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91157



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Mana Tohu Mātauranga o Aotearoa  
New Zealand Qualifications Authority

## Level 2 Biology 2025

### 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.**

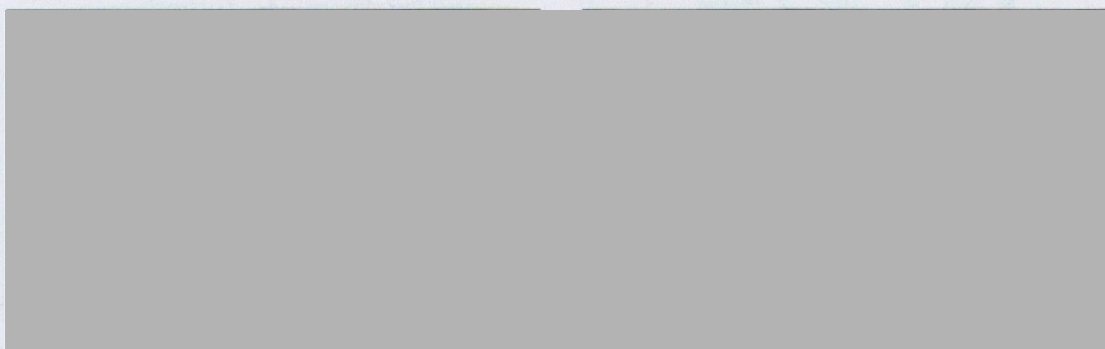
**Achievement**

**TOTAL 09**

**QUESTION ONE: Snake genetics**

Corn snakes (*Pantherophis guttatus*) are considered helpful to humans and are found in different parts of the eastern United States. This species lives in a wide variety of habitats including wooded areas, rocky hillsides, barns, and abandoned buildings.

They have a complete dominance inheritance pattern for body colour and scale pattern. The orange body-colour allele (G) is dominant to the white body-colour allele (g). The allele for striped scale pattern (B) is dominant to the allele for blotched scale pattern (b). The genes for body colour and scale pattern are not genetically linked.



Corn snake.

Anerythristic Hurricane Motley corn snake.

- (a) Conservationists crossed a corn snake homozygous for the orange body-colour allele and the striped pattern allele, with a corn snake homozygous for white body colour and blotched scale pattern.

State the genotype of the gametes produced by each parent:

Parent 1: GB Parent 2: gb

State the genotype of the F1 generation:

GgBb

- (b) Use the Punnett square below to show the gametes of the F1 generation, and all of the possible genotypes of the F2 generation.

$$\begin{array}{c|cc} G & 7 & 11 \\ \hline g & 67 & a11 \end{array}$$

		F1 gametes			
		GB	Gb	gB	gb
F1 gametes	GB	GGBB	GgBb	GgBB	GgBb
	Gb	GGBB	GGBB	GgBB	GgBb
	gB	GgBB	GgBB	ggBb	ggBb
	gb	GgBb	GgBb	ggBb	ggbb

$$\begin{array}{r} 9 \\ + 3 \\ + 3 \\ + 1 \\ \hline 16 \end{array}$$

- (c) Describe the predicted phenotype (F<sub>2</sub>) ratio produced by the cross.

9 Orange striped : 3 Orange blotched : 3  
White striped : 1 White blotched

- (d) The garter snake (*Thamnophis sirtalis*) is another species of snake and has often been bred in captivity. When snakes are crossed that are heterozygous for a striped pattern and rough scale texture, striped (E) is dominant over unstriped (e), and smooth texture (R) is dominant over rough texture (r).

With this cross, the observed ratio is frequently found to be:

7 striped smooth : 1 striped rough :  
1 unstriped smooth : 7 unstriped rough

7  
7  
1  
1  
16

(see)



Common garter snake.

Discuss how genes located on the same chromosome can show both linked and unlinked characteristics, using the information provided for BOTH species of snake.

In your answer, include discussion of:

- how the processes of crossing over and segregation can influence the inheritance patterns of both linked and unlinked genes
- the effect of gene location on the observed phenotype ratios
- why the dihybrid heterozygous crosses for these identified traits are so different in these two species of snake.

Crossing Over is the process of homologous pairs exchanging genetic material to create new combinations. Crossing over influences both linked and unlinked genes as if genes are linked they are likely to be inherited with each other, so when crossing over occurs these linked genes can exchange genetic material which influences their inheritance pattern. While unlinked genes are located in different chromosomes. This means these genes are less likely to inherit these genes when crossing over occurs. This changes

these genes inheritance patterns as they will mix with different genes during crossing over. Segregation is the process where homologous pairs are separated into daughter cells, which contain half of a homologous pair (diploid) to create variation. When separation occurs to linked genes, their homologous pairs split up into daughter cells with each having one non-sister chromatid/homologous chromosome with ~~different~~ <sup>in</sup> This affects their inheritance pattern as it could produce similar (linked genes being in the same chromosomes will likely result in them being similar) or different from their original gamete. While unlinked genes means they will likely create new gametes. ~~formation~~ <sup>in</sup> ~~each~~ The effect on gene location on the phenotype ratios shows that in the garter snake there are many linked genes, and a small amount of unlinked. This is due to the observed ratio showing 7ER:1Er:7er: ~~and~~ 1eR. Due to most genes being linked they create multiple of the same combinations, like ER and er, ~~while~~ this is due to linked genes being located in the same chromosomes with a high chance of being inherited together and similar. whilst due to a little amount of genes are unlinked, there will only be a few phenotypes that express their genotypes, which is a result of genes being located in a different chromosome.

chromosome. The dihybrid cross ratios 9:3:3:1 are different. with the ~~7:1:1:7~~ ratio ~~it is dif~~ because there could be a larger amount of unlinked and linked genes in the dihybrid cross of the  $GgBb \times GgBb$  snakes. This explains why <sup>there are different</sup> ~~there are~~ linked and unlinked phenotypes are expressed in the dihybrid cross, with 10 linked ( $9 \frac{GB}{GB}$  and  $1 \frac{ggb}{ggb}$ ) and 6 unlinked ( $3Gb$  and  $3gB$ ). which

## QUESTION TWO: The New Zealand giraffe weevil/pepeke nguturoa

The New Zealand giraffe weevil/pepeke nguturoa (*Lasiornychus barbicornis*) is an insect endemic to New Zealand. The most notable phenotypic variation in this species is observed in males, particularly in the length of their snout, known as a rostrum, and overall larger body size. These phenotypes are influenced by genetic and environmental factors and are subject to strong sexual selection (mate selection) where females are choosing the males based on their phenotypes.



New Zealand giraffe weevil.

The table below shows the common distribution of these phenotypes:

	North Island	South Island	Smaller offshore islands (limited food and habitat resources, smaller populations)
<b>Long-rostrum males</b>	Dense native forests (e.g. Waipoua Forest, Tongariro National Park).	Dense native forests (e.g. Fiordland National Park, Westland Tai Poutini National Park).	Phenotype distribution is far more random and shows less relationship to the dominant type of vegetation.
<b>Short-rostrum males</b>	More open or smaller patches of native forests.	Drier or more open habitats (e.g. Canterbury Plains).	

Discuss what factors may cause allele frequencies in a gene pool to change, using the information provided above.

In your answer, include discussion of:

- how the gene pool of the New Zealand giraffe weevil could be affected by their migration between habitats AND by genetic drift *founder*
- how sexual selection (mate selection) and natural selection may have influenced these two distinct phenotypes of long-rostrum and short-rostrum males.

The gene pool of the New Zealand giraffe weevils, ~~is~~ ~~is~~ affected by their migration between habitats as it increases the gene pool in their new environments. ~~It also affects~~ due to more species coming in. ~~It~~ ~~Gene~~ The gene pool of these weevils is also decreased as <sup>the</sup> genetic drift "founder effect" happens due to these individuals migrating in unoccupied habitats which could reduce the ~~amount~~ gene pool as they only a small portion of a population is migrating which can cause in a loss of alleles.

~~Sexual selection~~ ~~for~~ ~~long-rastum~~ ~~males~~ ~~sexual~~ selection affects them when females

In Dense native forests, more long-rastum males are seen, due to a larger-rastum being a beneficial phenotype to survive and repopulate in that environment. This results in more long-rastum males to survive and eventually reproduce causing more larger-rastum ~~that~~ males to be expressed in that environment. Additionally, due to larger-rastum males being the more beneficial phenotype in dense native forests. Female weevils will choose males with larger rastums to be their mate. Due to female weevils' weevils choosing individuals with ~~more~~ larger rastums, more large rastum individuals

will reproduce and will inherit this to their offspring.

Now, in more open and drier habitats, short-rostrum males are favoured, which means they can survive and reproduce there in those habitats better. Due to natural selection favouring short-rostrum males, females will choose to mate with weevils with shorter rostrums. This ~~allows~~ means more short-rostrum individuals will be seen in these environments, due to ~~more~~ the males passing on their short-rostrum alleles to their offspring.

### QUESTION THREE: Blood types

If a patient needs a blood transfusion during surgery, it is essential to match their blood type correctly. Receiving the wrong blood type can cause serious, potentially life-threatening reactions.

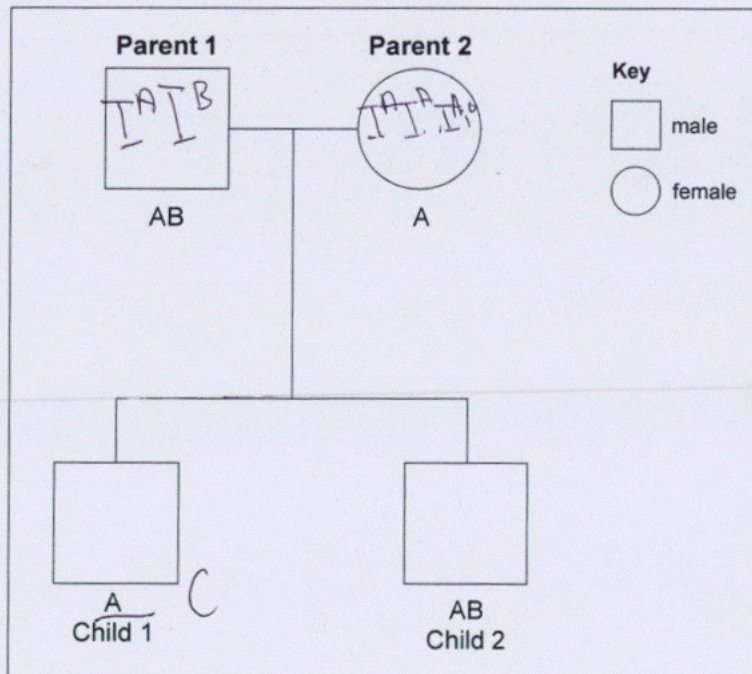
Blood type in humans is controlled by multiple alleles. The alleles  $I^A$  and  $I^B$  are dominant over  $i^O$ .  $I^A$  and  $I^B$  are examples of alleles that show co-dominance.

The pedigree chart below shows the blood types/phenotypes of two children and their parents.

#### Blood types

Phenotype	Genotype
A	$I^A I^A, I^A i^O$
B	$I^B I^B, I^B i^O$
AB	$I^A I^B$
O	$i^O i^O$

#### Pedigree chart



Discuss the inheritance of these blood types, using the information provided above. You may include a Punnett square to support your answer (optional).

In your answer, include discussion of:

- what is meant by the term multiple alleles
- the possible genotypes of Child 1
- the difference between dominant alleles and co-dominant alleles
- how to determine the genotype of Child 1 using the blood types of **his** children, if his partner is a blood type O female
- why the determination of Child 1's genotype may **not** be guaranteed as correct if determined using his children's blood types.

Multiple alleles is 3 or more alleles in the same locus. The possible genotypes of child 1 is either  $I^A I^A$ ,  $I^A i^o$ ,  $I^B i^o$ , and  $I^A I^B$ . This is due to child 1's parents having the possibility to have  $\{I^A I^B\}$  (parent 1) and  $I^A I^A$ ,  $I^A i^o$  (parent 2).

The difference between co-dominant and dominant alleles are that dominant alleles mask over recessive alleles resulting in a single phenotype, while co-dominant alleles are heterozygous causing both dominant alleles to be expressed in the phenotype.

To determine child 1's genotype we must look into the genotypes of ~~the~~ their offspring with blood O female. Because blood O female being having type O blood their  $i^o i^o$  genotype will always be recessive against child 1's potential genotype. Their offspring will either have  $I^A i^o$  ~~( $I^B i^o$ )~~ genotypes. Which could determine the genotype of child 1 to be  $I^A i^o$  or  $I^A I^A$ .

But due to child 1's offspring only having a  $I^A i^o$  genotype, there is ~~no guarantee~~ nothing that can show ~~if~~ ~~child 1's~~ ~~genotype~~ child 1 having a  $I^A I^A$  genotype.

because of this, it is not guaranteed  
to determine child's genotype  
to be either  $I^A I^A$  or  $I^A i$ .

## Achievement

**Subject:** Biology

**Standard:** 91157

**Total score:** 09

Q	Grade score	Marker commentary
One	A4	<p>The response:</p> <ul style="list-style-type: none"> <li>• stated the genotype for the F2 generation</li> <li>• gave the ratios of the phenotype</li> <li>• described the process of segregation,</li> <li>• defined unlinked genes.</li> </ul> <p>An explanation of both the processes of segregation and crossing over would have allowed this response to reach Merit level.</p>
Two	N1	<p>The response:</p> <ul style="list-style-type: none"> <li>• defined the process of natural selection</li> <li>• stated the processes identified in the question.</li> </ul> <p>The response could be developed by providing definitions of the processes stated and utilising the information to explain the idea of how natural selection has led to the different phenotypes in the different environments due to a change in the frequency of alleles.</p>
Three	A4	<p>The response:</p> <ul style="list-style-type: none"> <li>• stated the genotype for child 1 and parent 2 using the information provided in the pedigree chart</li> <li>• defined complete and co-dominance.</li> </ul> <p>The response could be improved by explaining the inheritance patterns based on the gametes passed on by the parents of child 1 OR the gametes passed on by child 1 and their type O partner.</p>