Assessment Schedule – 2023

Biology: Demonstrate understanding of genetic variation and change (91157)

Assessment Criteria

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate ***understanding*** involves: • defining, using annotated diagrams or models to describe, and describing characteristics of, or providing an account of, genetic variation and change.	*Demonstrate* ***in-depth understanding*** involves: • providing reasons as to how or why genetic variation and change occurs.	*Demonstrate* ***comprehensive understanding*** involves: • linking biological ideas about genetic variation and change; discussion of ideas may involve justifying, relating, evaluating, comparing and contrasting, or analysing.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 12	13 – 18	19 – 24

Evidence

Question One

<table>
<tr><th>Expected Coverage</th><th>Achievement</th><th>Achievement with Merit</th><th>Achievement with Excellence</th></tr>
<tr><td>(a): GgBb</td><td>• Identifies F1 genotype.</td><td></td><td></td></tr>
<tr><td>(b):
<table>
<tr><th></th><th>GB</th><th>Gb</th><th>gB</th><th>gb</th></tr>
<tr><td>GB</td><td>GGBB</td><td>GGBb</td><td>GgBB</td><td>GgBb</td></tr>
<tr><td>Gb</td><td>GGBb</td><td>GGbb</td><td>GgBb</td><td>Ggbb</td></tr>
<tr><td>gB</td><td>GgBB</td><td>GgBb</td><td>ggBB</td><td>ggBb</td></tr>
<tr><td>gb</td><td>GgBb</td><td>Ggbb</td><td>ggBb</td><td>ggbb</td></tr>
</table></td><td>• Punnett square completed with correct gametes for F2.</td><td></td><td></td></tr>
<tr><td>(c): Phenotype ratios: 9 green barred
3 green clear
3 blue barred
1 blue clear</td><td>• Phenotype ratio linked with appearance correct.</td><td></td><td></td></tr>
<tr><td>(d):
Meiosis is a type of cell division / reduction division that produces sex cells / gametes / sperm and eggs with half the number of chromosomes / haploid (as the body cell / parent cell / somatic cell).
Homologous chromosomes are similar but not identical. Each carries the same genes in the same order, but the alleles for each trait may not be the same.
The process of independent assortment is where the homologous pairs line up in a random / different order along the cell centre / equator.
Since the order is random, the maternal and paternal chromosomes are shuffled creating new combinations of alleles / recombinants; therefore, genetic variation is achieved / increased.
Crossing over is the exchange of alleles / segments of chromosomes / segments of DNA between homologous chromosomes. (Accept annotated diagram.)
This results in a reshuffling of alleles, creating new combinations between gametes and the parent, which increases genetic variation.</td><td>Describes:
• meiosis as a reduction / haploid cell division (idea of chromosome number reducing)
• that meiosis produces sex cells / gametes / sperm / eggs / pollen
• homologous chromosomes
• independent assortment
• crossing over
• segregation.</td><td>Explains:
• that independent assortment results in the reshuffling of chromosomes / alleles, creating new combinations / recombinants; therefore, each gamete has a different combination of chromosomes
• that crossing over results in chromosomes with different and / or new combinations of alleles from each other
• that segregation results in only one allele from each gene pair going into each gamete; therefore, each gamete has a different combination of alleles
• how one of either crossing over / independent assortment / segregation increase genetic</td><td>Discusses, demonstrating comprehensive understanding by:
• comparing and contrasting gametes produced via the parent (P) individuals' cells and F1 individuals' cells, in terms of at least two of: crossing over, segregation, independent assortment; uses genotype from context
• clearly linking two of the processes to producing genetic variety, due to gametes having unique combinations of chromosomes and unique combinations of alleles on each chromosome.</td></tr>
</table>

Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
Segregation is when homologous chromosomes are pulled apart / split / separated. During segregation, only one chromosome from each homologous pair is placed into the new cells / gametes made, resulting in only one allele from each gene pair going into each gamete; therefore each gamete has a different combination of alleles. Therefore, genetic variation is achieved / increased when the chromosomes pairs are separated because each new cell has a different combination of chromosomes / alleles from each other. During gamete formation, the homologous chromosomes separate so that only one chromosome from each pair goes into each gamete. This also means the alleles for each gene segregate / separate from each other, resulting in each gamete carrying one allele per gene. Since the parents (P) are homozygous for each gene / have all the same alleles on homologous chromosomes, even if homologous chromosomes cross over / segregate / independently assort, they still produce only one type of gamete (GB or gb). F1 individuals are produced when a GB gamete and a gb gamete fuse. These individuals are heterozygous / have different alleles at each locus on homologous chromosomes. Consequently, when crossing over occurs between homologous chromosomes, alleles cross over creating different combinations of alleles on homologous chromosomes. When homologous pairs line up randomly (independent assortment), they create different combinations of chromosomes in each gamete. Therefore, F1 individuals create four different gametes (GB, gB, gB, gb). Genetic variety is produced because independent assortment and segregation work together to produce gametes that have different combinations of chromosomes from each other. Crossing over and segregation work together to produce chromosomes that have different and / or new combinations of alleles on each homologous chromosome, which also results in genetic variation among the gametes. Diagram shows crossing over is the exchange of alleles / segments of chromosomes / segments of DNA between homologous / pairs chromosomes / non-sister chromatids / to create F2 individuals. *(Do not accept: Different combinations of genes.)*		variation (unique traits / characteristics) • why parents (P) have all the same gametes • why F1 parents have four different gametes.	

Not Achieved		Achievement		Achievement with Merit		Achievement with Excellence	
N1	**N2**	**A3**	**A4**	**M5**	**M6**	**E7**	**E8**
ONE evidence points at Achievement.	TWO evidence points at Achievement.	THREE evidence points at Achievement.	FOUR evidence points at Achievement.	TWO evidence points at Merit.	THREE evidence points at Merit.	ONE evidence point at Excellence.	TWO evidence points at Excellence.

N0 = No response; no relevant evidence.

Question Two

Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence

Multiple alleles are alleles of which there are more than two alternatives available at one locus / for one gene.
Incomplete dominance is when the heterozygous genotype shows an intermediate phenotype between the dominant and recessive genotypes.
Mutation is a permanent /irreversible change in DNA sequence / genetic material / genome / gene.
There is variation of *phenotypes* and *genotypes* in a species. Natural selection is the process where individuals with 'fit' phenotypes survive and reproduce at a higher rate than less fit phenotypes. These fit individuals pass the beneficial alleles for these phenotypes on to the next generation, thus increasing the frequency of beneficial alleles in the population.
A beneficial allele / mutation is one that increases the chances of survival /reproduction / fitness, while a harmful allele / mutation is one that decreases the chances of survival / reproduction/fitness.
Do not accept single words that are synonymous to the words 'beneficial' or 'harmful'.
The beneficial alleles in this case are for skin colour / melanin because melanin protects the DNA inside cells from UV rays, which cause mutations. Some mutations could negatively affect survival so people with dark skin / more melanin are more likely to survive in equatorial regions, and to pass on their beneficial skin colour alleles / genes. Any beneficial mutations / alleles for darker skin will be retained in the population through the process of natural selection.
However, humans also need UV light to make vitamin D inside their cells. There are high levels of UV light at the equator so indigenous humans can absorb enough UV light to make vitamin D even though they have darker skin colour. Over time, darker skin colour alleles become more abundant / are retained in equatorial populations because humans with lighter skin would have more harmful mutations decreasing survival / reproduction, and these harmful mutations / alleles would not be retained. Therefore, harmful alleles for lighter skin would be removed from equatorial populations through natural selection.
	Describes:
	• multiple alleles
	• incomplete dominance
	• natural selection
	• mutation
	• a beneficial allele / mutation
	• a harmful allele / mutation
	• advantages of more / less melanin:
	  ○ reduces chances of mutation
	  ○ increases absorption of vitamin D
	• disadvantages of more / less melanin:
	  ○ decreases absorption of Vitamin D
	  ○ increases chances of mutation.
		Explains:
		• how natural selection affected skin colour in humans
		• natural selection / why beneficial alleles are retained / harmful alleles are not retained
		• advantages of more / less melanin
		• disadvantages of more / less melanin
		• how multiple alleles and / or incomplete dominance affected selection of skin colour in humans.
			Discusses, demonstrating comprehensive understanding of:
			• the process of natural selection, and why people in equatorial regions have darker skin and people in higher latitudes have lighter skin colour, in terms of survival and reproductive success
			• melanin concentration because of multiple alleles and incomplete dominance linked to location in the world, and selection for or against alleles / genes and human survival.
			
			Uses data from the figure / map to support discussion.

Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
In contrast, humans living in higher latitudes / away from the equator have light colour skin alleles. It is an advantage to have lighter skin in these regions because UV levels decrease away from the equator, meaning humans need lighter skin colour so they can absorb enough UV to make vitamin D for survival / surviving childbirth. However, they still need some melanin to protect the DNA in their cells. Humans with very dark skin colour at these latitudes would be at a disadvantage. They cannot absorb enough UV to make vitamin D, meaning the alleles for dark skin are not beneficial at higher latitudes, and would be removed from the population / not be retained, through natural selection. Lighter skin is a survival advantage when there is less UV light so that enough vitamin D can be produced for reproductive success. It would be a disadvantage near the equator because the UV light would produce mutations that could hinder survival. Conversely, it is an advantage to have dark skin near the equator to prevent mutations caused by UV light that would hinder survival. Dark skin would be a disadvantage away from the equator because it would not allow enough vitamin D to be produced for reproductive success. We see populations with varying skin colours / phenotypes at different latitudes due to multiple alleles and incomplete dominance. Natural selection will produce darker skin colours towards the equator and lighter skin colours as you move away from the equator to higher latitudes. Natural selection at differing latitudes is selecting for phenotypes and alleles that produce enough melanin to prevent harmful mutations, yet still allow UV to be absorbed for vitamin D production. Individuals with these combinations of genes / alleles will have the skin colour / melanin to survive and reproduce.			

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Question Three

Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
Allele frequency: number / amount / percentage of each / an allele in a population / gene pool. **Gene pool:** total / sum of all alleles / genetic information in a population. **Genetic variation:** differences/ diversity in the genetic make-up / genotypes / total number of genetic characteristics in a species / population / genome / gene pool. **Genetic drift:** chance / random change in allele frequency / removal of alleles from a population. **Bottleneck:** sudden / catastrophic / rapid / drastic reduction in size of a population / gene pool. Tara iti are an example of the bottleneck effect because their once-large population has been reduced to a small number of individuals / breeding pairs that are only found in Aotearoa New Zealand. Genetic variation / allele frequency in a population is affected by genetic bottleneck through loss of alleles. Due to the bottleneck effect, alleles could become fixed / 100% established or lost / 0%. This results in an unrepresentative gene pool from the original population. Bottleneck results in lowered genetic variation / low number of differing alleles in a population. Genetic variation / allele frequency in a small population is more affected / large population is less affected by genetic drift. In a small population, genetic drift can have a larger proportional effect on allele frequencies / genetic variation and is more likely to lead to alleles becoming fixed / lost / reduced in variation. In a large population, genetic drift / bottleneck is less likely to lead to alleles becoming fixed / lost due to the buffer effect of the larger number of individuals. Therefore, large populations tend to have more genetic variation / high genetic variation / high number of differing alleles in the population. **Consequences of a small population:** populations are very likely to have low genetic variation because there are fewer individuals (less alleles) in the population, and it is more likely allele frequency will not be representative of the original / larger population / increased likelihood of inbreeding. Small populations are also more likely to lead to fixed alleles because death has a larger proportional effect / decreases genetic diversity / variation.	**Describes:** • allele frequency • gene pool • genetic variation • bottleneck • genetic drift • the effect of genetic drifts on small / large populations (significant, impactful / proportional) • one consequence of having a small population after a bottleneck • one challenge of expanding a small population after a bottleneck.	**Explains:** • how allele frequency is affected by bottleneck effect • why tara iti (small) populations most likely have low genetic variation / diversity • why larger populations most likely have higher genetic variation / diversity • one consequence of a small population after a bottleneck (effect on either allele frequency or genetic variation) • one challenge of expanding the small tara iti population after a bottleneck.	**Discusses**, demonstrating comprehensive understanding by: • comparing and contrasting how genetic drift affects allele frequency and genetic variation between both small and large populations • linking the consequences and challenges for the tara iti population if it expands after a bottleneck. *For E8: Must use tara iti context in the answer and discuss allele frequencies for second E point.*

Expected Coverage	Achievement	Achievement with Merit	Achievement with Excellence
In large populations, there are more individuals therefore greater chance of random mating which will result in greater variation. Larger populations tend to have higher genetic variation because they have proportionally more individuals / alleles and, therefore, are less likely to have fixed alleles. **Challenges**: Even if the tara iti population increases, it will face challenges to survival due to its original low genetic diversity. With less genetic variation and fixed alleles, the population would have similar phenotypes and would face a lower survival rate if the conditions change. Harmful alleles could increase in frequency. In addition, with less diversity, there is a higher likelihood of offspring receiving two copies of a harmful recessive alleles, which could limit survival. Populations with low genetic diversity face the same type of problems as inbreeding populations since they share similar alleles. Inbreeding populations often have lowered immunity, fertility, and rates of offspring survival.			

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