Assessment Schedule – 2019

Biology: Demonstrate understanding of evolutionary processes leading to speciation (91605)

Evidence Statement

Question One

Evidence	Achievement	Merit	Excellence
Speciation refers to the process by which new species are formed. Speciation forms when gene flow is prevented and reproductive isolating mechanisms are built up in the different populations. The formation of different species of cicada can be by either allopatric speciation or sympatric speciation. Allopatric speciation occurs when populations become geographically isolated, each are subjected to different selective pressures and reach a point where they are reproductively isolated, and no interbreeding can occur if they were to come across each other. The formation of cicada species in New Zealand could have occurred by allopatric speciation, as the cicada arrived from Australia and New Caledonia. About 11 million years ago New Zealand's geography was made up of smaller islands and larger land masses. For example the *Kikihia laneorum* and the *Kikihia subalpina* and the *Kikihia angusta*: because the different land masses were isolated geographically, so were the populations of cicadas, and no gene flow between the populations occurred. This would mean that each population were subjected to different selective pressures and evolved different behaviours such as songs and sharp clicking or clacking sounds for courting females. Once the land masses were joined due to uplift and lowering of the sea levels, the different populations of cicadas were unable to reproduce because their courting songs were so different they were no longer recognisable between the different populations. While sympatric speciation is when populations form a new species within the same geographical area as the parent species.	• Describes speciation. Speciation refers to the process by which new species are formed. • Describes how new species form. Speciation forms when gene flow is prevented. Reproductive isolating mechanisms are built up in the different populations. Can occur through anagenesis formation of a new species where no splitting is occurring, or cladogenesis, where new species are formed from a parent species. • Describes allopatric speciation. When populations become geographically isolated, each are subjected to different selective pressures and reach a point where they are reproductively isolated and no interbreeding can occur if they were to come across each other. • Describes sympatric speciation. When populations form a new species within the same geographical area as the parent species. • Describes adaptive radiation. As speciation where multiple	Explains how the different cicada species have formed in New Zealand. • Allopatric speciation explained in relation to New Zealand. Explains that they are reproductively isolated due to a named geographical barrier, e.g. the Tasman Sea or Pacific Ocean. Explains selective pressures. E.g. as the different migrations occurred, the different populations were introduced to different geographic areas. These areas had different selective pressures, like different temperatures and different plant species, as well as different climates. These would have selected the alleles that are best suited for the climate it first migrated to. • Explains change in courting behaviour linked to formation of new species. E.g. the formation of cicada species in New Zealand could have occurred by allopatric speciation as the cicada arrived from Australia and New Caledonia. About 11 million years ago New Zealands geography was made up of smaller islands and larger land masses.	Discusses the different patterns of evolution. • Divergent evolution discussed. Divergent evolution linked to common ancestor linked to different invasion events after New Zealand separated from Australia linked to explanation of speciation as for merit. E.g. this would be divergent evolution as the 42 different species of cicadas have originated from common ancestors that invaded New Zealand after it had separated from Australia. For example, *Kikihia laneorum* and the *Kikihia subalpina* and the *Kikihia angusta* all share the same common ancestor, while *Maoricicada alticola* and *Maoricicada oromelaena* both share a common ancestor and *Notopsalta sericea* has a different ancestor. *Kikihia, Maoricicada and Notopsalta* were all from different invasion events. Due to the different evolutionary processes, each species formed due to natural selection and no gene flow, which allowed them to develop different songs and clapping or clicking sounds. • Adaptive radiation explained and linked to information provided. (Adaptive radiation linked to biogeography) E.g. as New Zealand landscape changed between 11 mya and present-day, new niches were formed, due to lowering of the

Cicada species arrived from Australia and New Caledonia in many different invasion events. As they arrived and established themselves, **intraspecific competition** for resources could lead to different members in the population moving to a different plant in the same area. This could mean that they develop behaviours in isolation such as songs and sharp clicking or clacking sounds for courting therefore are reproductively isolated, and are so different they are no longer recognisable between the different populations. Both types of speciation are divergent evolution, because the 42 different species of cicadas have originated from common ancestors that invaded New Zealand after it had separated from Australia. For example, *Kikihia laneorum* and the *Kikihia subalpina* and the *Kikihia angusta* all share the same common ancestor, while *Maoricicada alticola* and *Maoricicada oromelaena* both share a common ancestor, and *Notopsalta sericea* has a different ancestor. *Kikihia*, *Maoricicada*, and *Notopsalta* were all from different invasion events. Due to the different evolutionary processes, each species formed due to natural selection and no gene flow which allowed them to develop different songs and clapping or clicking sounds. This is also adaptive radiation because when new niches are available, and the parent species are able to exploit the new niches because each new niche will have different selective pressures, each population will develop differently to each other, until they become reproductively isolated from each other, forming new species. As the New Zealand landscape changed between 11 mya and present-day, new niches were formed due to lowering of the sea level and the rising of the Southern Alps. This means that there are niches with different temperatures, rainfall and plant life, which would provide different selective pressures as New Zealand's geography changed, and the new niches became available. This would mean that during the different invasions, different niches were available for cicadas to exploit, and because they would have had variation, the variation in their genotypes provided variation in phenotypes which were selected for	species arise from a common ancestor due to exploiting different niches. • Describes divergent evolution. Divergent evolution is where two or more species form from a common ancestor. OR Describes the divergent evolution of the Kikihia spp. All the Kikihia spp share a common ancestor, which would have arrived in one of the invasions. OR Describes the divergent evolution of the Maoricicada spp. All the Maoricicada spp share a common ancestor, which would have arrived in one of the invasions.	For example, the *Kikihia laneorum* and the *Kikihia subalpina* and the *Kikihia angusta* because the different land masses were isolated geographically so were the populations of cicadas and no gene flow between the populations occurred. This would mean that each population was subjected to different selective pressures and evolved different behaviours such as songs and sharp clicking or clacking sounds for courting females. Once the land masses were joined due to uplift and lowering of the sea levels the different populations of cicadas were unable to reproduce because their courting songs were so different they were no longer recognisable between the different populations. • Sympatric speciation explained in relation to New Zealand. Cicada species that are found in the same geographic location become reproductively isolated and no interbreeding occurs. The different populations of cicada are exposed to different selective pressures due to differences in habitat (although they are found in the same geographical location), e.g. different tree or different parts of the trees. Over time, a change in courting behaviour / the type of song the male cicada sings may occur due to reproductive isolation. AND	sea level and the rising of the Southern Alps. This means that there are niches, with different temperatures, rainfall and plant life, which would provide different selective pressures. As New Zealand's geography changed, the new niches became available. This would mean that during the different invasions, different niches were available for cicadas to exploit and because they would have had variation, the variation in their genotypes provided variation in phenotypes which were selected for by the different environment and habitat conditions, which would also allow for the different selection in behaviours, such as courting songs and sharp clapping or clicking sound by rapidly tapping their wings against the branch they are on. • Sympatric speciation explained in relation to New Zealand. Where they came from, **linked to** reproductively isolated, but still found in the same geographic location **linked to** selective pressures, **linked to** a change in courting behaviour linked to formation of new species. E.g. Cicada species arrived from Australia and New Caledonia in many different invasion events. As they arrived and established themselves, **intraspecific competition** for resources; this could lead to different members in the population moving to a different plant in the same area. This could mean that they develop behaviours in isolation such as songs and sharp clicking or clacking sounds for courting therefore are reproductively isolated and are so different they were no longer recognisable between the different populations. • Where they came from **linked to** geographically isolated linked **to** selective

by the different environment and habitat conditions which would also allow for the different selection in behaviours such as courting songs and sharp clapping or clicking sound by rapidly tapping their wings against the branch they are on.		Because they can no longer sing the same song, they do not recognise each other as potential mates. • Adaptive radiation explained. When new niches are available and the parent species are able to exploit the new niches because each new niche will have different selective pressures, each population will develop differently to each other until they become reproductively isolated from each other, forming new species. • Explains divergent evolution. As the process of natural selection acting on different populations of the same species such as the *Kikihia spp* being reproductively isolated and being exposed to different selective pressures, therefore forming new species such as *K. laneorum* and *K. subalpine* and *K. angusta*. One reason they no longer recognise each other as potential mates may be that they have developed different cicada songs. They were once one species and could interbreed, but now no longer can.	pressures **linked to** a change in courting behaviour **linked to** formation of new species. E.g. the formation of cicada species in New Zealand could have occurred by allopatric speciation, as the cicada arrived from Australia and New Caledonia. About 11 million years ago, New Zealand's geography was made up of smaller islands and larger land masses. For example, the *Kikihia laneorum* and the *Kikihia subalpina* and the *Kikihia angusta*: because the different land masses were isolated geographically, so were the populations of cicadas and no gene flow between the populations occurred. This would mean that each population was subjected to different selective pressures and evolved different behaviours such as songs and sharp clicking or clacking sounds for courting females. Once the land masses were joined due to uplift and lowering of the sea levels, the different populations of cicadas were unable to reproduce because their courting songs were so different, they were no longer recognisable between the different populations.

Not Achieved			**Achievement**		**Merit**		**Excellence**	
NØ = no response or no relevant evidence.	N1 = 1 point.	N2 = 2 points from Achievement.	A3 = 3 points.	A4 = 4 points.	M5 = 1 point from Merit.	M6 = 2 points.	E7 = 1 point from Excellence.	E8 = 2 points.

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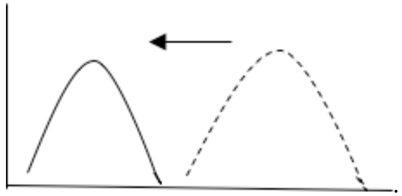
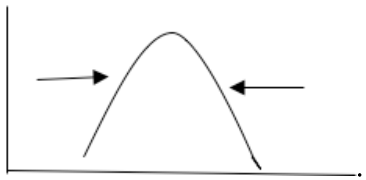
Question Two

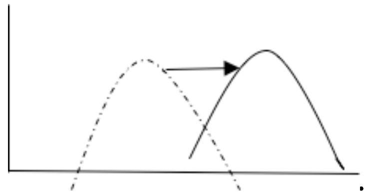
Evidence	Achievement	Merit	Excellence
The shape of the flowers is an example of **convergent evolution**. This is where the flower shape resembles the shape of the tūī's beak as the selection pressure of pollination for the flowers selects for flowers with a shape of the tūī's beak, as this allows access to the tūī as a pollinator. Over time the flax, the kākābeak, and the kōwhai all developed a similar shape to their flowers because they had the same selective pressure of the tūī acting as a pollinator. Homologous structures are structures that have similarities because they share a common ancestor. For example, the two species of flax have a similar shaped flower because they had a common ancestor, and the flower shape has been passed down through successive generations. The different plants all have a similar flower structure; this is an example of convergent evolution because the analogous structures / flowers of the different plants are pollinated by the same bird (tūī) and this acts as a selective pressure on the flower. Because there are many flowers with similar shapes to the tūī's beak, this reinforces the selective pressure for the tūī's beak to remain the same shape to access the nectary in the bottom of the flower, meaning the pollen gets brushed onto the head on one flower and transferred to the stigma of the next flower on another. Convergent evolution and coevolution are similar because they are both the result of selection pressures acting on reproductively isolated populations. For example, in convergent evolution of the kākābeak, kowhai, and the flax, flower shape and colour are due to having the same selective pressure by using the same pollinator – the tūī. This results in the different plants from different evolutionary paths forming analogous structures such as the flower's shape, which is similar to the shape of the tūī's beak, and colour, with *P. cookianum* and kowhai both having yellow flowers. While co-evolution also involves selective pressures, where both species reinforce the characteristic, positively selecting for plants with a similar shape to a tūī's beak and the plants, flowers select for tūī with that specific beak shape.	Patterns of evolution are described. • Convergent evolution. The flax, kākābeak and kōwhai are not closely related plant species, but all have developed similar flower structures independently of each other. • **Analogous** structures are structures with very different evolutionary origins that appear very similar because they carry out the same or very similar functions. • Bright colours for named flowers attract the Tui. *P. cookianum* and kowhai are yellow to attract the tūī. OR *P. tenax* and kākābeak are red to attract the tūī. • Coevolution described. This is where both species reinforce each other's phenotype. E.g. the flax, kākābeak and kōwhai flower shape influences the tūī's beak shape and the tūī's beak shape reinforces the flower shape. • Homologous structures described. Homologous structures are similar structures in different	• Explains co evolution. Explains that the flowers of the different plants are pollinated by the same bird and this acts as a selective pressure on the flower. Because there are many flowers with similar shapes to the tūī's beak, this reinforces the selective pressure for the tūī's beak to remain the same shape. To access the nectary in the bottom of the flower the pollen gets brushed onto the head on one flower and transferred to the stigma of the next flower on another plant of the same species. • Explains Homologous structures. Structures that are similar because they have been passed on from generation to generation, from a common ancestor. This is why the two flax species have very similar flowers. • Explains convergent evolution. All the different plant species, flax, kōwhai, and kākābeak, have similar shaped flowers. This is because they all have the same pollinator (tūī) which acts as the selective pressure. This means the flowers are curved to fit the curve of the beak of the tūī. The flowers have evolved to be either yellow like *P. cookianam* and kōwhai, or red like *P. tenax* and kākābeak. The plants are these colours because the tūī identifies	• Discusses 1 similarity and 1 difference between co-evolution and convergent evolution. Selection pressures: Convergent evolution of kākābeak, kōwhai, and the flax is due to having the same selective pressure of the same pollinator, the tūī. This results in the different plants from different evolutionary paths forming analogous structures such as flowers. Coevolution also involves selective pressures where both species reinforce the characteristics positively selecting for plants with a similar shape to a tūī's beak and the plants flowers select for tūī with that specific beak shape. Differences: Convergent evolution is more about all species having similar selection pressures and so develop similar structures. Coevolution – the tubular-shaped curved flowers fit the beak shape of tūī, allowing them to access the nectar source while allowing the plant to place pollen on a certain part of the tūī. The tūī and flowers therefore display a series of co-adaptations; any change in one provides selection pressure for changes in the other. Will accept for E7: • 3 linked explanations

Some differences are that convergent evolution is more about phenotypic similarities; at the genetic level all evolutionary pathways diverge. This means that each species do not share a common ancestor. Furthermore with coevolution, the tubular-shaped curved flowers fit the beak shape of tūī, allowing them to access the nectar source while allowing the plant to place pollen on a certain part of the tūī. The tūī and flowers therefore display a series of co-adaptations; any change in one provides selection pressure for changes in the other. This means that the phenotype of one organism is affecting the genotype of the other organism and vice versa.	species that have the same ancestor. • The two flax species have similar shaped flowers and have a common ancestor.	them as containing nectar, which select for these phenotypes and the alleles responsible for these colours. • Explains analogous structures. Analogous structures are structures that have similar structure, but have developed independently; they do not share a common ancestor, but have the selection pressure of using the same pollinator. This is why the flowers of the kōwhai species, flax species, and kākābeak species all have similar flower shape.	

Not Achieved			**Achievement**		**Merit**		**Excellence**	
NØ = no evidence or no relevant evidence.	N1 = 1 point.	N2 = 2 points from Achievement.	A3 = 3 points.	A4 = 4 points.	M5 = 1 point from Merit.	M6 = 2 points.	E7 = 1 similarity or 1 difference. OR 3 linked explanations	E8 = 2 similarities and 2 differences.

Question Three

Evidence	Achievement	Merit	Excellence
The snout-vent length for adult geckos increases from site 1 (Turakirae) to site 5 (Ocean Beach). Site 1 is mainly covered in *Muehlenbeckia complexa* and this vegetation changes to *Kunzea ericoides* (kanuka) and *Coriaria arborea* (tutu) at site 5. A cline is observed from site 1 to site 5 where the phenotype of snout-vent length gets larger from site 1 to site 5. The population of geckos in site 1 and 2 have a smaller **snout-vent length** they have a higher chance at surviving than middle sized or larger sized **snout-vent length** gecko. This means they are better adapted to living and surviving in vegetation mostly covered in *Muehlenbeckia complexa* in this site (adaptive advantage). Because the geckos are found on different plants, e.g. on *Muehlenbeckia complexa* and kanuka they might not meet to reproduce which is an example of **prezygotic isolating mechanism** and separation by **habitat preference**. *Over time with the populations across the 5 sites there could be:* • Directional selection for site 1, as the allele frequencies for small snout-vent length would be increasing. • If there was a random natural event that killed half the population, and by chance most of the individuals that carry the alleles for large snout-vent length then the allele frequency would change more rapidly caused by genetic drift. This would enhance the process of natural selection, specifically directional selection where the smaller snout-vent length was favoured at site 1. • Site 5 could also have directional selection towards alleles that code for a large snout-vent length because the geckos that survive best in this habitat	**Describes the trends in snout-vent length.** The snout-vent length for adult geckos increases from site 1 (Turakirae) to site 5 (Ocean Beach). At site 3 (Fisherman's Rock), individual adult geckos are intermediate in length. Male geckos also show an increase in size from little at site 1 (Turakirae Heads) to large. The length difference is smaller in females because adult males are larger than females at site 1 (Turakirae Heads), but similar in size to females at site 5 (Ocean Beach). • **Describes the trend in in sample site.** The habitat vegetation changes from site 1 to site 5 as site 1 is Turakirae, which has vegetation of mostly *Muehlenbeckia complexa*, which changes to mostly kanuka and tutu by site 5. • **Describes genetic drift.** Genetic drift is the random fluctuations in the numbers of alleles in a population. • **Describes reproductive**	• **Explains how natural selection could play a role in *W. maculata*.** In sites 1 and 2 the geckos that have a smaller snout-vent length have a higher chance at surviving than middle sized or larger snout-vent length geckos. This means they are better adapted to living and surviving in vegetation mostly covered in *Muehlenbeckia complexa* in this site. In site 2, the male and female geckos are a bit larger in snout-vent length, due to a slight change in vegetation still mostly covered in *Muehlenbeckia complexa* with <u>some</u> kanuka and <u>some</u> tutu growing. It seems this phenotype has a selective advantage.  Short medium large. Snout-vent length phenotypes. **In site 3**, the male and female geckos were larger than sites 1 and 2, but smaller than sites 4 and 5 This means they had an intermediate size and had a selective advantage of living in a mixture of about 50% *Muehlenbeckia complexa* with about 50% kanuka and tutu.  Short medium large. Snout-Vent Length Phenotypes.	Analyses the reproductive isolating mechanisms. • **Links reproductive isolation to natural selection.** Explains that habitat preference is a **prezygotic isolating mechanism** which could prevent breeding between geckos between populations at different sites. Larger individuals at site 5 are better suited to living in kanuka and tutu. This means that they have an adaptive advantage and are better able to reproduce and survive at site 5 than the geckos with a <u>snout-vent length small–medium.</u> This means that there is directional selection towards large snout-vent length. AND In site 5, the population could become reproductively isolated by many different processes, both prezygotic and postzygotic mechanisms. This would provide a barrier to gene flow. A single barrier might not completely isolate a gene pool but more than one isolating mechanism could isolate the populations and lead to speciation. Prezygotic isolating mechanisms could include: Habitat preference – where the different populations of gecko at site 1 to site 5 prefer different types of vegetation.

have large snout-vent length. Therefore, they will be better at gaining resources and surviving than the mid-smaller **snout-vent length** geckos in the kanuka and tutu habitat. Site 3 could show **stabilising selection** where large and small **snout-vent length** are selected against and the medium sized **snout-vent length** are better adapted to the 50% *Muehlenbeckia complexa* with about 50% kanuka and tutu habitat. In all cases, the selection factor on the direction of speciation is dependent on how the environment changes over time, especially how the habitat and vegetation changes. Other factors, such as geographical changes, could also enhance natural selection by processes such as genetic drift, where the allele frequency is affected because the population is small. Other isolating mechanisms that could affect the different populations at sites 1 to 5 are: • Behavioural incompatibility. Being isolated due to habitat preference could also lead to changes in behaviour – timing of feeding relating to timing of fruit the tree they live under might be producing. When they mate, mating recognition based on size of their **snout-vent length**. • Other considerations such as structural compatibility might change over time, reducing the ability to reproduce between populations at each site.	**isolating mechanisms**. **Prezygotic** – reproduction is prevented before fertilisation. **Postzygotic** isolating mechanisms are mechanisms that prevent the formation of fertile offspring. • Describes natural selection. Natural selection is the survival of a phenotype in a population that is then better able to reproduce and pass on its favourable alleles to the next generation.	**In site 4 and 5** the male and female geckos were larger than sites 1 and 2 and 3. This means they had a larger size and had a selective advantage of living in a a habitat of mostly kanuka and tutu. This would provide a selection towards the larger phenotype.  • **Explains how genetic drift could play a role in speciation of *W. maculata*.** Because the populations are relatively small in the coastal region, any floods and or slips could have killed some individuals, therefore causing a change in the allele frequency of larger individuals in site 5, leading to more individuals of larger phenotypes. OR Because the populations are relatively small in the coastal region, any floods and or slips could have killed some individuals, therefore causing a change in the allele frequency of medium sized individuals in site 3, leading to more individuals of medium snout-vent length phenotypes to breed and reproduce. • Reproductive isolating mechanism explained.	Behaviour incompatibility – the different populations could have specific rituals habits to recognise potential mates**.** **Structural incompatibility –** different reproductive structures could develop due to isolation preventing reproduction between the different populations. **Physiological incompatibility –** differences in gametes could also prevent populations from interbreeding over time. • **Speciation linked with genetic drift,** which a random natural event, such as an earthquake or mudslide etc., could by chance kill a few individuals removing the allele for small snout-vent length from site 5. This causes the allele frequency of the large allele to change more quickly (become fixed in the population). At site 3 stabilising selection could be occurring, as the medium phenotype of snout-vent length is favoured by the habitat of a 50% mix of *Muehlenbeckia complexa* with about 50% kanuka and tutu.

Not Achieved			Achievement		Merit		Excellence	
NØ = no response or no relevant evidence.	N1 = 1 point.	N2 = 2 points from Achievement.	A3 = 3 points.	A4 = 4 points.	M5 = 1 point.	M6 = 2 points.	E7 = 1 point.	E8 = 2 points.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 8	9 – 14	15 – 18	19 – 24