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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.

Merit

TOTAL 15

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 is the process in which an established species diverges into two or more reproductively isolated species. Reproductive isolating mechanisms are the restraints of an organisms of different species, preventing them from interbreeding. This may be prezygotic (mechanical,

habitat, behavioural difference) or postzygotic (~~the~~ hybrid breakdown).

One of the key components influencing the separation of the two distinct groups is the behavioural differences between the apple maggots and hawthorn fly. Due to the apples ripening earlier in the season than the hawthorn fruit, the ~~maggot~~ apple maggot flies, over time, have altered their behaviours to best suit the ripening of the apples for optimal reproductive success. If the maggot flies begin to lay eggs earlier than the hawthorn fly, a lack of overlap in timing will ~~aff~~ allow for further divergence of the groups. — Thus the timing times having already pronounced affect on the species. Furthermore a difference in hatching location has produced a further decrease in mating between groups, as innate behaviours of parents returning to the same plant they were hatched in proves different amongst both species, thus the fertilisation of different flies is decreased. Additionally, the maggots of both flies develop over different amounts of time, further affecting the relationship between the two groups in decreasing chances of offspring forming. The two ~~sp~~ groups have not been

defined as separate species yet due to there
 being prominent factors affecting their reproductive
 isolation and removal of gene flow which
 would create speciation. The apples
 were only introduced 200 ya, which has
 not provided enough time for speciation
 occur. The flies both live within the
 same area (thus being sympatric speciation
 in process as opposed to allopatric -
 speciation occurring in the same geographical
 area, as opposed to being due to separation
 of geography) this means that both groups
 move into the niches best suited for
 them, however, the niches are similar
 enough, and the time period is
 too short for speciation to have occurred.
 In addition, the physical ^{characteristics} ~~similarities~~
 remain similar, so breeding between
 the groups could still be possible,
 therefore decreasing the chances of
 speciation due to gene flow between
 populations. Over time, the groups could
 continue to drift, and mating
 times and locations will become
 prominent enough for there to be no
 gene flow between groups, thus pre-
 causing speciation.

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 is when two unrelated species occupy similar niches, to then evolve and adapt similar traits

(analogous structure).

Analogous structures are the similar physical traits which may not appear the same, but achieve the same function.

The lamprey and eel appear similar even though they have been a different species for millions of years - this being a display of convergent evolution.

Analogous structure similarities between the eel and lamprey include their long, flexible bodies, lack of fin, tolerance of low oxygen environments, etc. However, despite similarities, there are still major differences

in the make-up of the organisms such as the lamprey's cartilage skeleton vs the eel's bony skeleton, backbone or no backbone,

lives in rivers and reproduces in rivers or lakes in rivers, reproduces in the ocean, respectively.

Convergent evolution occurs due to selection pressures favouring particular traits for the benefit of their own survival (natural

selection). For the eel and lamprey, ~~these~~ convergent evolution would have been dictated by the similar niches that they both occupy. By needing to manoeuvre through tight and narrow spaces, the traits of being long and flexible would be favoured by both populations. Both species ~~would~~ live in areas of minimal oxygen levels, so overtime, traits which could withstand such pressures would become common in the population, while others would die out. Eventually, overtime the eels began to ~~express~~ express the traits best suited for their environment to be evolved.

The species both have significant differences that disallow their abilities to interbreed, however, by occupying similar niches, they have evolved to present similar traits. Scientists, in confirming convergence, could extract sections of DNA to analyse the differences in base coding and identifying the different mutations that have expressed these similar traits as each trait would be caused by different random mutation. If the similarities were as a result of divergence, there would be some similarity or trace of relation in genetic make-up. Additionally, egg and sperm of both species could be tested as they would not produce viable offspring.

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.

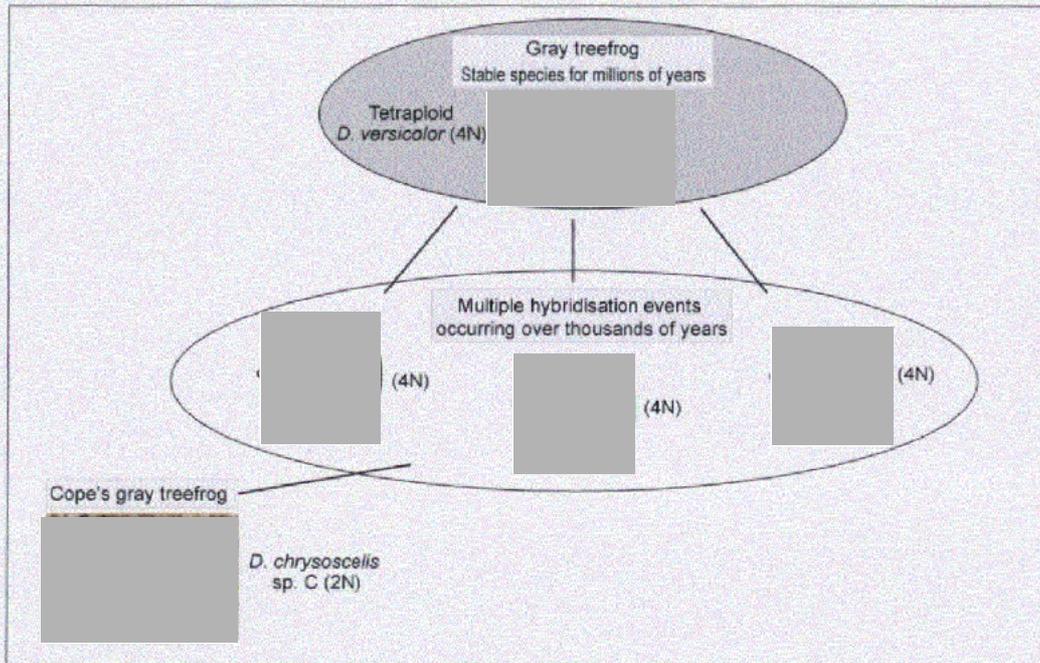


Figure 6: Polyploid speciation in treefrogs.

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.

hybridization refers to the mating between species which produce fertile offspring.
 Polyploidy refers to a set number of chromosomes multiples which define the

development of an organism, this causes new sequencing and coding. Polyploidy can produce hybrid individuals as the chromosome combinations can match and form viable offspring.

Allopatric speciation is that which is defined by geological barriers. Species that could originally mate and produce offspring are no longer able due to isolation.

Sympatric speciation ~~is~~ occurs where one parent ancestor diverges into two or more species to which occur within the same environment, but move into niches which best suit their adaptations. The tree frogs ~~Allopatric~~ are a result of sympatric speciation as both the Gray treefrog and the Cope's gray treefrog occupy the same habitat and are therefore exposed to the same environmental niches. The Gray treefrog is related to the Cope's treefrog, ~~and~~ yet they can be differentiated by their different mating calls and chromosome number. The Gray treefrog has double the amount of chromosomes than the Cope's treefrog, therefore both are easily identifiable by scientists. The Gray treefrog has a slower, musical mating song, which would not attract the Cope's gray treefrog, therefore the individuals

would not be able to mate, as their ads of courtship would not be identified.

Punctuated equilibrium occurs when a stable, established species (in this case the Gray treefrog) is rapidly diverged and branched off due to environmental changes, — this formed the rapid, spontaneous establishing of the Cope's tree frog. Gradualism, in contrast, is slow and steady, with many intermediate forms of evolution to the morphological value of an individual. Due to polyploidy's affect on hybridisation which is immediate, the evolution of the Gray frog to the Cope's, — is of punctuated equilibrium.

Despite ~~the~~ both frogs having similar phenotypic traits, and the same behavioural responses, the difference in chromosome number and mating calls has meant the species to change.

Merit

Subject: Biology

Standard: 91605

Total score: 15

Q	Grade score	Marker commentary
One	M5	The response identified and explained TWO relevant pre-zygotic RIMs (temporal and behavioural) linked to the resource material and explained how this has led to a reduction in gene flow between the two groups of flies.
Two	M5	The response explained that convergent evolution causes analogous structures in the lamprey and eel, as they have experienced similar selection pressures over time. In addition, an explanation is included of how DNA evidence can be used to determine that convergent evolution has occurred between the two species and not divergence.
Three	M5	The response explained: <ul style="list-style-type: none">• why this context is an example of sympatric speciation by linking in polyploidy, and the calling behaviour of the two different species of frogs• why this context is an example of punctuated equilibrium and not gradualism.