

Assessment Schedule – 2013

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

Assessment Criteria

	Evidence	Achievement	Merit	Excellence
ONE	35 mya populations of NZ skink became isolated when much of NZ's land-mass became covered in water and underwent allopatric speciation. Those that were able to adapt filled the remaining available land niches. Approx 23 mya tectonic activity / uplift led to more land exposure and the northern skink populations were able to expand into new available niches. By now speciation had occurred and different northern skink species now exist sympatrically, but reproductively isolated in similar niches. <i>O. smithi</i> has greater distribution, so there is a lot of gene flow between populations and high genetic diversity. <i>O. suteri</i> have limited distribution, so gene flow between populations is limited and genetic diversity is low. Biologically <i>O. suteri</i> is larger, nocturnal and lays eggs, which means it is more easily seen and predated by cats and dogs. It probably needs a warmer climate for eggs to hatch and either the eggs are not protected or <i>O. suteri</i> is limited to nocturnal foraging for food to protect itself and its eggs. It would be expected to have smaller populations with reduced genetic diversity. <i>O. smithi</i> young have more chance of escaping predators due to live birth. <i>O. smithi</i> can protect their young for longer, before they give birth and can have their young in a greater variety of areas. Due to reproductive differences, no interbreeding between <i>O. suteri</i> and <i>O. smithi</i> is possible. Isolation on islands has meant that genetic and reproductive isolation of the two species has been maintained.	Name AND describe type of speciation with reason Eg, EITHER - Allopatric speciation due to geographical isolation / land masses being isolated. OR - Sympatric speciation due to being in the same place / niche differentiation / active during day <i>O.suteri</i> nocturnal / active at night. Describes aspects of geographical and / or biological differences relevant to the type of speciation identified. Eg, allopatric speciation: - NZ land mass was reduced to small islands 35 mya, as most parts were covered by water. - Geographically separated, so no gene flow. Eg, sympatric speciation: - RIM may exist in same areas but reproduce differently / active at different times / look different OR name type of RIM, behavioural, temporal with description. Eg, for both: - Subject to different selection pressures, so different adaptations / alleles selected for:	Gives reasons for geographical and biological differences of <i>O. smithi</i> and <i>O. suteri</i>., relevant to the type of speciation named. Eg, allopatric: 35 mya most of NZ land mass was submerged. Changes in the environment and geographic isolation would have led to only those with suitable phenotypes to be able to survive, leading to speciation. - Tectonic activity / land uplift 23 mya opened up more ecological niches so skinks could occupy new areas, now existing as sympatric species with different behaviours. Eg, sympatric: <i>O. smithi</i> has better survival chances as active during day to avoid predators and live young at less risk from predators, so more varied reproduction chances. - Biological differences: <i>O. suteri</i> are nocturnal egg layers and more limited to warm environments / more at risk from predation / safer at night. Eg, both:	Discusses biological and geographical factors contributing to speciation and evaluates differences in genetic diversity of two northern skinks. Eg: - An answer that includes an explanation about how it is initially allopatric speciation and then changes to living sympatrically, (sympatric speciation) as sea levels drop they can no longer interbreed because of RIM. 35 mya most of NZ land mass was submerged. Changes in environment and geographic isolation would have led to only those with suitable phenotypes able to survive and undergo speciation. Tectonic activity / land uplift 23 mya opened up more ecological niches so skinks could occupy new areas, now existing as sympatric species with different behaviours. - Genetic diversity: high in <i>O. smithi</i> due to wide distribution and plenty of breeding between populations, so high allele frequencies. Low in <i>O. suteri</i> as distribution and method of reproducing is limited and lots of in-breeding so low allele frequencies. Genetic drift may put species at risk. <i>O. suteri</i> being larger, nocturnal and egg laying is more limited to warmer

				Genetic diversity and ability to adapt to habitat, eg <i>O.smithi</i> has greater variation so more adaptable to wider variety of habitats.	- RIM developed between the skinks resulting in an inability to breed and so there was no gene flow. - Temporal or behaviour RIM existed that prevented skinks from mating, eg differences in skink activity <i>O. smithi</i> diurnal / active during day <i>O.suteri</i> nocturnal / active at night. Reasons for differences in genetic diversity. Eg: - High in <i>O. smithi</i> due to wide distribution and plenty of breeding between poplns. Low in <i>O. suteri</i> as distribution is limited and lots of in-breeding. - Genetic drift alters the frequency of alleles in a small population over time, this and inbreeding reduced genetic variation.	climates / more at risk from predation. No interbreeding with other species possible due to reproductive isolation. <i>O. smithi</i> young have a greater chance of survival. <i>O. smithi</i> and <i>O. suteri</i> have few similarities apart from sharing the same niche so reproductive isolation will be physical and behavioural.			
	Not Achieved			Achievement		Merit		Excellence	
	NØ = no response or no relevant evidence.	N1 = 1 point, from Achievement.	N2 = 2 points from Achievement.	A3 = Names and describes type of speciation plus 1 other point from Achievement.	A4 = Names and describes type of speciation plus 2 other points from Achievement.	M5 = 1 point from Merit.	M6 = 2 points from Merit.	E7 = 1 point from Excellence.	E8 = 2 points from Excellence.

	Evidence	Achievement	Merit	Excellence
TWO	The lineage of pukeko and takahe from a common ancestor shows an example of punctuated equilibrium, where periods of stasis are followed by shorter periods of divergence. Takahe arrived in NZ 5 mya when there were no ground-dwelling mammals and no predators, so they filled the ground-dwelling, dense scrub grazing niches and lost the ability to fly. The energy needed to maintain wings and fly was not necessary. A low reproductive rate maintained the popln within its limits / capacity and genetic diversity. Ecological changes 1000 years ago due to climate changes and / or the arrival of humans reduced takahe to isolated alpine habitats and sent the N.I. takahe extinct. On the other hand, the pukeko evolved in Australia and the Pacific amongst ground dwelling mammals and adapted to survive, largely by living in groups, cooperative breeding and retaining some ability to fly. When arriving in NZ, millions of years later, though sharing a common ancestor with takahe, it had several selective advantages, enabling it to fill and successfully thrive in the swampy, open grasslands of NZ. Takahe are now a threatened species with high inbreeding, low genetic diversity and very low numbers, whereas pukeko thrive with wide genetic diversity and large populations.	Punctuated equilibrium described Eg: • Rapid divergence after long periods of stasis. Different establishment patterns described. • Takahe endemic to NZ / very early arrival before mammals, pukeko much later. • Takahe evolved flightless ground-dwelling way of life but pukeko evolved in Australia / Pacific with mammals, then arrived in NZ. • At least two pukeko colonisations of NZ. Selection pressures affecting each species identified. e.g. • Mammals compete with / kill ground-dwelling takahe. • Pukeko breed cooperatively / retain some flight, so more offspring survive • Human arrival / climate change negatively affected takahe reproductive success rates. • Pukeko evolution in Aust / Pacific prepared them for survival in NZ. • Takahe slow breeding rates could not replace loss of population in adverse conditions.	Explains punctuated equilibrium. Eg: • The evolutionary lineage shows early divergence of takahe and moho from a common ancestor, which would have had adaptive advantages to exist in NZ. A period of stasis (approx. 5my) followed when the reduction in takahe numbers opened up available niches in NZ for the divergence and colonisation by swamp hen from Australia and the Pacific. Explains evolutionary selection pressures affecting either species. Eg: • Takahe existed in NZ before ground dwelling mammals so could fill ground dwelling niches and remain isolated. Slow / limited reproduction suited takahe to maintain popln numbers and flightlessness was more efficient. • Pukeko existed in Australia and Pacific Islands before arriving in NZ and have only developed behaviours to exist successfully with competing / predatory ground dwelling mammals. They breed more rapidly and successfully than takahe and still retain some flight, which enables them to exist successfully in open swamps and grasslands of NZ. Explains how selection pressures have shaped processes of evolution of	Compares & contrasts how the evolutionary selection pressures have shaped the evolution and survival of both species. Eg: • Takahe and pukeko share a common ancestor and show different episodes of divergence and colonisation, examples of punctuated equilibrium. • Takahe existed in NZ before ground dwelling mammals so could fill ground dwelling niches and remain isolated. Slow / limited reproduction suited takahe to maintain popln numbers and flightlessness was more efficient. On the other hand, pukeko existed in Australia and Pacific Islands before arriving in NZ and have only developed behaviours to exist successfully with competing / predatory ground dwelling mammals. They breed more rapidly and successfully than takahe and still retain some flight, which enables them to exist successfully in open swamps and grasslands of NZ. • Takahe isolation for at least 5 mya meant niche specialisation, low reproduction rates, single mate for life, loss of flight, poor defences. Competition and predation and possibly climate and habitat changes has reduced spp to only a few in remote isolated Fiordland habitat, so they are subject to low genetic

						either species. • Takahe isolation for at least 5 mya meant niche specialisation, slow reproduction rates, loss of flight, poor defences. Competition and predation and possibly climate and habitat changes has reduced spp to only a few in remote isolated Fiordland habitat, so they are subject to low genetic diversity, genetic drift, in danger of extinction. • Pukeko well adapted to post-human NZ and have breeding behaviours to survive in open grassland niche. Rapid reproduction and cooperative breeders mean large numbers and high genetic diversity, so large stable populations. At least two episodes of colonisation from different origins.		diversity, genetic drift, in danger of extinction. Whereas pukeko, due to their evolutionary past, are well adapted to post-human NZ and have breeding behaviours to survive in open grassland niche. Rapid reproduction and cooperative breeders mean large numbers and high genetic diversity, so large stable populations.	
	Not Achieved			Achievement		Merit		Excellence	
	NØ = no response or no relevant evidence.	N1 = 1 point, from Achievement.	N2 = 2 points from Achievement.	A3 = 3 points from Achievement.	A4 = 4 points from Achievement.	M5 = 1 point from Merit.	M6 = 2 points from Merit.	E7 = 1 point from Excellence.	E8 = 2 points from Excellence.

	Evidence	Achievement	Merit	Excellence
THREE	Speciation is a process where different populations of the same species split into separate species as a result of becoming reproductively isolated. In the case of the monarch flycatcher, a mutation in the MC1R gene has led to different alleles that have led to a change in one amino acid in the genome, resulting in differing colouration / phenotype on the breast of the birds. Male birds are territorial, but when presented with a male of different colouration, no territorial response is shown, as the male does not recognise the bird with different colouration as a threat, nor, as a potential mate if the bird was female. Due to lack of recognition and incompatible reproductive behaviour, the birds with differing colourations are not interbreeding, which, over time, will lead to increased differences in allele frequencies and eventual separation into two different species. The birds are not separated by large geographical barriers. They live on islands that are close, so this is not an example of allopatric speciation. They have tended, however, to move to separate islands, indicating mating preferences and compatible mate availability, which suggests this is a case of sympatric speciation, due to the phenotype / colouration differences, which will contribute to their reproductive isolation.	Describes speciation: Eg: • Process where different populations of the same species split into separate species. Describes an impact of the MC1R mutation: Eg: • Different colour birds have different alleles / versions of the MC1R gene (NOT different genes). Describes a behavioural difference between birds: Eg: • Monarch flycatchers will not mate with birds they don't recognise, even though they are the same species. Describes sympatric speciation OR recognises sympatric speciation: Eg: • Birds from the same species live close to each other, but are losing the ability to interbreed. • Birds are grouping together according to their reproductive preferences.	Explains impact of MC1R mutation: Eg: • MC1R mutation has resulted in different alleles for the gene producing melanin and therefore different phenotypes, which has led to birds with different colourations so not recognising each other as being from the same species / compatible. Explains evidence for reproductive isolation: Eg: • Male birds are territorial, but do not recognise male birds with differing colouration as a threat, hence differences in colouration has impacted on species recognition. Explains effect on species: Eg: • Despite living in close proximity, the species is undergoing sympatric speciation, as birds exhibiting colour differences do not readily reproduce, resulting in reproductive isolation.	Analyses and discusses how and why the MC1R gene has impacted on the species: Eg: • The MC1R gene mutation has resulted in different alleles, which has caused differences in phenotype, due to an amino acid change. The males with differing colouration no longer perceive each other as a threat, and do not recognise the differing females as compatible breeding partners. As a result, the birds are becoming reproductively isolated on the basis of colouration or phenotype differences, leading to increased differences in allele frequencies. Analyses and discusses effects of reproductive isolation on the populations within the species: Eg: • Over time, despite being in close proximity (neighbouring islands) and presumably able to reproduce viable offspring, individuals with differing colourations will not readily interbreed, as their courtship behaviour is not triggered / wrong signals / sign stimuli. This keeps the populations reproductively isolated. Birds have grouped with others they are compatible with, so that they are on different islands, which will increase their isolation and lead to increased differences in allele frequencies. Over time, the populations will become more distinct and they will become separate sympatric species.

	Not Achieved			Achieved		Merit		Excellence	
	NØ = no response or no relevant evidence.	N1 = 1 partial point from Achievement.	N2 = 1 point from Achievement.	A3 = 2 points from Achievement.	A4 = 3 points from Achievement.	M5 = 1 point from Merit.	M6 = 2 points from Merit.	E7 = 1 point or both partially discussed from Excellence.	E8 = Discusses genetic impact and reproductive isolation effects on population.

Judgement Statement

	Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
Score range	0 – 7	8 – 13	14 – 18	19 – 24