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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Biology 2024

91605 Demonstrate understanding of evolutionary processes leading to speciation

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of evolutionary processes leading to speciation.	Demonstrate in-depth understanding of evolutionary processes leading to speciation.	Demonstrate comprehensive understanding of evolutionary processes leading to speciation.

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 room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (////). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 21

QUESTION ONE: Kōura

Kōura (freshwater crayfish) have inhabited New Zealand for millions of years. Their exoskeletons are dark and blend into the environment (e.g. between logs and in mud), giving them good camouflage to protect them from predators. They often live in small populations, where mating among relatives leads to inbreeding. At night, they search for food, finding fish, plants, and snails.

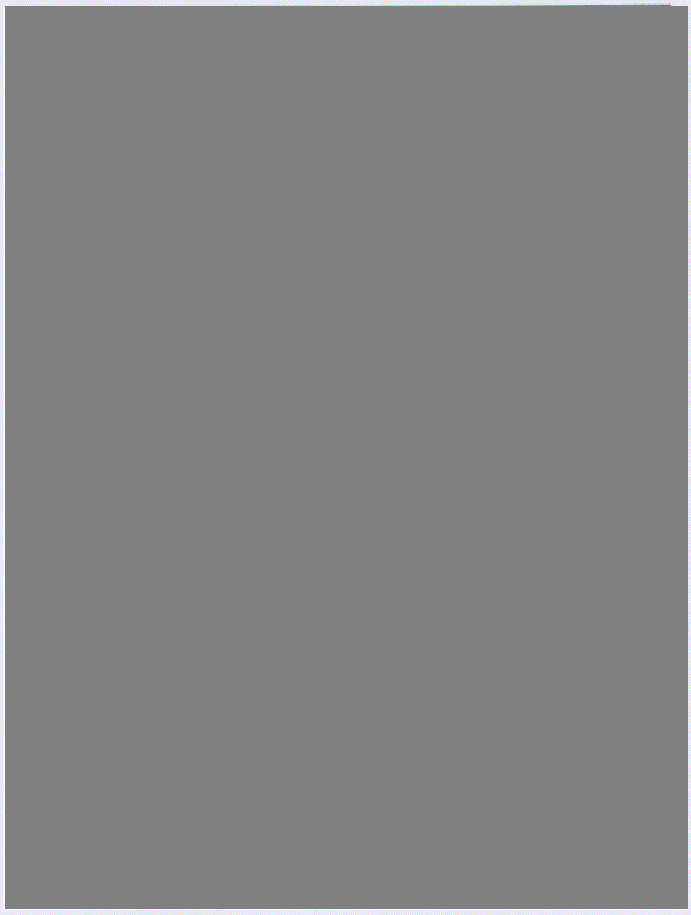
Kōura are a species valued by Māori as kai. In the past, they were also traded for other food items. Māori used to move some kōura between areas, and this was found to help with the success of each of the populations.

When looking at mitochondrial DNA (mtDNA), scientists found three major groups, indicated on the map below. The West Coast group (green) is more closely related to the southern group (yellow) than the northern group (purple). The groups were thought to diverge around the time of mountain building that formed the Southern Alps and before the formation of the Cook Strait.

Although there are two named species (*Paranephrops planifrons* and *P. zealandicus*), there are three distinct groups shown by genetic evidence. This suggests that the morphology used to classify the two species could be misleading.

In 2016, scientists at the University of Canterbury measured the genetic diversity of kōura populations. Results showed low genetic diversity **within** kōura populations but high genetic diversity **between** populations. This means populations were highly inbred but had strong genetic differences between the populations.

An adult kōura from Lake Rotomā.



Distribution of the three major mtDNA groups.

Discuss factors affecting the evolution of kōura. In your answer, include discussion of:

- the terms founder population and gene flow
- how the formation of the Southern Alps may have helped lead to divergent evolution by allopatric speciation
- why moving kōura between areas prevents speciation.

The founder effect is when a small number of individuals emigrate from a main population or become geographically isolated from their original population. This small number of individuals takes away a random sample of the original population's alleles/gene pool. The alleles in this smaller population is not a representative sample of the original populations alleles. This smaller population of individuals that have emigrated from a main population or become geographically isolated from their original population is known as the founder population. Gene flow is the movement of alleles between populations. Gene flow consists of immigration and emigration. Immigration is when individuals enter a population and bring in/introduce new alleles into the population's gene pool. Emigration is when individuals leave a population and remove alleles from the population's gene pool. The formation of the southern alps may have helped lead to divergent evolution by allopatric speciation. Divergent evolution is when two or more species evolve from a common ancestor. Divergent evolution occurs due to gene flow between populations being ~~stopped by~~ stopped/prevented, usually by a geographical barrier. Allopatric speciation is the formation of a new species from a common ancestor when gene flow is prevented/stopped by a geographical barrier. The formation of the Southern Alps separated populations of kaura and acted as a geographical barrier. In the separated populations of kaura, mutations occured, ~~and~~ since gene flow between the separated populations of kaura was stopped/prevented by the Southern Alps, mutations that occured in one population of kaura did not flow into other populations of kaura. As the separated populations of kaura accumulated genetic differences due

to mutations, the separated populations of Koura diverged into different species. This led to the formation of three distinct groups of Koura. On top of this, the separated populations of Koura were subjected to different selection pressures (selection pressures are factors that affect fitness/reproductive success), such as temperature. Because of this, the separated populations of Koura had different alleles that were beneficial/"selected for". Alleles are beneficial/"selected for" because the individuals with these alleles are better adapted to their environment, have a higher chance of survival, and will pass on the alleles. Since the separated populations of Koura had different alleles that were beneficial/"selected for", they also had different phenotypes that were beneficial/"selected for". By having different genotypes/phenotypes the separated populations of Koura were able to be classified as different species. This led to the formation of three distinct groups of Koura.

Moving Koura between areas prevents speciation. Speciation is the formation of a new species. By moving Koura between areas, it is forcing Koura to breed with different species of Koura, and this would result in no viable offspring. Because no offspring is produced when different species of Koura breed, speciation does not occur.

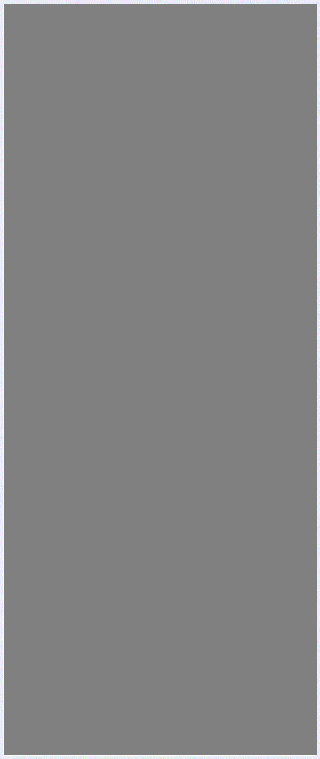
QUESTION TWO: Patterns of evolution in wallabies

In their native Australia, tammar (*Notamacropus eugenii*) and parma (*N. parma*) wallabies are allopatric and have very different habitat use, social structure, and mating times.

A tammar wallaby.

Parma wallabies grazing.

In New Zealand, they occur sympatrically on Kawau Island because of introductions in the late 19th century. Both species show differences, as seen in Australia. *N. parma* is more solitary and is frequently found in bush areas, while *N. eugenii* tend to be found in open grass areas. Genetic data shows no evidence of hybridisation despite living together in a new environment.



Kawau Island, 60 kms north of Auckland.

Figure 1: Phylogeny showing adaptive radiation of wallabies in Australia.

Discuss factors of the evolution of wallabies in Australia and New Zealand.

In your answer, include discussion of:

- the terms sympatric and species, including definitions
- the rate of evolution shown in Figure 1, identifying if it is either gradualism or punctuated equilibrium
- why adaptive radiation is seen in wallabies in Australia, but not in New Zealand
- TWO reproductive isolating mechanisms (RIMs) that may keep the wallabies from hybridising despite being sympatric on Kawau Island.

A species is a group of organisms that can successfully interbreed to produce fertile offspring. Sympatric species are species that are found living in the same location at the same time.

Gradualism is the accumulation of changes due to natural selection at a fairly constant rate. A species changes slowly step by step until the organisms are so different that it is considered a new species. With gradualism selection pressures remain constant. Mutations still randomly occur but there is no major change in form selected for. A fossil record containing many transitional forms can be used to support gradualism.

In punctuated equilibrium, we can see long periods of relative stability (stasis) due to the same form being selected for as a result of similar/constant selection pressures. However, these long periods of relative stability (stasis) are interrupted by periods of rapid evolution due to a different form being selected for as a result of diverse selection pressures. The sudden appearance of species in the fossil record can be used to support punctuated equilibrium. In figure 1, there is no sudden appearance of species so it is gradualism.

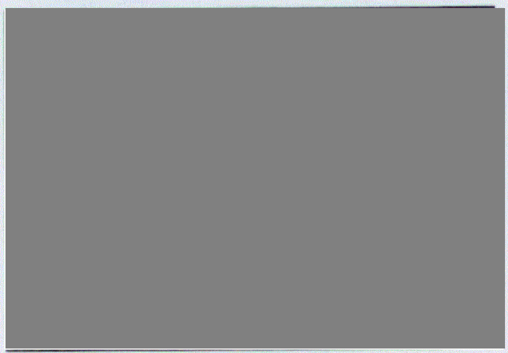
Adaptive radiation is a special form of divergent evolution. It is when multiple species evolve from a common ancestor in a relatively short period of time. As new unoccupied niches/habitats become available, populations of wallibies in Australia adapted to fill the new habitats. With adaptive radiation, populations of wallabies ended up in different areas of Australia. The populations of wallabies in different areas of Australia each had mutations.

Gene flow between the populations of wallabies in different areas of Australia was prevented/stopped so mutations that occured in one population of wallabies did not flow into other ~~spec~~ populations of wallabies. As the populations of wallabies in different areas of Australia accumulated genetic differences due to mutations, they diverged into different species ~~which is basic theory~~ such as the agile wallaby, the red-necked wallaby etc. On top of this, the populations of wallabies in different areas of Australia were subjected to different selection pressures. Because of this, the population of wallabies in different areas of Australia ~~were~~ had different alleles that were beneficial/"selected for". Alleles are beneficial/"selected for" because the individuals with these alleles are better adapted to their environment, have a higher chance of success, and will pass on the alleles. Since the populations of wallabies in different areas of Australia had different alleles that were beneficial/"selected for", they also had different phenotypes that were beneficial/"selected for". By having different genotypes/phenotypes the populations of wallabies in different areas of Australia were able to be classified as different species such as the black wallaroo, the swamp wallaby etc. Adaptive radiation is seen in wallabies in Australia but not in New Zealand because Australia has a lot of new unoccupied habitats that populations of wallabies can adapt to but New Zealand specifically Kawau Island doesn't have new unoccupied habitats that populations of wallabies can adapt to. Reproductive isolating mechanisms may keep the wallabies from hybridising despite being sympatric on Kawau Island. A reproductive isolating mechanism is any factor that prevents successful reproduction/interbreeding between different species. One of these reproductive isolating mechanisms is structural/mechanical isolation. Structural/mechanical isolation is when structural differences in the anatomy of reproductive organisms prevent transfer of male gametes between the wallabies of different species. This would prevent the wallabies from hybridising. Another one of these reproductive isolating mechanisms

is chemical isolation. Chemical isolation is when gametes from the different species of wallabies are incompatible so even if the gametes meet, fertilisation is unsuccessful. This would prevent the wallabies from hybridising. Another reproductive isolating mechanism is temporal isolation. Temporal ~~isolating~~ isolation is when members of the different wallabie species ~~wanted~~ mate or are active at different times. This would prevent the wallabies from hybridising.

QUESTION THREE: A case of convergent evolution

Flight has evolved numerous times in different animal groups, and those different groups have evolved different mechanisms for flight. For example, the honeybee wing is not made of bone, but it does serve the same function as the bird wing. The pattern of muscle attachments is different in the honeybee and the bird, and the way in which the wing is used to achieve lift is also different. However, due to the demanding nature of flight, there are distinct similarities between bee and bird wings.



Honeybee wing.

Bird wing.

A bird catching a beetle while both are in flight.

Discuss how convergent evolution is linked to selection pressures.

In your answer, include discussion of:

- selection pressures, including descriptions with examples
- how genetic data is used to show convergent evolution
- how the process of natural selection has resulted in analogous structures.

Selection pressures are factors that affect fitness/reproductive success. ~~Examples include~~ An example is ~~[illegible]~~ flight ~~[illegible]~~
This acts as a selection pressure on the bird and the honeybee and has caused ~~it~~ them to evolve wings. Other selection pressures include temperature, predators etc.

Genetic data is used to show convergent evolution. Convergent evolution is when species evolve to be similar to each other ~~[illegible]~~ with

convergent evolution, the same phenotypes are seen but they have not come from the same mutation. Convergent evolution comes about through independent mutations for the same trait. The nucleotide sequences of DNA and the sequences of proteins of different species can be analysed. By analysing the nucleotide sequences of DNA and sequences of protein of different species, we can see if there mutations are the same. If the mutations are not the same (different mutations or similar mutations but at different loci), then this shows convergent evolution.

The process of natural selection has resulted in analogous structures. Natural selection describes that the individuals with the more beneficial alleles will most likely be fitter and will survive long enough to reproduce and pass on their alleles to their offspring. This increases the allele frequency of the more beneficial alleles. Natural selection occurs when populations of organisms are subjected to similar selection pressures. Analogous structures are a form of evidence for convergent evolution. Analogous structures are structures with the same function but with different origins. In this case, the analogous structures are the wings of the honeybee and the bird. This is because the wings of the bird and the honeybee have the same function of being used for flight but they have different origins. The bird and the honeybee have both evolved to have wings because they have been subjected to a similar selection pressure. Convergent evolution is when species evolve to be similar to each other, due to the species having the same niche/habitat or being subjected to similar selection pressures. In this case, the bird and the honeybee have been subjected to the similar selection pressure of needing to fly/flight which has resulted in them both evolving wings. The bird needed to fly to catch prey such as beetles and to travel, which is why it evolved to have wings. On the other hand, the honeybee needed to fly to be able to reach food sources such as the nectar of flowers and to travel,

which is why it also evolved to have wings.

Excellence

Subject: Biology

Standard: 91605

Total score: 21

Q	Grade score	Marker commentary
One	E7	This response provides a detailed account of the divergent evolution and allopatric speciation of the kōura by linking the accumulation of random-mutations coding for different phenotypes. It uses examples from the stimulus material and demonstrates an understanding of the concepts of gene flow and the founder group, and the influence this has on species.
Two	E7	This response discusses in detail the adaptive radiation of wallabies in Australia compared to New Zealand; and the reproductive isolating mechanisms (RIMs) that may be preventing hybridisation. It includes references to time and niche availability, as provided in the resource material.
Three	E7	This response discusses how genetics is used to show structures that are analogous. It makes links to mutation and selection pressures of the phenotype coded for in the given context and how natural selection has led to the evolution of bird and insect wings.