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91605



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Mana Tohu Mātauranga o Aotearoa  
New Zealand Qualifications Authority

## Level 3 Biology 2025

### 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 22

### QUESTION ONE: The apple maggot fly and the hawthorn fly

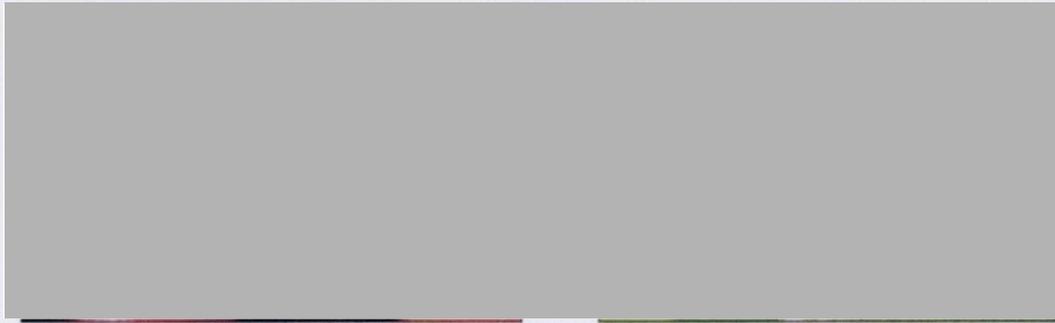


Figure 1: Apple maggot fly laying eggs in apple fruit.

Figure 2: Hawthorn fly on a North American hawthorn tree.

*Rhagoleti pomonella* is a fly species native to North America. The species originally laid its eggs on the red fruit of the hawthorn tree (also native to North America) as a food source for larvae.

Approximately 200 years ago European settlers introduced apples to North America, and *R. pomonella* evolved into two distinct groups – the apple maggot fly and the hawthorn fly. These groups are physically similar and are still considered to be the same species. There is no geographic separation between the two groups.

The hawthorn fly lays its eggs in the native North American hawthorn fruit as a food source for its larvae, while the apple maggot fly now prefers to lay its eggs in apples. Apples ripen earlier in the season than hawthorn fruit, so apple maggot flies emerge earlier. Females and males prefer to mate and lay their eggs in the same type of fruit they are hatched in.

Data shows that the two groups have differences in their enzymes. They also differ genetically in their development time: maggots in apples develop in about 40 days, while maggots in hawthorn fruit develop in 55–60 days.

Discuss speciation and the mechanisms leading to the formation of the two different groups of fly.

In your answer, include discussion of:

- speciation and reproductive isolating mechanisms, with definitions
- how TWO named isolating mechanisms may have caused the formation of the two groups of fly
- a suggestion as to why the two groups are not yet considered separate species.

Speciation refers to the formation of a new species from an existing or ancestral species.

Reproductive isolating mechanisms are mechanisms that act to prevent successful reproduction and prevent gene flow between two groups or between species.

The formation of the two groups of fly is a

sympatric process in which the two groups have evolved from their ancestral species in the same area with no geographical separation between them. Thus, non-geographical barrier isolating mechanisms in place have caused the formation of the two groups.

Firstly, niche preference is a mechanism that has caused the 2 separate groups to form. The ancestral population that lay eggs on hawthorn trees was suddenly available to a whole new niche when settlers introduced apples to North America, and some of the ancestral population would have laid eggs on these new apple trees, ~~subsequently, the offspring of these flies would have~~ as this avoids competition for space with the other flies laying their eggs on hawthorne plants. Subsequently the offspring of these flies would have mated and laid their eggs in the same type of fruit (apples) thus giving rise to a separate group that is separate from the hawthorne fly in terms of the niche they occupy.

A second isolating mechanism that would have maintained these 2 separate groups is temporal isolation. Apples ripen earlier and thus at a different time to hawthorn fruit, so the 2 fly groups likely lay their eggs on the fruit at different times. Additionally Apple maggot flies emerge earlier, therefore because of a short lifespan of a fly is it made less likely that the two groups will cross each other when both are in the stage of life in which

they are sexually mature and able to reproduce, this temporal isolation is present in which the 2 groups are isolated from mating with each other by timing of their maturity and this gene flow between the groups is made less likely to occur, maintaining 2 reasonably separate groups, since the maggots in hawthorn fruit take longer to develop.

However, the 2 groups are not completely isolated as there is no geographical barrier between them, this gene flow and movement of alleles between the 2 groups has ~~not been~~ been seen enough to not fully reproductively isolate them yet, as some hawthorn flies may still be able to mate with apple maggot flies if sexually mature at the same time ~~on~~ on occasion. Additionally the introduction of the niche of apple trees only arrived 200 years ago which is not enough time for the 2 ~~species~~ groups allele frequencies in their gene pool to have changed from each other drastically enough to change their genetic make ups from each other <sup>so</sup> much that reproductive isolating mechanisms <sup>(RIMS)</sup> form to prevent successful breeding such as structural or gametic incompatibility. As such, since a biological species is a group of individuals able to interbreed and produce fertile viable offspring, the lack of RIMS developed in this 200 year time frame yet maintains that the 2 groups are still 1 species as they can technically ~~still~~ still successfully reproduce and have fertile offspring.

## QUESTION TWO: Lamprey and eels

The lamprey (*Petromyzontiformes*) is an ancient fish. Adult lamprey look like eels physically even though they have been separate species for millions of years. The similarities between the two include:

- a long flexible body that can move through narrow spaces
- swimming in an undulating (wave-like) motion
- no paired fins
- covered in mucus
- tolerance of low oxygen environments.



Figure 3: Phylogenetic tree for the lamprey.

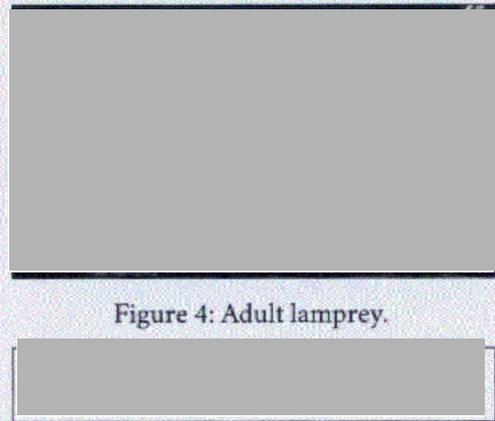


Figure 4: Adult lamprey.



Figure 5: Longfin eel.

However, there are many differences, as listed in Table 1 below.

Table 1: Differences between lamprey and eel.

Lamprey	Eel
Cartilage skeleton	Bony skeleton
No jaw; mouth is a circular sucker, filled with hundreds of small teeth and a rasping tongue	Bony jaw and teeth
Continuous dorsal (back) fin only	Dorsal (back), pectoral (arm), anal fins
Seven gill openings on each side of head with no gill cover	Single gill opening on each side of head covered by a bony gill cover
No scales, skin is smooth and slimy	Tiny scales, which are hard to see
No backbone	Has a backbone
Many parasitic species that use sucker-like mouths to attach to fish for feeding or to scavenge	Most species are predators or scavengers
Live in the ocean and reproduce in rivers	Live in rivers and reproduce in the ocean

Discuss the evolution of lamprey and eel using the information provided.

In your answer, include discussion of:

- convergent evolution and an analogous structure, including descriptions
- how TWO named selection pressures influenced the similarities between lamprey and eel
- TWO examples of scientific evidence that can be used to determine that the physical similarities between the lamprey and the eel are an example of convergent evolution, not divergent evolution.

Convergent evolution refers to the pattern of evolution in which species do not share a common ancestor, but have evolved to have similar features due to occupying similar niches and being subject to similar selection pressures. Convergent evolution ~~is~~ occurring for the lamprey and eel has given rise to them having analogous structures such as a long flexible body or being mucus covered, structures that do not share the same phylogenetic origin but have arisen separately in the 2 species due to the similar selection pressures they faced.

A selection pressure that likely affected both the ancestral lamprey and eel populations was a lack of oxygen rich water. This external environmental factor therefore would have acted in both species to favour those with the phenotype of better tolerance to a low oxygen environment. Additionally, both ancestral groups would have faced the selection pressure of predators. As the 2 ancestral groups are not sharing a common ancestor, mutations would have occurred independently in the 2 groups to give rise to new alleles in their respective gene pools such as those that give the traits of a longer more flexible body and better tolerance with

low oxygen. Thus, the selection pressures of low oxygen and predators would have favoured those with these mutations in both separate gene pools, leading those analogous structures to become more common in both species populations over generations.

Divergent evolution is the process by which one species branches to form 2 or 3 separate species, thus the new species share a common ancestor.

There is scientific evidence to support that the lamprey and eel do not share a <sup>recent</sup> common ancestor and underwent convergent rather than divergent evolution, such as that lampreys have no backbone while eels do. This suggests that their ancestral species diverged a much longer time ago at the point in which ~~invertebrate~~ vertebrate animals started to evolve, a divergence too early in history for the lamprey and eel to have shared a recent common ancestor <sup>(700 mya)</sup> and diverged from it, ~~early~~

The tracking of mitochondrial DNA can also be used as evidence of convergent rather than divergent evolution. As mitochondrial DNA (mtDNA) is not found in nucleus it is unaffected by variation caused by processes of recombination in meiosis so the changes in mtDNA over time are only caused by mutations at a certain rate, making this a reliable way to gauge how much DNA they share from an ancestor. As they ~~diverged~~ split over 600 mya, their mitochondrial DNA will not be similar thus showing evidence their features are due to convergent rather than divergent evolution.

### QUESTION THREE: Tetraploid treefrogs

The gray treefrog (*Dryophytes versicolor*) and Cope's gray treefrog (*Dryophytes chrysoscelis*) are identical in physical characteristics and behaviour. However, the two species can be identified by different mating calls and chromosome numbers.

The tetraploid gray treefrog is related to the diploid Cope's gray treefrog and is thought to have evolved through multiple hybridisation events, with different diploid ancestors. Gray treefrogs have double the number of chromosomes. This has caused their mating call to be a slower musical call than that of Cope's gray treefrog, which is faster and more high-pitched.

The treefrogs share similar habitats, but the two species do not interbreed.

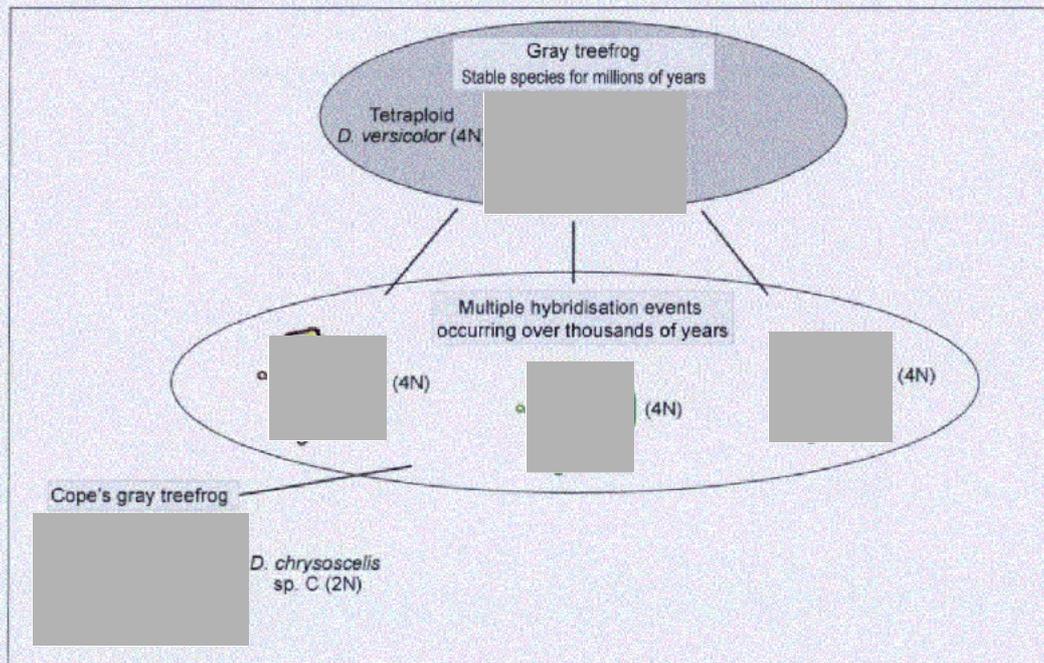


Figure 6: Polyploid speciation in treefrogs.

Discuss processes that caused the gray treefrog and Cope's gray treefrog to become separate species with different evolutionary patterns. You may use diagrams to support your answer.

In your answer, include discussion of:

- hybridisation and polyploidy, including definitions
- how polyploidy can produce hybrid frogs
- why the process of speciation in treefrogs is an example of sympatric speciation and not allopatric speciation
- why this is an example of punctuated equilibrium and not gradualism.

Polyploidy is the duplication of whole sets of chromosomes to 3 or more complete sets of chromosomes.

Polyploidy can occur because of nondisjunction, which is the failure of the spindle fibers produced in

meiosis to properly separate the homologous pairs of chromosomes to opposite poles of the cell, causing the formation of gametes that are diploid ( $2n$ ) rather than haploid ( $n$ ).

Hybridisation refers to 2 different parent species mating to form hybrid offspring. If nondisjunction occurs in 2 separate Cope's gray frog individuals and their gametes ( $2n$ ) meet when mating, this results in the offspring produced being tetraploid, thus the gray tree frog ( $4n$ ) arises. As the Gray tree frog has multiple different

diploid ancestors, this is an example of allopolyploidy in which polyploidy has occurred in the offspring of a hybrid of 2 species. The process of polyploidy to produce the Gray tree frog is an ~~it's~~ instant

speciation event as because the offspring are tetraploid while the ancestral species are diploid, the

offspring are <sup>instantly</sup> reproductively isolated from the parents. \* <sup>sack of paper</sup> This is an example of sympatric speciation as a new species has arisen in the same area as the parent species with no geographical separation between them, rather than allopatric speciation (where ~~spe~~ a new species forms due to isolation caused by a geographical barrier).

Punctuated equilibrium refers to the pattern of evolution where species stay similar for long periods of time ~~to~~ (stasis) followed by sudden bursts of rapid evolution. A gradualism evolutionary model refers to species slowly diverging from each other over time due to

accumulating different adaptive characteristics over time due to different selection pressures faced.

Thus, the evolution of the Cope's gray frog is an example of punctuated equilibrium as the polyploidy event causing speciation and reproductive isolation of the offspring from the parent species each time is an instantaneous event rather than a gradual evolution over time.

Extra space if required.  
Write the question number(s) if applicable.

QUESTION  
NUMBER

3) \* Additionally, the doubled number of chromosomes has created a reproductive isolating mechanism of behavioural isolation in which tetraploid frogs are unable to mate with diploid frogs due to their different mating calls being incompatible with each other.

## Excellence

**Subject:** Biology

**Standard:** 91605

**Total score:** 22

Q	Grade score	Marker commentary
One	E7	<p>This response demonstrated a comprehensive understanding of the process of speciation and why the two groups of flies are not yet considered separate species. This included a discussion of how competition for the food resource / apples has led to the formation of RIMs, which has restricted gene flow between the two groups. However, there has been insufficient time for full isolation, so cannot be considered as separate species as gene flow is still occurring.</p>
Two	E8	<p>The response included both points in their discussion of the evolution of the lamprey and eel:</p> <ul style="list-style-type: none"><li>• A comprehensive discussion on convergent evolution in these species and how selection pressures are linked to analogous structures.</li><li>• TWO examples of scientific evidence (comparative anatomy and molecular biology) and how the methods can be used to determine that the physical similarities are examples of convergent evolution, as opposed to divergent evolution.</li></ul>
Three	E7	<p>The response included detailed discussion of how polyploidy can produce hybrid frogs, and why the process of speciation in treefrogs is an example of sympatric speciation and not allopatric speciation.</p>