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91157



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## Level 2 Biology, 2017

### 91157 Demonstrate understanding of genetic variation and change

2.00 p.m. Wednesday 22 November 2017  
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

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

**Achievement**

**TOTAL**

**10**

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## QUESTION ONE: PIGEON GENETICS

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USE ONLY

Pigeon wing pattern and leg feathering both show complete dominance. The bar wing allele (**B**) is dominant to the barless allele (**b**). The allele for leg feathers (**F**) is dominant to the allele for not feathered (**f**). These two genes are not linked.



**Bar (B)**

**Barless (b)**

<http://learn.genetics.utah.edu/content/pigeons/pattern/>



**Feathered (F)**

**Not Feathered (f)**

<http://unews.utah.edu/pigeon-foot-feather-genes-identified/>

- (a) A breeder crossed a pigeon homozygous for the bar allele and the leg feathers allele with a pigeon that had a barless wing pattern and no feathers on its legs.

State the genotype of the F1 generation:

Bb Ff

State the phenotype of the F1 generation:

Barred wings and Leg feathers

- (b) Use the Punnett square below to show the gametes of the F<sub>1</sub> generation and all of the possible genotypes of the F<sub>2</sub> generation.

		F <sub>1</sub> gametes			
		BF	bF	Bf	bF
F <sub>1</sub> gametes	BF	BBFF	BbFF	BBFf	BbFf
	bF	BbFF	bbFF	BbFf	bbFf
	Bf	BbFf	BbFf	BBff	Bbff
	bF	BbFf	bbFf	Bbff	bbff

- (c) Describe the predicted phenotype ratios produced by this cross.

9 Bar wing leg feathers : 3 Bar wing no leg feathers :  
 3 barless wing leg feathers : 1 barless wing  
 no leg feathers.



- (d) If the wing pattern and leg feather genes were linked, the phenotype ratios would be 3:1 with:
- 12 bar wings and leg feathers
  - 4 barless wings and no leg feathers.

Discuss why the phenotype ratio from the F2 cross in part (c), is different to the 3:1 ratio of the linked genes.

You should refer to your Punnett square in part (b), and the given phenotype ratios, in your discussion.

Note: Crossing over is NOT required in your answer.

In your answer include:

- a description of linked genes
- a discussion that contrasts how independent assortment affects the inheritance of linked genes AND unlinked genes
- a discussion of how linked AND unlinked genes affect the genetic variation of offspring.

*You may use diagrams to clarify your discussion.*

Linked genes are genes that are found on the same chromatid and are almost always inherited together.

Independent assortment is the stage of meiosis where chromosomes are randomly segregated. ~~At~~ genes that ~~are~~ not linked will be split up during independent assortment ~~meaning that~~ meaning that there is a smaller probability that the two ~~genes~~ <sup>genes</sup> will be inherited together. ~~is less~~ ~~At~~ Since linked genes are found on the same chromatid, during independent assortment the genes will not be separated meaning the probability of the two genes being inherited together is large.



Linked genes will also be more likely to appear in offspring than unlinked genes which would lead to less genetic variation in the offspring. Genetic variation is a genetic change in an individual that may be advantageous for survival. For example if two birds with barred wings and leg feathers mate there is a high ~~large~~ chance that the offspring will also have barred wings and leg feathers. This means there is less genetic variation in the offspring. Since meiosis occurs in the gametic cells (sperm and eggs) this means the genes can be passed on to offspring or other individuals and is added to the gene pool.



## QUESTION TWO: SOUTH ISLAND SADDLEBACK

The South Island saddleback's gene pool has been affected by both the founder effect and the bottleneck effect at different points in history. The South Island saddleback was originally widespread over the mainland and also had established populations on some of the offshore islands, such as Big South Cape Island, because they were within flying distance from the mainland. The graph below compares the genetic diversity of historic saddleback populations on the offshore island of Big South Cape Island and the South Island mainland in the 1800s with the current population (in 2005) on Kaimohu Island.

After Māori and European settlers arrived, the South Island saddleback eventually became extinct, with the exception of the population on Big South Cape Island. In 1964 all South Island saddlebacks were removed from Big South Cape Island and taken to pest-free island sanctuaries such as Kaimohu Island. Safe from rats and other predators, the South Island saddleback population on Kaimohu Island is increasing, and is being used to establish other populations around the South Island.

Discuss how the founder and bottleneck effects have influenced the current South Island saddleback gene pool on Kaimohu Island.

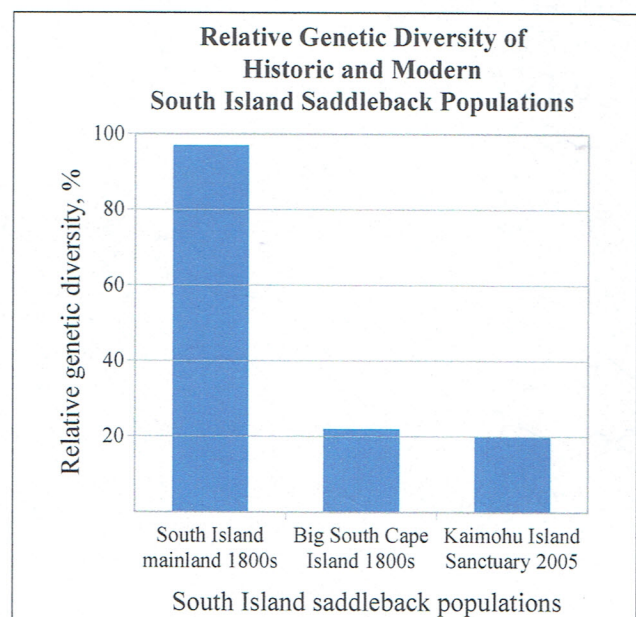
Refer to the information above, and the graph, to support your discussion.

Your discussion should include:

- a description of a gene pool
- an explanation of the bottleneck effect AND the founder effect
- a discussion of why the 1800s Big South Cape Island population had low genetic diversity compared to the 1800s South Island population
- a discussion of why the Kaimohu Island population has low genetic diversity.



<http://nzbirdsonline.org.nz/species/south-island-saddleback>



Adapted from: Jameson, Ian G., 2009, 'Loss of genetic diversity and inbreeding in New Zealand threatened bird species'. *Science for Conservation* 293, p. 20. Department of Conservation, Wellington.

The gene pool is the number of unique alleles in a total population.

The bottleneck effect is organisms in a species with unfavourable characteristics



for survival die out leading to the population to be small with low genetic variation. This small population then reproduces and the genetic variation in the species increases again. ~~The founder~~

The founder effect is when a single organism in a species with favourable characteristics for survival will reproduce which leads to a population with a larger number of organisms with favourable survival characteristics.

The population of Saddlebacks on Big South Cape island had a lower genetic diversity than the population on the South island mainland because it was a smaller population. Since the South island mainland has a larger population this means that more breeding is occurring which leads to more genes and different phenotypes being produced. Since the Big South Cape island had a smaller population this means there was less breeding occurring which leads to lower genetic diversity. The current Kaiwharua island population has low genetic diversity. This is because since it consists of the few remaining Saddlebacks the remaining ones must have the most suitable genes for survival. Therefore the birds with unfavourable characteristics will most likely die off leading to low genetic diversity in the population of Saddlebacks.

N2



### QUESTION THREE: NATURAL SELECTION AND MIGRATION

Lactase is an enzyme produced by babies that allows them to digest and gain nutrition from milk. Most young children lose the ability to produce lactase after they stop drinking their mother's milk, at about three years old. Adults and older children who cannot produce lactase suffer severe stomach upsets if they drink milk. This is called lactose intolerance.

Between 7 000 and 9 000 years ago, two different mutations arose independently in north-European and African populations that allowed these populations to produce lactase into adulthood (lactose persistence – see areas A and B on the map). Both populations A and B used cattle and their milk as a food source. Over time, the mutations became established in each of these European and African populations.

The map below shows the percentage of humans in the population who can digest milk today.



<http://www.hhmi.org/biointeractive/making-fittest-got-lactase-co-evolution-genes-and-culture>

Discuss how a mutation would become established in a population's gene pool and spread to other gene pools.

Your discussion should refer to specific populations on the map, and include:

- a description of both natural selection AND migration
- an explanation of how the mutations became established in A and B populations
- a discussion of why populations B, C, and D would have different percentages of the mutation.

Natural selection is the process where organisms with suitable characteristics tend to survive longer and produce offspring. Migration is the process where an organism



\* A mutation is the changing of the structure of a gene that results in a new allele.

will move from one population to another for the purpose of genetic variation. \*

The mutation of lactose persistence became established in populations A and B because the mutations arose from these two populations. The mutation is now more common in these areas because they have been inherited to more people in each population.

Populations B, C, and D have different percentages of the mutation because of where they are located. The three factors of mutation are barriers, mobility of the species and choice. Between 7000 and 9000 years ago mobility would be a large restriction for mutations. This is why there are 60% of people in population C with the mutation, because some people from population B were able to migrate to C. Population D only has 10% - 30% of people with the mutation because only a very small amount of people from populations A, B, or C would be able to migrate to population D. meaning the mutation would be much less common there.

Subject: Biology		Standard: 91157	Total score: 10
Q	Grade score	Annotation	
1	A4	Learner is able to identify genotype and phenotype, complete the F2 punnett square and describe the phenotypic F2 predicted ratios. They have not been able to explain or discuss that the <i>homologous</i> chromosomes assort into different gametes at Independent Assortment. They have not contrasted how IA affects linked <u>and</u> unlinked genes thus missing on the Merit points.	
2	N2.	Basic definitions for Founder effect and Bottle Neck effect were incorrect. Learner has written about smaller and larger populations but not referred to the graph that clearly indicates that it is the <i>genetic diversity</i> that is different in the three populations not the size. Due to a lack of understanding of the Founder Effect and Bottleneck effect, a link to explaining the effect on the 1800's population in the Big South Cape Island or Kaimohu island was not attempted correctly.	
3	A4	Learner was able to define Natural Selection, migration and mutation. They had the idea that people were migrating between populations but an explanation or discussion with reference to the biological term of <i>Gene Flow</i> between populations and increase in Allele frequency as a result of migration or mutation being established over a long time period did not come through in the answer.	