AS91157 Demonstrate understanding of genetic variation and change

Population Genetics

(2017,2) SOUTH ISLAND SADDLEBACK

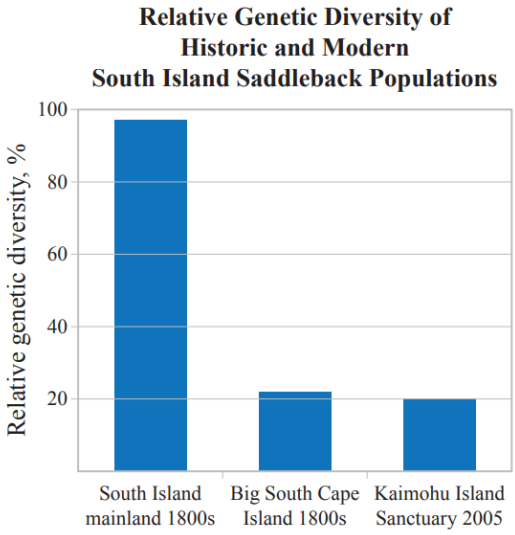
The South Island saddleback's gene pool has been affected by both the founder effect and the bottleneck effect at different points in history.

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.

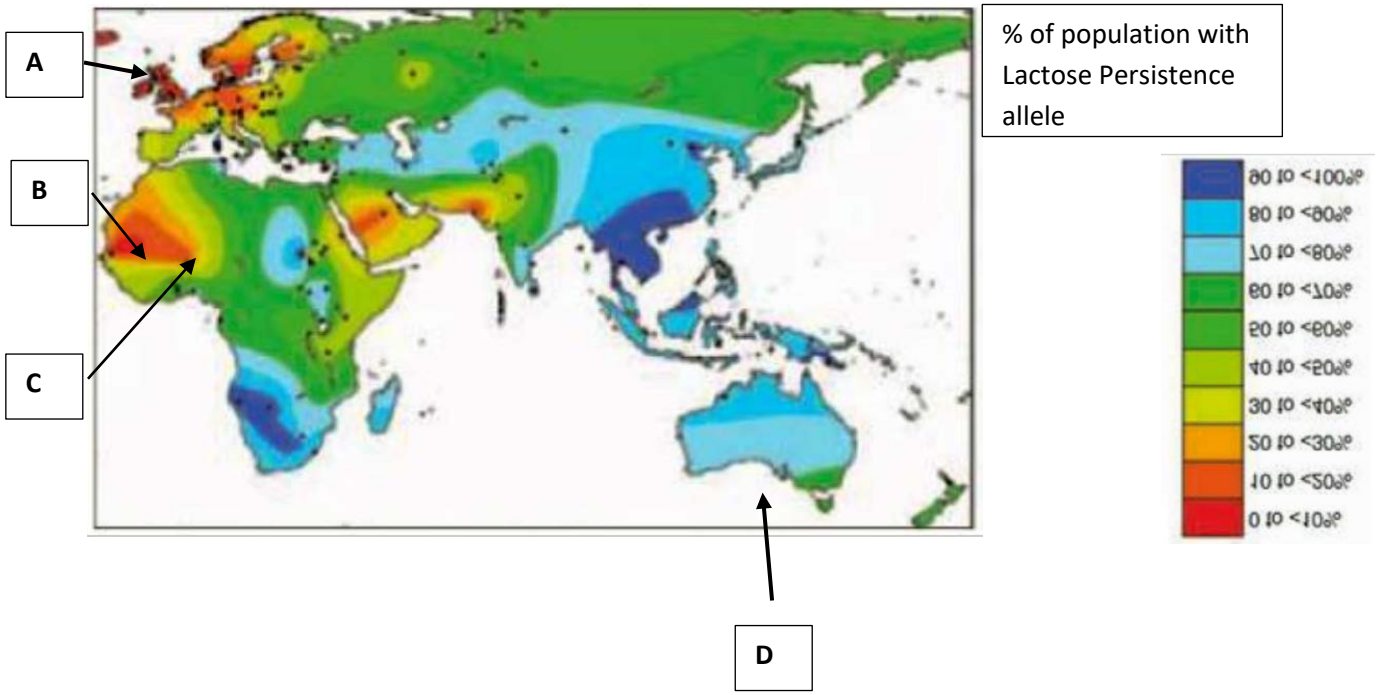
(2017.3) NATURAL SELECTION AND MIGRATION

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 7000 and 9000 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.



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:

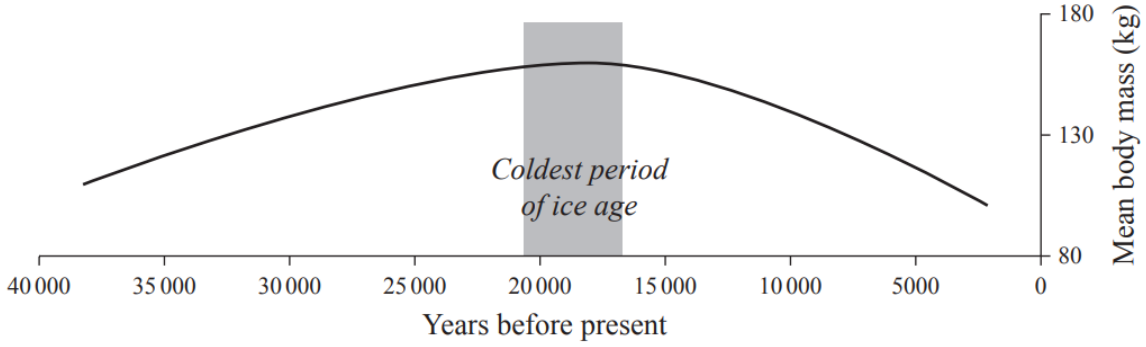
- a description of both natural selection AND migration
- an explanation of how the mutations became established in A and B populations
- a discussion of why populations B, C, and D would have different percentages of the mutation

(2016, 2) NATURAL SELECTION IN MOA

A large body mass is an advantage in cooler climates because its low surface area to volume ratio helps animals to retain heat. Many examples of this, such as polar bears, walrus and large polar sea mammals, are seen today.

Fossil evidence shows that during the last ice age, the population of heavy-footed moa, *Pachyornis elephantopus*, contained much larger individuals than the same species of moa that existed during warmer times.

As the ice age ended and temperatures warmed, the fossil evidence shows that the heavy-footed moa's body mass became smaller again.



Moa body mass data calculated from femur bone circumferences.

The large body mass allele may have entered the population via a mutation.

Discuss how the allele for large body mass became established in the heavy-footed moa gene pool during the last ice age.

Your answer should include:

- a description of what a gene pool is
- a description of what a mutation is and an explanation of how it affects genetic variation in a species
- a discussion of the process of natural selection and how it affected both the body mass and the gene pool of the heavy-footed moa
- a discussion, with justified reasons, why the body mass of the heavy-footed moa returned to a smaller mass once the climate warmed again.

(2016,3) GENETIC DRIFT AND MIGRATION

Many of New Zealand's native species have suffered population bottlenecks due to hunting, introduced predators, and habitat destruction.

The Department of Conservation has successfully saved some of these species from extinction by moving several breeding pairs from mainland populations to predator-free islands. However, maintaining genetic diversity on island populations can be difficult for many species of flightless birds, such as the takahe, *Porphyrio hochstetteri*.

Discuss the issues of maintaining genetic diversity in small island populations of flightless birds, such as the takahe.

Your answer should use the takahe and include:

- a description of what genetic diversity is
- an explanation of how allele frequency in a population is affected by genetic drift and migration
- a discussion of how migration and genetic drift affect genetic diversity of flightless birds on small island populations compared to larger mainland populations.

(2015, 1)

BLACK ROBINS

Introduced species such as cats and rats caused the Chatham Island black robin (*Petroica traversi*) population to plummet to five individuals in 1980. Due to intensive conservation efforts, the species now has over 250 individuals in the gene pool.

(a) Describe the term gene pool.
(b) Explain how genetic drift affects the black robin's gene pool.

Female black robins usually lay eggs inside their nests. However, conservationists found some birds laid eggs on the rims of nests, where the eggs could not survive. So, they pushed the eggs back into the nests where they could be incubated and hatch successfully. However, this selection pressure from humans caused the rim laying allele to increase to 50% in the black robin population. They decided to stop pushing eggs back into the nests to prevent the behaviour from spreading throughout the population. In 2011 only 9% of the population laid eggs on the rims of nests.

Discuss why some female black robins lay eggs on the rims of nests, while most lay eggs inside the nests, and how humans affected this behaviour.

In your answer include:

- a description of what allele and allele frequency mean
- an explanation of what selection pressures are, and how they affect natural selection
- a discussion of natural selection using the black robin egg laying example
- a discussion of why the rim laying behaviour increased with human intervention, then decreased once the intervention stopped.

(2014, 3)

CHANGES IN A GENE POOL

The lowland longjaw galaxias (*Galaxias cobitinis*) is New Zealand's rarest freshwater fish. It has been isolated from other galaxias species for millions of years and now is found only in a six kilometre stretch of the Kauru River, in North Otago.

Lowland longjaw galaxias.

A change in allele frequency in a population can result in a new species forming from an ancestor species.

Discuss how genetic drift and migration can contribute to a change in gene pool and allele frequency in isolated populations, such as the lowland longjaw galaxias.

In your answer:

- describe the terms genetic drift, migration, and allele frequency
- explain how genetic drift and migration cause changes in allele frequencies
- discuss how genetic drift and migration affect the lowland longjaw galaxias's small population compared to a galaxias species with a larger population.

(2013, 3)

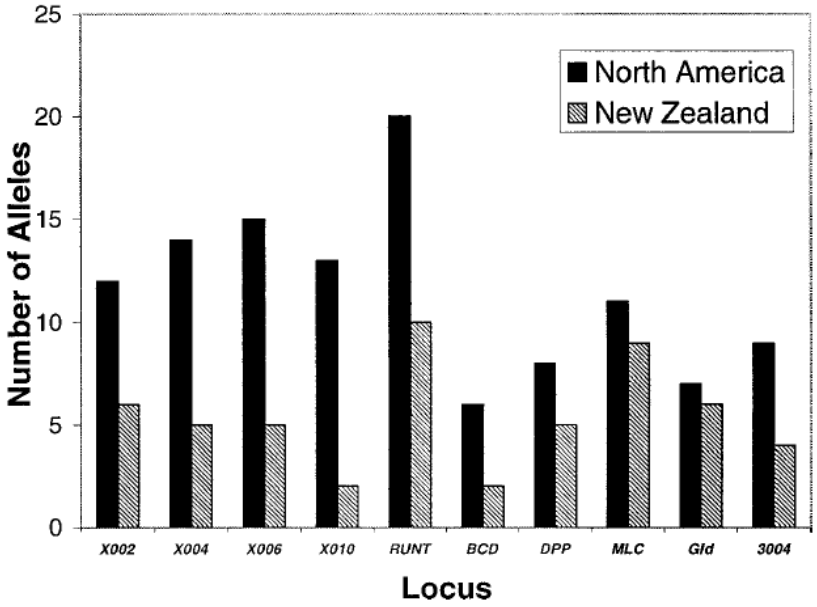
GENE POOLS

The fruit fly *Drosophila pseudoobscura* is endemic to North America. Within the last 50 years, the species has invaded New Zealand.

Recent genetic analysis comparing the North American and New Zealand populations has shown a strong founder effect of *D. pseudoobscura* colonising New Zealand, with 6 individuals in the founding population.

A comparison of the number of alleles in *Drosophila pseudoobscura*

in North America and New Zealand



The New Zealand population shows fewer alleles at each gene locus studied.

Discuss why the New Zealand population of *D. pseudoobscura* shows such low genetic diversity compared to the North American population.

In your answer include:

- a description of the founder effect
- an explanation of how genetic drift has affected New Zealand's population
- a discussion of why the New Zealand population has fewer alleles at each locus compared to the North American population.

(2012, 3)

CHANGES IN A GENE POOL

Changes occur in the gene pool of populations over time. Examples in New Zealand include tussock grasses and the Chatham Island black robin.

Discuss how genetic drift, natural selection and migration can contribute to these changes.

You should refer to the examples given, or any other New Zealand examples to help to clarify your answer.

These following questions were collated from the expired Level 2 AS 90459 Describe genetic variation and change but are still useful for the new AS91157

(2011:3)

The Hawaiian island chain has formed from volcanic activity over a long period of time. The islands are arranged in a series, from the oldest (Kauai) to the youngest (Hawaii).

Differences that can be seen in most Hawaiian species and populations are in step-like progressions down the island chain, from the oldest to the youngest.

The species that show the greatest differences are on islands that have the greatest separation in both distance and time of formation.

Discuss how **natural selection**, **migration**, **mutation** and the **founder effect** may have led to the variation seen in this isolated island chain.

(2010:3)

The Chatham Islands lie to the east of New Zealand.

These islands emerged from the ocean after the rest of New Zealand.

A small population of oystercatchers was established on the islands. Today, the Chatham Island oystercatcher (Torea) is recognised as a different species. It has a shorter, thicker beak, larger legs and less distinct black and white patterning, compared to the mainland oystercatcher.

Chatham Island oystercatcher

Mainland oystercatcher

Discuss how **natural selection**, **genetic drift**, and the **founder effect** may have led to the development of the Chatham Island oystercatcher.

(2009:3)

The takahē is a flightless bird native to New Zealand. Now there are less than 250 takahē, from a much larger population that was once found in many areas of New Zealand.

Takahē

Tuatara

The **northern tuatara** is a native reptile of New Zealand, found on 29 islands with a population of over 60 000 individuals. In 2007, 130 were taken from one island to the predator-free Karori Wildlife Sanctuary in Wellington to set up a new population.

Using the examples above, compare and contrast a population bottleneck with the founder effect, **and** discuss why genetic drift is likely to occur in **both** of these populations.

(2008:3)

Genetic biodiversity can change in a population, even though the size of the population remains fairly constant.

Discuss the factors that affect the frequency of alleles in the gene pool of a population.

In your answer, consider:

- how alleles can enter the gene pool
- how alleles become established in, or eliminated from, the gene pool
- how the frequency of alleles in the gene pool can change over time.

(2007:2)

(a) Define the term **gene pool**.

(b) Explain how new alleles can enter and become established in a population.

(2007:3)

The Australian sheep blowfly, *Lucilia cuprina*, was first identified in New Zealand in 1988, and is now found to have spread throughout many sheep-farming regions. In 1995, a study was carried out to determine the genetic effects of the colonisation. The populations of Australian and New Zealand flies were found to have a number of genetic differences.

Ultimately, the New Zealand population may give rise to a new species.

(a) Two processes that could be responsible for the genetic change in the New Zealand population of blowflies are **genetic drift** and **natural selection.**

Explain how **each** of these two processes works to change the allele frequencies of the populations.

(b) **Discuss** why the arrival of the blowfly in New Zealand is considered to be an example of the **Founder Effect** rather than a **Population Bottleneck**.

(2006:4)

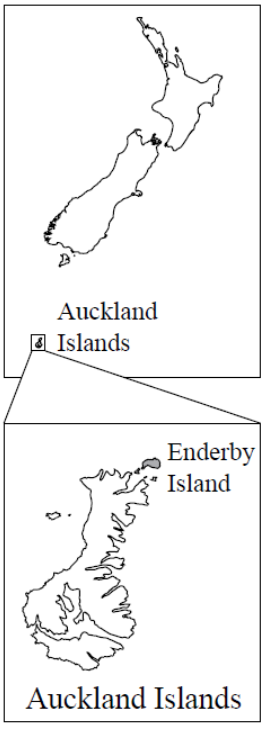
The recovery of the black robin from near extinction is an internationally renowned conservation success story.

In 1980 there were only 5 black robins in New Zealand, with just a single breeding pair left. Today the population is over 250. This has caused changes in the black robin gene pool.

(a) Define the term **gene pool**.

(b) Discuss how this near-extinction affected the gene pool of the black robin **and** why it is still classified as **endangered**.

(2005:3)



Enderby Island is an island of a Sub-Antarctic group known as the Auckland Islands. The environment is cold, windy, and wet with a high humidity.

Enderby Island rabbits are considered the world's rarest rabbit breed. They have evolved from 12 English Silver Greys, which were released on to Enderby Island in 1865. The rabbits were able to thrive and multiply, and provided food for stranded sailors. Over the past 129 years, the rabbit population has fluctuated between very low numbers and approximately 7000, depending on the available food and hunting. Enderby Island rabbits are approximately half the size of Silver Greys and their coat is more open, longer and softer in texture. They are generally black or dark in colour. In 1991 they were removed from the island to protect the natural environment.

The **founder effect** and **natural selection** have been important selection processes in the evolution of the Enderby Island rabbit.

(a) Two other selection processes that could be responsible for the genetic change in the Enderby Island rabbits are **genetic drift** and **bottleneck effect**.

Define these processes.

(b) **Discuss** how selection processes have led to the evolution of the Enderby Island rabbit.