lacked normal chlorophyll development and never survived.

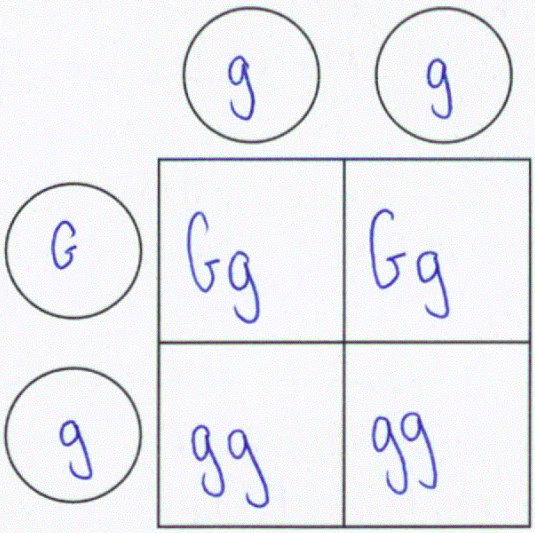
Baur is now recognised as the first scientist to discover lethal alleles in a plant, although they had already been recognised in animals, including humans.

Antirrhinum majus, snapdragon in bloom.

(a) Describe what is meant by the term **lethal allele**.

A Lethal allele is and allele that is harmful to the organism. lethal alleles can cause ~~deth~~ premature deth or ~~deth~~ death after the organism has been born. this is because lethal alleles cause an organism to not be able to properly function. in this case & When golden leafe allele is inherited together the plant lacks Chlorophyll causing death.

(b) In the space below, show the Punnett square for a test cross between a green-leaf plant and a surviving, golden-leaf plant:



Genotype ratio: 2Gg : 2gg

Phenotype ratio: 2golden : 2green

(c) This lethal allele gives a dominant, non-lethal phenotype in the heterozygote. However, we say that the lethality (ability to prevent survival) is recessive in the snapdragon, even though the colour phenotype is dominant.

Using the information provided, discuss why this snapdragon allele must be recessive for lethality and why dominant lethal alleles are rare but can be found in some adult populations, including humans.

In your answer, include discussion of:

- the terms and meaning of dominant and recessive alleles
- why the snapdragon's allele must be recessive for lethality and how the test cross shows this
- why dominant lethal alleles are rarer than recessive ones, but can sometimes exist in adult organisms.

a dominant allele is an allele that is always expressed in the phynotype it masks the recessive allele. a recessive allele is not always expressed in the phynotype ~~or~~ because it is masked by the dominant allele. recessive allele needs two to be expressed in the phynotype. ~~and~~ dominant alleles are more rare because they mask recessive meaning that

if a dominant allele is ~~inher~~ more likely to be inherited but for an organism to pass an allele on they have to be able to survive. it is more common to have a recessive allele because they are not as commonly inherited together are you would need two recessive alleles to have the lethal effect this means that both your parents must also have lethal alleles heterozygous. for you to be able to inherit both. they can exist in adult organasims through having heterozygous meaning that you have both alleles.

Achievement

Subject: Biology

Standard: 91157

Total score: 09

Q	Grade score	Marker commentary
One	A4	This response successfully describes the F1 genotype and uses it to complete a dihybrid cross, leading to the correct description of the phenotype ratio. Additionally, the response correctly defines co-dominance and complete dominance.
Two	N1	The information given in the response largely repeats content from the question, resulting in no additional evidence. However, credit was awarded for suggesting gene flow as a solution to the low genetic diversity issue in takahē. This response provides incorrect definitions for both the bottleneck effect and the founder effect.
Three	A4	The response correctly defines lethal alleles, as well as dominant and recessive alleles. Information provided in the question to complete a monohybrid cross illustrating a test cross was accurately used.