Assessment Schedule – 2018

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

Evidence Statement

Question One

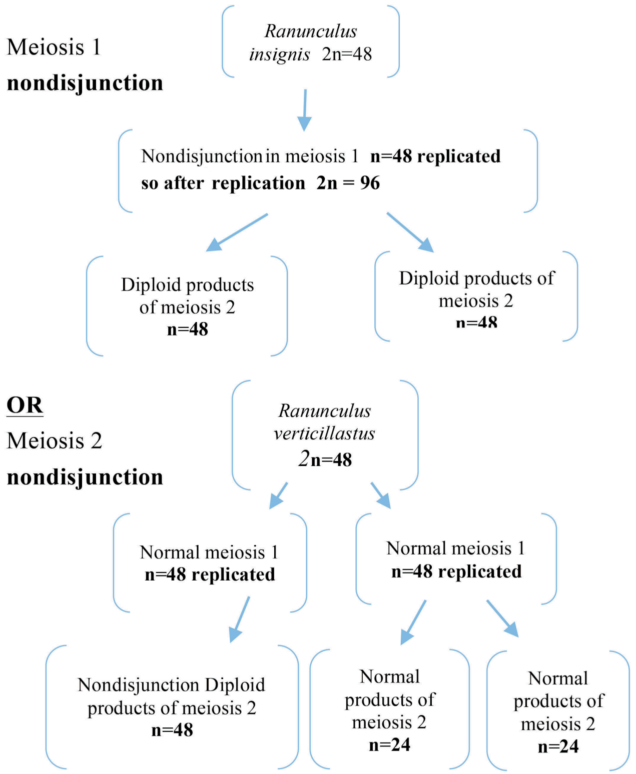
Evidence	Achievement	Merit	Excellence
A species is a group of members in a population that can interbreed to produce fertile offspring. A mutation is a change in the normal base sequence of DNA. This must have occurred in the eels as those that spawn in different areas could have a variation in the gene that determines navigation, and as the young eels do not have any parental guidance, they make this journey on their own to rivers in New Zealand. The mode of speciation is **allopatric speciation**; this is because the shortfin eel and the longfin eel have different breeding areas – the longfin eels' area is near New Caledonia while the shortfin eels' is near Samoa. This is a **reproductive isolating mechanism**. Another type of reproductive isolating mechanism is **temporal separation**, as the shortfin eel males migrate for reproduction during February – March while the longfin eel migrates in April. Both of these are prezygotic isolating mechanisms that prevent individuals from mating. This speciation could have occurred in two ways: 1. By a migrating eel getting carried off course by a large storm event. This means that when the mature eels return for reproduction they swim to the area where they were first hatched. 2. If the allele responsible for migration carried a mutation and because the two variants of this mutation isolate, the longfin migrated to the coast of New Caledonia while the shortfin eel migrated to the coast of Samoa. This is a form of **divergent evolution** as displayed in the Anguilla Phylogeny – that the *Anguilla australis* and the *dieffenbachii* share a common ancestor.	Describe the pattern and modes of speciation that could have occurred, causing the formation of *Anguilla australis* and *Anguilla dieffenbachii.* **Species concept** The idea that members of a population that can interbreed naturally to produce fertile offspring over successive generations. **Process of natural selection described** • There is **natural variation** in the ancestor species with alleles responsible for timing for migration, and alleles for navigation to breeding grounds (this caused variation in the population). • Because the ancestor population formed two isolated populations, **selection pressures** selected for alleles that were best suited for shortfin eels' migration. **Mutations** • Mutations in the alleles affecting their migration distance and therefore breeding grounds means that they do not migrate to where their parents did and changed their breeding grounds to the coast of Samoa for the shortfin eel and the coast of New Caledonia for the	Explains the patterns and modes that could have occurred, causing the formation of *Anguilla australis* and *Anguilla dieffenbachii.* **Patterns linked to natural selection** • This is an example of **divergent evolution** because both the longfin and shortfin eels were a part of a large ancestral population when a few **mutations** affecting the alleles responsible for migration occurred. This caused longfin eels to migrate towards New Caledonia and shortfin eels to migrate to Samoa. **Linked process (natural selection)** • Because individuals with mutations for different migratory routes are selected for, and had alleles that helped with their migration, they were better able to survive the migration and breed, meaning their alleles are represented in the offspring. **Mutations** • The original parent population gained mutations in their alleles that affected migration distance (positive selection) as individuals with these mutations were better able to survive and pass on their successful alleles to their offspring. **Explains reproductive isolating mechanisms** • **Spatial / geographical** prezygotic isolating mechanisms: because the eels	Discusses the patterns and modes that could have occurred, causing the formation of *Anguilla australis* and *Anguilla dieffenbachia.* **Discussion linking genetic basis for natural selection** E.g. Both species of eels, *Anguilla australis* and *Anguilla dieffenbachii*, have a common ancestor where they were once a single population. They would both head to the same breeding grounds. Because they had a mutation occurring on the gene responsible for navigation on their migration, it changed, and some eels then were migrating to a different breeding ground. This means that they are genetically isolated from the other population. Because a few eels are able to reproduce, their alleles and characteristics were selected for in the population and are, therefore, directional selection in terms of size and migration as the shortfin eel has further to go so the eels with the alleles best suited for this migration are better able to survive and, therefore, reproduce. **Any reasonable justification of the physical / behavioural / georaphical differences linked to genetic isolation E.g. Links to geographical isolation.** Could have occurred by a chance event

Another pattern is **punctuated equilibrium** as there are long periods of stasis followed by rapid periods of change. This also shows that the speciation of *A. australis australis* and *Anguilla dieffenbachii* share a common ancestor. Because the populations are genetically isolated by the different breeding grounds, they have been able to accumulate favourable mutations suited to their habitat and migration route. This is a form of **allopatric speciation** as the populations are separated by the **geographic barrier of distance of the breeding grounds**. This means that male and female eels with the mutations to travel to Samoa (shortfin) will be reproductively isolated from the ones that travel near New Caledonia. **Links mode of speciation** Because the populations are genetically isolated by the different breeding grounds, they have been able to accumulate favourable mutations suited to their habitat and migration route. This is a form of **allopatric speciation** as the populations are separated by the **geographic barrier of distance of the breeding grounds**. This means that male and female eels with the mutations to travel to Samoa (shortfin) will be reproductively isolated from the ones that travel near New Caledonia. **Explains reproductive Isolating Mechanisms** • **Spatial** Prezygotic isolating mechanisms: because the eels have different breeding grounds they do not interbreed. This means their alleles do not mix and they may accumulate differences due to **mutations**; that means their allele frequency will change due to the different selective forces that they are exposed to in their different habitats. • **Temporal prezygotic** isolating mechanism: because the eels are migrating at different times, they do not cross paths and do not meet to reproduce. This temporal separation ensures that **there is no mixing of alleles.**	longfin eel. **Patterns** • One pattern is **divergent evolution** as both species share a common ancestor and would have been one population. • Another pattern is **punctuated equilibrium** as there are long periods of stasis followed by rapid periods of change. **Reproductive isolating mechanisms** • **Spatial / geographical** prezygotic isolating mechanisms: the parent species (common ancestor) diverged as the two groups developed **in different breeding grounds**; this means the populations are genetically isolated and there is no mixing of alleles. • **Temporal prezygotic isolating mechanism:** populations are separated as they are breeding at different times, as the **shortfin** males leave in **February – March** and the **longfin** males leave in **April**. • Behavioural isolating mechanisms. OR Behaviour described. **Mode of speciation described** • The mode of speciation in this example is **allopatric speciation** because the populations are separated by a geographic barrier related to the breeding grounds location. **Describes how a physical or behavioural difference could have occurred.**	have different breeding grounds, they do not interbreed. This means their alleles do not mix and they may accumulate differences due to mutations; that means their allele frequency will change due to the different selective forces that they are exposed to in their different habitats. • **Temporal prezygotic** isolating mechanism: because the eels are migrating at different times, they do not cross paths and do not meet to reproduce. This temporal separation ensures that **there is no mixing of alleles / no gene flow**. **Explains mode of speciation** • This is a form of **allopatric speciation** as the populations are separated by the geographic barrier of distance of the breeding grounds. Because the populations are genetically isolated by the different breeding grounds, they have been able to accumulate favourable mutations suited to their habitat and migration route. This means that male and female eels with the mutations to travel to Samoa (shortfin) will be reproductively isolated from the ones that travel near New Caledonia.	where during the migration the eels are taken off course due to a change in the currents or a storm that caused the shortfin eels to be taken to the new breeding grounds. Because the young eels know only this area as the breeding ground they will return to this breeding ground. This provides a founder effect and this new population will have only the alleles in the population that were of the original parents. Because they are geographically isolated from the longfin eels, they will produce only traits and characteristics that are selected for by the environment they are exposed to. **E.g. Links to physical differences** Due to the founder effect longer length body, and longfin eel has over time only been breeding with individuals found in the breeding grounds, and will have only the alleles in the gene pool that carry the longer length body and longer fin. Due to the founder effect, shorter sized shortfin eel has over time been breeding only with individuals found in the breeding grounds and have only the alleles in the gene pool that carry the shorter length body and fin. **E.g. Links to behavioural differences** The migration at different ages would be linked to sexual maturity and the shortfin males seem to migrate February-March while the longfin males tend to migrate in April suggesting that… **E.g. Links to physiological differences** **AND** **Links reproductive isolating mechanisms to natural selection .** **OR** **Links reproductive isolating**

	E.g. the length of the dorsal fin linked to where they are found in the rivers or the distance of the migration path.		**mechanisms to modes of speciation.**

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.

Question Two

Evidence	Achievement	Merit	Excellence
The processes that could lead to the formation of *Ranunculus nivicola 2n = 96* Nondisjunction during meiosis 1 results from the failure of chromosomes to separate during cell division because the spindle does not function properly. As a result, all the chromosomes finish up in the same nucleus, which has twice as many chromosomes as it should have. This can happen in two ways. Either way, the normal halving of the chromosome number fails to occur and two diploid nuclei result, which later give rise to diploid gametes.  • Autopolyploidy involves the multiplication of the entire genome within a single species. Thus an autotetraploid has 4	Describes the process and patterns of speciation in *Ranunculus nivicola.* • **Sympatric species** are species that are found living in the same location at the same time. • **Sympatric speciation** is the formation of a new species from parent species in the same location. **Patterns** • This is also an example of **punctuated equilibrium** because there are long periods of little or no change followed by periods of rapid speciation events. • **Gradualism** is the process of slow small periodic changes in the gene pool over long periods of time. **Process** • **Polyploidy** results from hybridisation between species. This occurs when chromosomes do not separate properly and so gametes have a diploid number of chromosomes. • **Directional selection** described /	Explains the process patterns and mode of speciation in *Ranunculus nivicola.* **Process explained** • **Polyploidy**: Polyploids which originated by doubling the chromosome number of a *Ranunculus nivicola* resulting in two sets of chromosomes in the gametes from two parent species. E.g. Polyploidy involves the multiplication of the entire genome within a single species. An autotetraploid has four sets. Autopolyploidy results **from the failure of chromosomes to separate during cell division** because the spindle does not function properly. As a result, all the chromosomes finish up in the same nucleus, which has twice as many chromosomes as it should have. This can happen in two ways. Either way, the normal halving of the chromosome number fails to occur and two diploid nuclei result, which later give rise to diploid gametes. If a diploid gamete from *R. insignis* subsequently fuses with a diploid gamete from *R. verticillatus*, a tetraploid zygote is produced. An example of this is *Ranunculus nivicola*. which has 96 chromosomes (48 + 48 = 96) 48 chromosomes from *R. insignis*. 48 chromosomes from *R. verticillatus*. These gametes were by chance able	Discusses the process, patterns and mode of speciation in *Ranunculus nivicola.* **Process linked to pattern** • Polyploidy explained **AND** linked to punctuated equilibrium. E.g. Polyploidy results **from the failure of chromosomes to separate during cell division** because the spindle does not function properly. As a result, all the chromosomes finish up in the same nucleus, which has twice as many chromosomes as it should have. This can happen in two ways; either way, the normal halving of the chromosome number fails to occur and two diploid nuclei result, which later give rise to diploid gametes. If a diploid gamete from *R insignis* subsequently fuses with a diploid gamete from *R verticillatus*, a tetraploid zygote is produced. An example of this is *R. nivicola*, which has 96 chromosomes (48 + 48 = 96). Because the new species, *Ranunculus nivicola*, have different gametes as they have more chromosomes, they are reproductively isolated as they produce incompatible gametes. **Linked to:** **This is an example of punctuated evolution** because the formation of *R. nivicola* occurred over one generation which is very quick evolutionary change as the new species was formed when fertilisation occurred between *R. insignis* and *R. verticillatus*. That before this was periods of stasis / no change**.** **(Links in example to explanation.)**

sets of chromosomes. Autopolyploidy results **from the failure of chromosomes to separate during cell division** because the spindle does not function properly. As a result, all the chromosomes finish up in the same nucleus, which has twice as many chromosomes as it should have. • This can happen in two ways; either way, the normal halving of the chromosome number during meiosis fails to occur and two diploid nuclei result, which later give rise to diploid gametes. If a diploid gamete subsequently fuses with another diploid gamete, a triploid zygote is produced. An example of this is *Ranunculus nivicola* which has 96 chromosomes (48 + 48 = 96) chromosomes. This is a form of instantaneous speciation because the formation of this new tetraploid individual is genetically isolated from both the parent species as the gametes may be incompatible. Because these plants can reproduce asexually, they can produce seeds which are released and grow. These will produce gametes which are compatible, and a new population could become established. This is considered an example of **punctuated evolution** because the formation of ***R. nivicola*** occurred over one generation, which is very quick as the new species was formed when fertilisation occurred between *R. insignis* and *R. verticillatus*. Before this were periods of stasis / no change. **(links in example to explanation)** If this were to be **gradualism**, there would be small changes in the gene pool of ***R. nivicola* over successive generations through time.** (**explains why it can't be gradualism**)		to join during fertilisation and produce ***R. nivicola 2n 96 (tetraploid)*** **Patterns explained** • This is considered an example of **punctuated evolution** because the formation of ***R. nivicola*** occurred over one generation which is very quick as the new species was formed when fertilisation occurred between *R. insignis* and *R. verticillatus*. Before this was periods of stasis / no change. **(Links in example to explanation.)** • This is not gradualism - If this were to be **gradualism**, there would be small changes in the gene pool of *R. nivicola* over successive generations through time. **(Explains why it can't be gradualism.)** **Mode of speciation** • This is an example of **sympatric speciation** because *R. insignis* and *R. verticillatus* are located in the same geographic area. **And links** Because of polyploidy, the new species ***R. nivicola*** is reproductively isolated from *R. insignis* and *R. verticillatus*. **Directional selection is explained** • At lower temperatures *R. nivicola* will survive better than *R. insignis* and and *R.verticillatus* while if the temperature increases *R. insignis* and *R. verticillatus* would survive better. **(No data used to justify the**	• If this were to be **gradualism** there would be small changes in the genepool of ***R. nivicola* over successive generations through time.** **(PE linked to explanation of why it can't be gradualism.)** • **Discussion of evolutionary effects if the climate changes.** E.g. All three species can survive if the temperature increases in the alpine region up to 10°C. *R. nivicola* is best suited to growing in a range of temperatures from 3°C to 5°C. It is found in the same areas geographically as *R. insignis* and *R. verticillatus* as it has the same upper temperature tolerances; however, it seems to be out-competed in the 5°C to 10°C range. This means that in the *R. nivicola* population there would be selective pressures for individuals in the population better adapted at surviving warmer conditions that would lead to directional selection. E.g. Because *R. nivicola* is also able to withstand cooler temperatures, it would out-compete *R. insignis* and *R. verticillatus* as they do not have the same lower tolerances of about 3 °C. This would cause directional selection for these two populations, to having a higher tolerance to lower temperatures.

		answer.)	

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 point from Excellence	E8 = 2 points.

Question Three

Evidence	Achievement	Merit	Excellence
Biogeography After the bottleneck event in the Oligocene, the wren common ancestor moved out to fill vacant niches due to the lowering of the sea level as the climate began to cool and water was being stored in the polar caps and in glaciers. New land was exposed and new niches became available. The different populations spread out formed a cline where neighbouring populations were exposed to slightly different conditions and had slightly different selection pressures such as food sources from the bottom of the South Island to the top of the North Island. **Natural Selection** This is **natural selection** because the once large population was reduced due to the Oligocene drowning, when the large ancestor population was reduced to small populations caused by warming and melting of the glaciers and polar caps. These populations' allele frequencies may not be representative of the original population, which is a form of genetic drift. As the water levels decreased due to uplift and periods of cooling, the different populations spread though the length of New Zealand, which opened up new niches. There is an increase in population as there were few natural predators and on the ground was the safest area. So the population increased. **Variation** Individuals vary from each other in many characteristics – some are more suited to the niche than others. The different populations formed a **cline** where neighbouring populations are exposed to slightly different conditions and had slightly different selection pressures such as food sources. Some live in ranges from 900 m to subalpine altitudes of 2500 m foraging for insects in the low shrubs and bare rocks. Because they are poor flyers, they are unable to move great distances and they developed alleles that suited their environment. Other populations were more suited to bush and scrub environments and they feed among the branches. Other wrens feed in higher altitude forests, foraging in the canopies, eating small insects. **Competition**	**Describes** the evolution of the wren in New Zealand outlining the patterns, modes and conditions leading to speciation in the wren. • **Natural selection** Natural selection is the process whereby organisms better adapted to their environment tend to survive and produce more offspring. • **A cline** The continual increase or decrease in some characteristics between neighbouring populations. Which can be related to the change in biotic and abiotic factors in a given range. • **Adaptive radiation** This is an example of adaptive radiation as there is movement of the ancestor wren into different niches in the North and South Islands. • **Divergent evolution** This is also a form of divergent evolution as all wren share a common ancestor. 24 mya. Rock wren diverged from bush wren about 18 mya. • **Convergent evolution** NZ Wren compared to UK Treecreeper. This is an example of	**Explains** the evolutionary patterns and processes shown by the New Zealand wren and the UK treecreeper. **Explains Natural Selection.** **Overproduction** – species produce more young than will survive. **Variation –** Individuals vary from each other due to different alleles. **Competition –** There is competition among offspring for resources (food, nesting sites, mates, etc). **Survival of the fittest phenotype –** individuals with the most favourable characteristics survive and pass on their alleles to the next generation. **Change in allele frequency in the population** - As individuals with the better suited characteristics and therefore alleles survive, they are better able to survive and reproduce. The next generations will have a higher number of those alleles in the population over time. **Biogeography / cline explained – linked to example** E.g. After the bottleneck event in the Oligocene the wren common ancestor moved out to fill vacant niches due to the lowering of the sea level as the climate began to cool, and water was being stored in the polar caps and in glaciers. The land mass above the water increases and more niches become available. The different populations formed a cline where neighbouring populations were exposed to slightly different conditions and had slightly different selection	**Compare and contrast** the patterns and processes that led to speciation in the New Zealand wren and the UK treecreeper. **Discussion that links Natural Selection and Biogeography** The bottleneck effect occurred in the Oligocene era when there were a lot of populations of wrens that died out because the landmass above water reduced, because the warming period melted glaciers and polar caps (interglacial period). This meant that populations in the North Island and / or South Island of New Zealand were limited and decreased significantly. This may have altered the allele frequency compared to the larger populations that covered New Zealand in the Middle Miocene era 45 million years ago. The early wrens distributed themselves in the Early Miocene as vacant niches became available as the land mass increased. New Zealand's above-sea-level land mass increased due to a period of cooling, and the wrens increased their population to take advantage of the available resources. They spread out from the bottom of the South Island to the top of the North Island, which created many overlapping populations called a cline, to take advantage of the new niches available which is adaptive radiation. Each population is called a deme, and each deme had different selective pressures, and therefore each population would have different selective pressures. **Compares divergent evolution in the wren species to convergent evolution**

If all the ancestor wren competed for the same food source competition would be too high. Because there is **variation** in the species, some moved to different niches and because they filled slightly different niches, their populations selected for different alleles. This isolation in the different populations caused **little to no gene flow**. The different population allele frequency changes as they selected for different conditions. **Survival of the fittest** Individuals with the most favourable combinations of alleles and therefore characteristics will be better able to survive and pass on their alleles and characteristics to the next generation. **Change in allele frequency** Each new generation will have a slightly different allele frequency as directional selection will occur in all three populations as they fill slightly different niches and conditions. **For example:** The bush wren has a wide range of abilities to forage for food – higher altitudes in forests. This means they are not in direct competition with the rifleman wren for foraging areas and food. In islands off Stewart Island, they have been seen to forage on the ground due to no introduced predators. The bush wren is also found on some of these islands, foraging on the ground. Their behaviour with mating, and where they are found, to colour identification, are all reasons that prevent gene flow between populations.	convergent evolution, where these two birds have different evolutionary origins but have developed similar characteristics.	pressures such as food sources. **Convergent evolution explained** Wren compared to UK treecreeper: This is an example of **convergent evolution**, where these two birds have different evolutionary origins but have developed similar characteristics **because** they are placed under similar selective pressures, such as foraging for small insects by probing the bark of trees with their beaks. They are small birds with a thin bill, which are adaptations that suit both species. **Divergent evolution explained** The NZ Wrens are an example of divergent evolution because they all share a common ancestor and have filled available niches which have selected for favourable alleles. This means that each wren is different from each other genetically and phenotypically.	**with the wren and the treecreeper** Explains that the **convergent evolution** is the process of two unrelated species developing homologous structure like the small wings, small legs, sharp beak, because treecreeper in the UK is an example of convergent evolution, and that they have similar adaptations as they are exposed to similar selective pressures. This is because they share similar niches as they both get insects with sharp beaks that probe beneath the bark. They are both small and not well suited for long flight. **(...compared with divergent evolution in the wren...)** This is where the different species of wren have developed from a common ancestor, which means that they have faced slightly different selective pressures to a point where they can no longer interbreed and produce fertile offspring. Convergent evolution is similar to divergent evolution because both patterns rely on natural selection selective pressures and changes in allele frequencies. Convergent evolution is different to divergent evolution because one involves similar niches and selection pressure without common heritage, the other involves common heritage and different selection pressures. (Need to include examples from resource materials.)

Not Achieved			Achievement		Merit		Excellence	
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Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 13	14 – 18	19 – 24