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2

91157



NEW ZEALAND QUALIFICATIONS AUTHORITY  
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## Level 2 Biology, 2016

### 91157 Demonstrate understanding of genetic variation and change

9.30 a.m. Friday 18 November 2016

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.**

Excellence

TOTAL

22

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## QUESTION ONE: INHERITANCE AND MEIOSIS

Roses display complete dominance in both their flower colour and in their susceptibility to some diseases. The allele for red petals (R) is dominant to the allele for white petals (r). In addition, the allele for healthy leaves (H) is dominant to the allele for being susceptible to leaf lesions (h). Leaf lesions are spots on the leaf that are very prone to disease and injury. The genes for petal colour and healthy leaves are located on different chromosomes.



Leaf with lesions.

<https://edis.ifas.ufl.edu/pp267>



<http://www.tophdwallpaersland.com/red-white-rose-wallpaper.htm>

A rose that was homozygous for both red petals and healthy leaves was crossed with a white rose that was susceptible to leaf lesions.

- (a) State the genotype of the F<sub>1</sub> generation this cross produces.

100% (all) RrHh

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

RRHH  
F<sub>1</sub> gametes

		RH	RH	RH	RH
		rh	RrHh	RrHh	RrHh
rrhh F <sub>1</sub> gametes		rh	RrHh	RrHh	RrHh
		rh	RrHh	RrHh	RrHh
		rh	RrHh	RrHh	RrHh

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

The predicted phenotype ratio produced by this cross is all (100%) red petals and healthy leaves, as all the offspring produced are heterozygous ( $RrHh$ ) so the dominant alleles completely mask the effect of the ~~recessive~~ recessive alleles.

- (d) Discuss the processes that produce genetic variation during meiosis, and how gametes differ from parent cells.

Your answer should include:

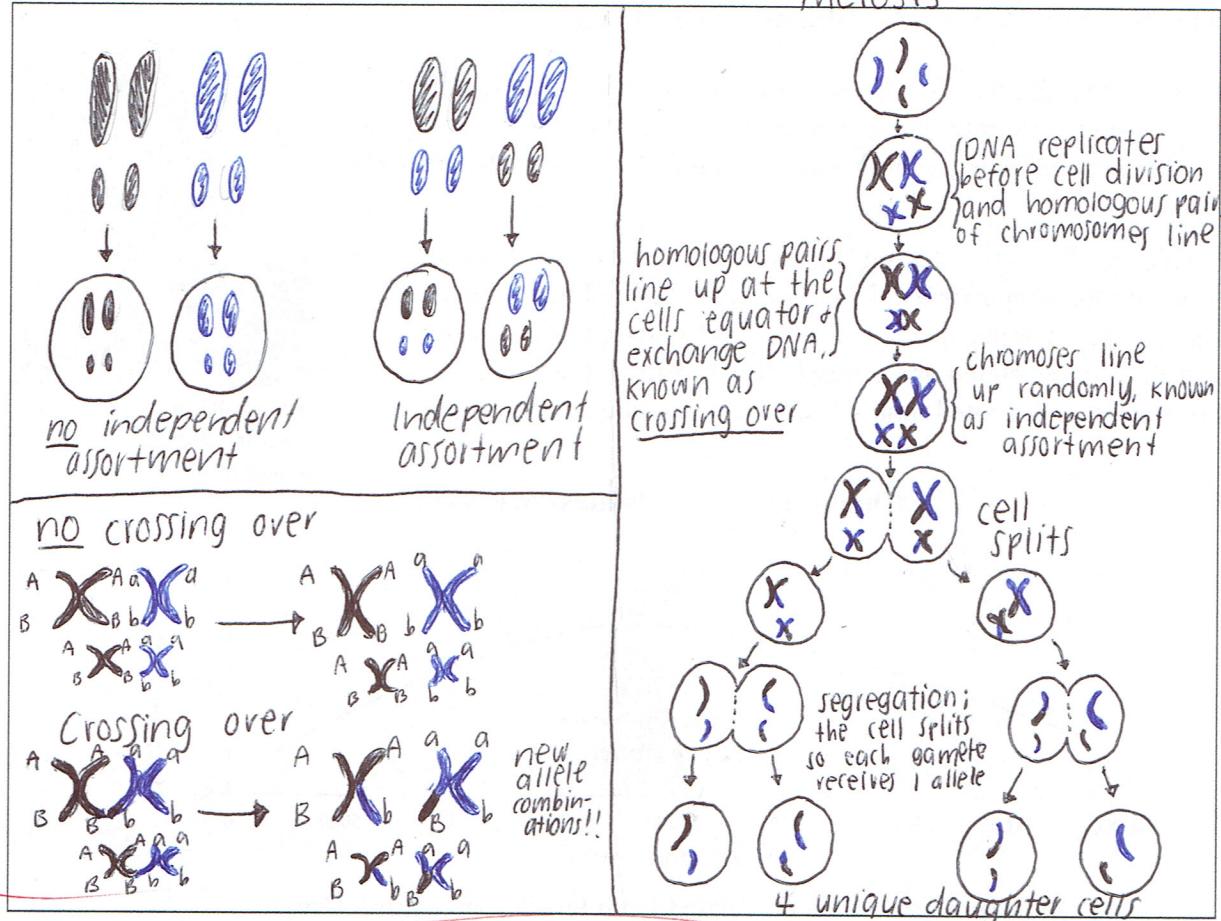
- a description of meiosis and the type of cells produced by meiosis ✓
- an explanation of the processes of independent assortment, segregation, and crossing over ✓
- a discussion of how each process contributes to the genetic variation of cells produced.

You may use diagrams in your answer.

~~Meiosis is a special type of cell division used to produce both male and female gamete (ovum in the females and sperm for males). Through the processes of independent, assortment, segregation and crossing over, meiosis results in the production of 4 daughter cells. Gamete are reproductive cells that contain the haploid number of original chromosomes (23).~~

Crossing over occurs during meiosis when homologous pairs of chromosomes line up at the cell equator and non-sister chromatids exchange sections of DNA. Because they are exchanging sections of DNA, therefore genes, this breaks up the combination of alleles that were inherited together, by the parents. This means they will have different combinations of alleles to the parents and this will lead to genetic variation! Genetic variation is the differences amongst individuals in a population, caused by genetic difference (genotypic variation) or by effects of the environment (phenotypic variation). Independent assortment is the segregation and assortment of chromosomes, that led to each gamete being genetically unique. During independent assortment, chromosomes line up randomly, ~~Because they line up in no particular order,~~

## Meiosis -

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this increases genetic variation as it could result in any combination of alleles. In fact, in humans, independent assortment with our 23 pairs of chromosomes means that there are over 8 million different combinations!! This process thus contributes to each gamete being completely different from one another ~~and~~ AND from the parent cells. Segregation is the separation ~~of~~ (segregation) of chromosomes so that each gamete only receives 1 allele from each pair. Segregation further increases genetic variation in the cells produced, as it splits the homologous pairs of chromosomes and separates them into 4 daughter cells, which results in each gamete to be genetically unique and contain its own unique set of alleles. //

E8  
M

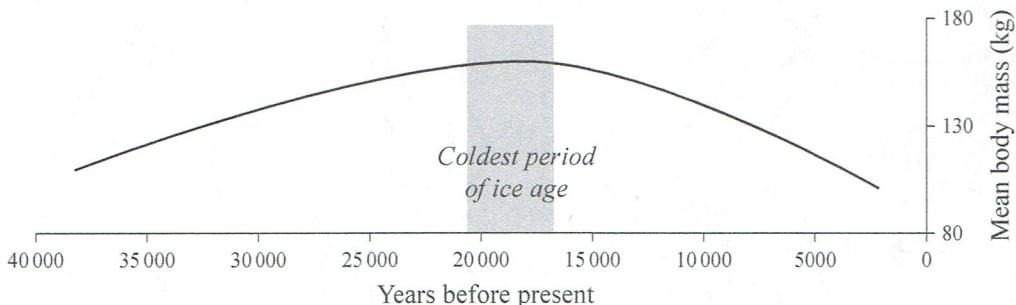
## QUESTION TWO: NATURAL SELECTION IN MOA

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.

[http://collections.tepapa.govt.nz/search.aspx?term=Heavy-footed moa](http://collections.tepapa.govt.nz/search.aspx?term=Heavy-footed%20moa)

Change in moa body mass over time



Moa body mass data calculated from femur bone circumferences.

Worthy, Trevor H. and Richard N. Holdaway, 2002. *The Lost World of the Moa. Prehistoric life in New Zealand* (Indiana University Press, Bloomington), Table 5.6, p. 20.

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. ✓

(A gene pool is the combination of all the different alleles (type, size, variety), found in a population.)

A gene pool is the total sum of all the different alleles found in a population. A mutation is a permanent change in the base sequence of DNA and can occur naturally during DNA

replication. There are 3 types of mutations; silent, harmful or beneficial. Silent is when it has no observable effect on the organism and harmful is when it may effect the survival of the organism. In this case, the mutation that created a new allele for large body mass established in the heavy-footed moa gene pool during the last ice age, was a beneficial mutation. This is because it gave the moa a survival advantage against other members of the population, and helped the moa to survive during the cold ice age, when others may have died from the cold. Due to this mutation, it increased the genetic variation in the heavy-footed moa gene pool, as it allowed for diversity between individuals in the population, so that when the environment suddenly changed to freezing temperatures, some moas died, whereas others were able to survive because of this beneficial mutation. The mutation that created this new allele, may have resulted due to a chromosomal mutation or a gene mutation. A chromosomal mutation affects whole genes, it is likely to occur due to problems caused during meiosis or exposure to mutagens. Common mutagens include chemicals (such as those found in fatty foods), radiation (~~radiation~~), or ultra-violet light. It results in changes in the number of chromosomes in a cell or changes to the structure of a chromosome. Gene mutations on the other hand, occur on a much smaller scale than block/chromosomal mutations, as it affects the base sequence of DNA, as opposed to a block of genes or an entire chromosome. Natural selection is when individuals with

EF

→ (continued on back)



### QUESTION THREE: 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*.



[www.nzbirdsonline.org.nz/species/south-island-takahe](http://www.nzbirdsonline.org.nz/species/south-island-takahe)

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. ✓

Genetic diversity is the measure of different genetic combinations within a gene pool. Allele frequency is the occurrence of a particular allele within a gene pool. Allele frequency in a population is dramatically impacted by genetic drift and migration. Genetic drift describes how the allele frequency can change due to chance, rather than selective pressure. Because genetic drift ~~causes~~ is caused by chance, this could mean that some alleles could be lost. Because it is a small island population of flightless birds, this means that genetic drift will have a greater impact, as it not only could decrease the allele frequency of certain alleles, however it could remove the allele completely from the population. This would decrease the genetic diversity within the population, yet increase

the genetic diversity between populations. ~~Migration~~

~~Migration~~ In larger mainland populations however, genetic drift will not have such a huge impact on the genetic diversity, as ~~the population~~ the population is bigger so allele frequencies may reduce, but ~~they~~ alleles won't be fully removed from the gene pool, or at least it is very unlikely. This would allow for the birds to continue breeding and regenerate the allele frequency back to its original state, ~~as~~

~~that~~ meaning that it would not decrease the genetic diversity. ~~Migration~~ Migration is the emigration (moving out) or immigration (moving in) of organisms in a population. If birds emigrate from a population, and move into a new one, this would have a negative impact on the allele frequency ~~as~~ on the original population, by decreasing the allele frequency as it will be taking away alleles from the population. If the birds were to ~~migrate~~ immigrate, this would increase the allele frequency of the population they are moving into, as it is contributing more alleles. On small island populations, migration has a significant impact by increasing the genetic diversity, as they are ~~a~~ very few alleles and contributing more <sup>drastically</sup> further increases genetic diversity. On larger mainland populations however, it would not have as much of an impact on genetic diversity, unless it was a large group of birds migrating. This is because the big population already has many alleles and ~~consistently~~ many organisms are consistently breeding, so //

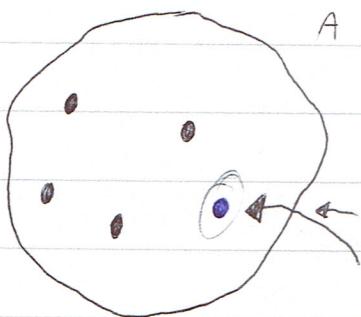


Extra paper if required.  
Write the question number(s) if applicable.

- 2) beneficial phenotypes tend to be preserved, ~~and lost~~ in a population while individuals with unfavourable phenotypes tend to be lost. Because the mutation of the large body mass allele was favourable during the time of the ice age, natural selection acted on this by removing ~~most~~ moas (and their alleles) that failed to produce offspring in this environmental change, and instead increase the number of moas (and their alleles) that were particularly good at producing offspring in the same situation. This resulted in a higher allele frequency of large body mass in the gene pool of the heavy-footed moa. When the climate warmed up again, this meant that the mutation was no longer favourable, and needed so the few moas left carrying the smaller body mass alleles, survived and successfully produced offspring. By doing so, ~~and this~~ increased the allele frequency of smaller body mass, and more smaller body mass moa's were present in the gene pool. Therefore, the selective pressure of the ice age allowed for large body mass ~~alleles~~ moas to thrive, although when the climate became warmer, this selective pressure instead favoured smaller body mass, as they no longer needed to keep warm. See

Extra paper if required.  
 Write the question number(s) if applicable.

- 3) the addition of a few more alleles will increase the genetic diversity, just not have as much impact as it would for a small population with a ~~smaller~~ smaller allele frequency. for example

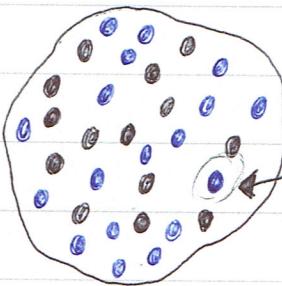


A bird immigrating into a  
• SMALL population

original allele  
frequency:  
4 black

New allele  
frequency  
4 black  
1 blue!

*huge increase  
in genetic  
diversity*



A bird immigrating into a  
• LARGE population

Original allele  
frequency:  
14 black  
18 blue

New allele  
frequency:  
14 black  
19 blue.

*very insignificant  
change in genetic  
diversity*

Excellence exemplar for 91157 year 2016		Total Score	22
	Annotation		
E8	Candidate has made errors in (b) and (c). However, candidate has provided a comprehensive answer to all parts of section (d). There is a very clear discussion with each of the processes namely, Independent Assortment, crossing over and Segregation and link to how genetic variation is provided. The answer is a holistic E8 ( top down marking) as candidate discusses and justifies the reason as to why these gametes are distinctly different to parent cells.		
E7	The answer is a holistic E 7 because the candidate has clearly unpacked the question and provided a solid discussion on how the mutation for large body entered the gene pool and provided a survival advantage to the Moa and changed the allele frequency. A large amount of unnecessary information on types of mutations has been provided which was not required. The candidate also provides a clear indication to show that there exists variation in the original gene pool and it changes over time due to the mutation. The answer provides no evidence to justify what survival advantage a small body mass provided to the Moa in the warm periods. This is why it was marked at E7 and not at E8.		
E7	Candidate provides a very clear, well-articulated discussion to compare how both allele frequency and genetic diversity affects mainland population and island population. Comparisons and justifications are elucidated further with a diagram. No mention is made as to how flightless Takahe can be brought into the island (eg by DoC in future bird transfers) or removed (Eg by sudden death in island population) to support migration (addition or deletion of alleles from gene pool) in small island populations. Script has been marked at a Holistic E7 as candidate has provided a clear understanding of genetic drift and how it affects the two populations in terms of genetic diversity.		