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Level 3 Biology, 2017

91605 Demonstrate understanding of evolutionary processes leading to speciation

9.30 a.m. Thursday 16 November 2017
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 and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

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

Merit

TOTAL 17

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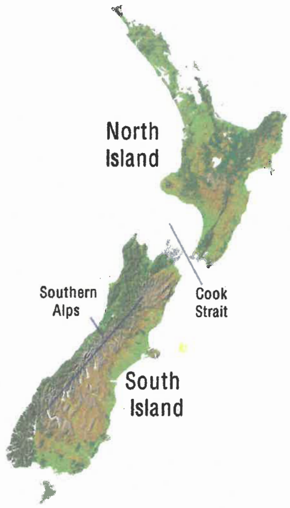
QUESTION ONE

Distribution, dimensions, habitat preference, and bill morphology of moa



Adapted from: Bunce M, et al. 2009. 'The evolutionary history of the extinct ratite moa and New Zealand Neogene paleogeography'. *Proc. Natl. Acad Sci. USA.* 106: 20646–20651; and Attard M, et al. 2016. 'Moa diet fits the bill: virtual reconstruction incorporating mummified remains and prediction of biomechanical performance in avian giants'. *Proc. R. Soc.* 283: 2015–2043

Moa were the dominant group of herbivores in ecosystems in New Zealand/Aotearoa until their extinction about 550 years ago. Moa species had a wide diversity of sizes and significant differences in the structure, strength, shape, and biomechanical performance of the skull and bill. Evidence suggests a single lineage of moa existed 25 million years ago (mya) in the South Island. Recent genetic analysis indicates new species started emerging about 5.8 mya, and by 1.4 mya, all nine known species existed. Fossil evidence indicates many of these species overlapped in geographical range.

Analyse the events that may have led to evolution of the moa. Adaptive Radiation

In your answer you should:

- describe the terms allopatric speciation and sympatric speciation
- describe the pattern of evolution shown by moa, AND explain how this type of pattern can arise
- discuss the evolutionary significance of the diversity in moa bill shape
- analyse the evolutionary processes that contributed to moa speciation.

Allopatric speciation is speciation that occurs in different geographical areas, due to geographic barriers such as rivers, mountains, glaciers etc. Sympatric speciation is speciation that occurs in the same geographic area, due to ~~other~~ barriers that are not geographic, such ~~as~~ as gamete incompatibility, temporal isolation etc. The pattern of ~~speciation~~ evolution shown by the moa is Adaptive Radiation. This occurs when there ~~is~~ are many vacant ecological niche's and a species rapidly evolves to fill them. The diversity in the Moa's bill shape provides evidence as to what type of geographical area each species of moa lived. For example, the bill shape of both the Pinornis and the pachyornis moa are similar. They both have short to medium length, slightly pointed bills, and both lived in similar open forest and grassland habitats. Their bill shape would have evolved because of the habitat they liked to live in. Open forests / grasslands have exposure to wet weather, meaning the ground is not too hard so the moa would not have to dig its bill too far into the ground to find food, and there would have been plenty of food to forage for. In comparasin, both the Anomalopteryx and the megalapteryx species have longer, thinner and pointier bills. The Anomalopteryx lived in ~~coastal~~ more protected areas which would have been drier, meaning they had to dig with their bills to find food. Similarly the megalapteryx lived in subalpine and high country areas, which are also dry and potentially ~~snowy~~ snowy,

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meaning they also would have had to use their bills to dig for food. The evolutionary processes that contributed to moa speciation were geographical separation, such as the Cook Straight and the Souther Alps, preventing gene flow and interbreeding between species. Reproductive isolating mechanisms would also have contributed to moa speciation. pre-zygotic isolating mechanisms such as temporal and ethological would mean that, even though some of these species ovelapped geographically, behaviourly they would not have interbred because they were not attracted to another species or they bred at different times. post-zygotic isolating mechanisms would mean that if two species did interbreed, it would lead to hybrid inviability, hybrid sterility or hybrid breakdown - where the gametes do not survive to form a zygote, the offspring is ~~fertile,~~ sterile, ~~or~~ or the offspring's offspring is infertile.

The candidate shows in-depth understanding by explaining adaptive radiation and allopatric speciation linked to reproductive isolating mechanisms. Bill shape is linked to the differences in ecological niches and food resources.

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QUESTION TWO

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https://vtnews.vt.edu/articles/2016/06/fralin-garter.html

The rough-skinned newt (*Taricha granulosa*) is distributed throughout North America. Many populations contain the poison tetrodotoxin (TTX) in the skin, which acts as a defence against predation. Despite TTX being one of the most powerful neurotoxins known, the garter snake (*Thamnophis sirtalis*) is able to prey on the rough-skinned newt. The levels of toxicity of newts and the resistance of the garter snakes vary geographically.

TTX Resistance vs Speed at which the garter snake can move

TTX resistance	Number of amino acid mutations	Speed at which the snake can move
Least resistant	1	fast
Intermediate resistant	2	intermediate
Most resistant	3	slow

Analyse the evolutionary relationship between the rough-skinned newt and the garter snake.

In your answer you should:

- describe the **pattern of evolution** shown by the relationship
- explain how this kind of relationship develops
- discuss the role of **natural selection and mutation** in the evolution of the features shown
- analyse the selection pressures that work both for AND against the relationship.

The pattern of evolution is co-evolution, where predator and prey evolve at the same time and have signficant biological

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relationships with one another, and significant effect on one another. This relationship develops over time as a predator, like a garter snake, develop advantageous adaptations to assist with hunting the prey, like a newt. The newt will then develop advantageous adaptations to assist with the survival of its predator. Natural selection is when the environment selects against the disadvantages adaptations, and for the advantageous adaptations so the population develops a more desirable phenotype. A mutation is a permanent change in the base sequence of DNA which can be harmful, beneficial, or silent, and can be passed on to offspring if it occurs in the gametes. The rough skinned newt would have natural selection acting on it - the newts with the weakest amount of TTX would have a much higher chance of being eaten by a snake. The Garter snakes have developed a mutation, which allows them to ingest the TTX. Both natural selection and mutation for these animals is beneficial. For the newts with a weak amount of TTX, natural selection by the snakes means that they cannot survive to reproduce, wheeas the ones with higher amounts of TTX have more of a change of escaping and surving to reproduce. For the Garter snakes, a beneficial mutation means that some populations are able to prey on the rough skinned newt, and

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therefore can survive to reproduce and pass on this mutation. The selection pressures that work ~~for~~ against this relationship are that some rough skinned newts only have low levels of TTX, meaning that snakes without the mutation can still ingest them, and survive to reproduce. ~~selection pressures that work~~ other ~~snakes~~ predators without the mutation ~~can~~ could also ingest newts with very low levels of TTX, meaning there is less natural selection for the garter snakes to survive to pass on the favourable phenotype. Selection pressures that work for this relationship are the levels of TTX in the newts, and the mutation of the garter snakes.

The candidate describes co-evolution, mutation and natural selection. The candidate shows in-depth understanding by explaining how low levels of TTX in the newt affects the garter snakes evolution and phenotype.

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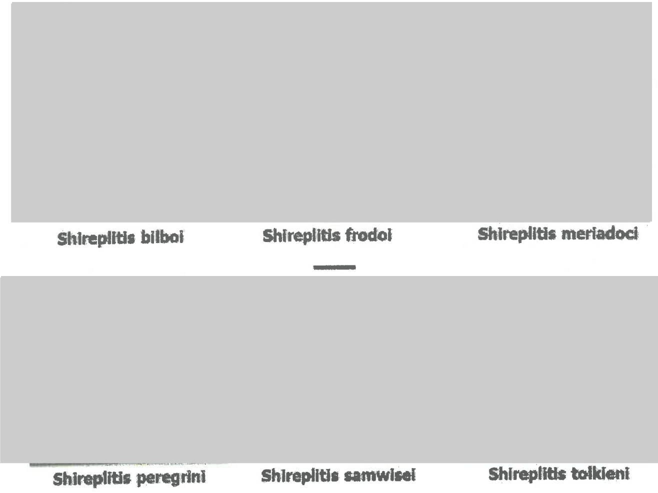
QUESTION THREE

Shireplitis is a newly discovered genus of wasp endemic to New Zealand/Aotearoa. These species are mostly found in moss, litter, or tussock grasslands, at moderate altitude on mountain ranges.

Paroplitis is an unrelated genus of wasp, mostly distributed in Europe and North America, with some species living at moderate altitudes.

Shireplitis and *Paroplitis* look similar, with shared features being their relatively small size with a body length of about 2 mm, short and smooth abdomen, dark colour, short and robust legs, and short antenna. *Shireplitis* and *Paroplitis* both parasitise caterpillars. Host caterpillars are only known for the European species *Paroplitis wesmaeli*. One of these host species feeds on moss while another feeds on moss and grasses. Biologists hypothesise that *Shireplitis* may parasitise caterpillars that feed on moss, leaf-litter, dead wood, or fungi.



The six species of *Shireplitis*.

http://microgastrinae.myspecies.info/microgastrinae/shireplitis

Paroplitis wesmaeli

http://microgastrinae.myspecies.info/gallery?f[0]=im_field_taxonomic_name%3A28649&f[1]=im_field_taxonomic_name%3A28644

Discuss the evolutionary pattern AND selection pressures that have contributed to this pattern for *Shireplitis* and *Paroplitis*.

In your answer:

- describe selection pressure AND the pattern of evolution shown by *Shireplitis* and *Paroplitis*
- describe homologous structures and analogous structures
- using the information above, explain how analogous structures are related to the pattern of evolution shown by *Shireplitis* and *Paroplitis*
- discuss, using the evidence from the resource material, how this evolutionary pattern could arise.

The pattern of evolution shown by Shireplitis and Paroplitis is convergent evolution. This is when two unrelated species experience similar selection pressures and evolve to have similar phenotypes. Selection pressure is something that acts on a population and leads to

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the natural selection for the favourable phenotype for that specific selection pressure. Homologous structures have the same origin but different functions, and analogous structures have different origins but a similar function. Shireplitis and paroplitis have undergone convergent evolution - they are unrelated but due to the environments in which they live have experienced similar selection pressures. Analogous structures are related to this pattern of evolution because they do not have the same origin, but have developed similar functions. For example, both these species have similar wings, which have the same function. Convergent evolution could arise because of the environment in which these wasps live. Both species live in moderate altitudes, and feed on moss, leaf-litter etc and live in grassy areas. Both environments would have similar selection pressures, such as weather and predators. Living in grassy areas, both species have evolved to have a dark colour which would help them to blend into the environment and not be so susseptible to predators. Having short and robust legs, and short antenna would help both species to forage for food in moss and harder things such as wood. ~~Wa~~ Living at moderat altitudes it is also colder, meaning that both species have adapted a smaller body so ~~they~~ it is easier to stay warm.

There is more space for your answer to this question on the following page.

Candidate shows in-depth understanding by explaining why this is an example of convergent evolution in terms different evolutionary origins and provides examples of named selective pressures such as foraging in the leaf litter and the link to similar niches and therefore selection for named analogous structures. Such as small body, dark colouration small antenna.

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Extra paper if required.
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