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# OUTSTANDING SCHOLARSHIP EXEMPLAR



Mana Tohu Mātauranga o Aotearoa  
New Zealand Qualifications Authority

## Scholarship 2024 Biology

Time allowed: Three hours  
Total score: 24

### ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write your answers to all THREE questions in this booklet.

Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–27 in the correct order and that none of these pages is blank.

Do not write in the margins (XXXX). 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.**

## PLANNING

Hector's Dolphins

- Bottleneck - inbreeding Maui
- Founders
- limited diet
- echolocation - disrupted
- predation
- Small home range - more competition, fewer resources
- single sex groups - no mating
- K selection
- any male - not fittest, no sexual selection
- late maturity
- low reproductive rate
- nylon nets
- fishing - trawling
- Captive breeding - selective
- protect more
- sewerage
- hybridisation.

## PLANNING

Q2 : Olive Shells.

→ adaptive radiation

→ diff selection pressures in diff areas in NZ,  
(larger shell/smaller)/colour

→ natural selection

Allopatric speciation

→ African, Phillipines

Founders effect → some washed over to NZ fixed alleles

DNA

→ molecular clock

See when diverged

Common 9.3 mya : base adaptive radiation then  
long period of stasis ← fossil record

Figure 5 - enviro change = new species.

Figure Alternative - each species came over by itself.

## PLANNING

## Q3: Woolly Rhinoceros

Niche - role, habitat, diet, behaviours, relationships

Cold - mammoth steppe area

→ Grasses, herbs, shrubs

Small ears

→ didn't use hearing to hunt, few predators

Thick hair

→ warmth in winter, insulation falling snow

Short hair on limbs

→ maybe not get stuck in snow during winter, thermoregulation

Short legs → closer to ground / low grasses

→ Fighting, horn worn, display, choose mates

→ Fat reserve - few resources in winter

→ Plant diet ... - teeth, stomach, enamel

Ice age - few resources, more competition, fighting, injury

→ Humans compete - drive to extinction?

→ Humans hunt them

→ hunter-gatherers

→ Controlled use of fire

→ bone marrow extracted

→ stone tools

→ art - abstract thought

→ co-existed

→ caves

~~The Maui dolphin has undergone~~

## Question 1: Hector's Dolphins

The Maui dolphin has undergone a genetic bottleneck as it only has 48-64 dolphins left. This means there was a loss of alleles and decreased genetic diversity. The small population is more susceptible to genetic drift where alleles are lost randomly due to chance events or alleles can become fixed. This means the population cannot adapt to environmental changes. A small population of Maui dolphins means there may be high levels of inbreeding, increasing the chance of harmful alleles being expressed. This could have led to the small population.

Hector's dolphins have a limited diet of just red cod, Flatfish and squid. There may be lots of interspecific competition for these foods so less food available for Hector's dolphins to eat/hunt  $\therefore$  the Hector's dolphins cannot sustain larger populations.

Hector's dolphins use echolocation to navigate, catch prey and communicate with other dolphins. Seismic acoustic surveys and seabed mining could interfere with echolocation causing dolphins to lose their way or not be able to find prey, leading to starvation. This could have led to a decrease in population numbers of Hector's dolphins.

There is an exploitation/predation relationship where the sharks prey on Hector's dolphins, especially young calves. This can lead to infant mortality, decreasing the reproductive success of Hector's dolphins, leading to low population numbers.

Hector's dolphins navigate within a small 50km home range. This limits the availability of food resources within the home range. This means there is less food/prey to hunt so less dolphins can survive in the area, leading to the small population numbers.

Hector's dolphins live primarily in single-sex groups of similar ages. This means it is harder to find mates during the year, limiting breeding to only during the breeding season where mixed-sex groups form. This decreases reproductive success.

Hector's dolphins are K-strategists. Females birth a single calf every 2-3 years and there is a large energy expenditure of the mother to raise the calf in the first 1-2 years. This means there is a low reproductive rate and a high energy expenditure to raise a calf. The population increase will therefore be low (2% each year).

There is high infant mortality rate at 36% in the first 6 months. This means that reproductive success is low, making population increase slow.

There is no sexual selection as males will mate randomly, attempting to reproduce with as many females as possible. There is no agonistic behaviour or aggression towards other males. This means that any male, even those with unfavourable alleles, are able to pass on ~~also~~ these unfavourable alleles to the next generations. This reduces the fitness of the next generation, making them less likely to survive, leading to small population numbers.

Hector's dolphins ~~male~~ reach sexual maturity very late at 6-9 yrs for males and 7-9 yrs for females. As dolphins only live to 20-25 years, there isn't much time to reproduce so the reproductive rate is low. Also, many dolphins may die before they reach sexual maturity and are able to reproduce, leading to a small population. ~~with time~~

The introduction of nylon nets led to the deaths of many dolphins, from 1970s onwards. Dolphins cannot detect the nets and become trapped and die as bycatch, reducing population numbers.

Hector's dolphins are attracted to trawling vessels and as a result are often caught by fishers and die. Other human intervention

Such as oil spills, agricultural run-off and recreational water activities can harm the dolphins and their habitat, decreasing their survival. Seabed mining destroys the marine habitat and ecosystem with flow on effects throughout the food-web as prey of the Hector's dolphins are killed.

Plastic pollution can be ingested by both dolphins and their prey, leading to health issues and death. This ~~number~~ further decreases the Hector's dolphins population size.

Unicellular parasite carried by cats can also kill Hector's dolphins by forming lesions on lungs, lymph nodes, liver and adrenal glands. This, along with brucellosis (from which leads to late-term abortions) decreases Hector's dolphins population numbers.

Captive breeding could be an effective solution to help increase population numbers. Genome sequencing could be used to breed together Maui dolphins that are least related (most genetic variation) to decrease inbreeding. Selective breeding of Hector's dolphins that are more resistant to disease such as unicellular parasite and brucellosis can be used to increase disease resistance in offspring, increasing their survival.

The area which is protected from gillnet and trawl-fishing could be expanded to include more of the Hector's and Maui dolphins habitat. Currently, only areas close to the coast are protected, but by extending the area, fewer dolphins would be caught and killed, helping to sustain population numbers. ✓

Sewerage systems could be fixed to avoid runoff into the ocean. This would decrease the amount of unicellular parasite from cat faeces that the dolphins come into contact with, it could reduce deaths from the parasite. It would also reduce the habitat destruction and exposure to other harmful pollutants from agricultural and industrial, sewerage and stormwater runoff/discharge. ✓

During breeding seasons, water activities/tourism could be restricted/banned to help increase reproductive success by minimising the impacts of human disruptions. This would help to increase Hector's dolphin numbers. ✓

By translocating South Island Hector's dolphins to the Maui dolphin population, gene flow is established. Hybrids may result. These hybrids might have hybrid vigour and be fitter than the parent species. Over time, there may become only one species.

of Hector's dolphin as a result of hybridisation. Translocating individuals could help to introduce beneficial mutations to the Maui dolphin population to increase survival and genetic diversity. 

The Fishing-related mortality limit (FRML) could be reduced for the east coast of the South Island so that protections for Hector's dolphins would be put in place once a smaller number of dolphins were identified as bycatch. This would mean the Hector's dolphins would have better protections from fishing in affected regions so less dolphins would die, increasing the survival of the species and the number of dolphins able to reproduce, thereby increasing the Hector's dolphins population over time. 

## Question 2: Olive Shells.

There are nearly 100 species of Olive Shell distributed across the Pacific and Atlantic oceans. Among these, there are 7 in New Zealand alone. This indicates that adaptive radiation has occurred, where many species diverge from a common ancestor in a short period of time to fill new, available niches.

There are different selection pressures in different areas of New Zealand. These selection pressures would have worked with natural selection to select for different alleles depending on the habitat. For example the shells around Golden Bay and Wellington seem to have had a large shell size selected for due to different selection pressures, leading to New Species over time.

Mutations are the ultimate source of new alleles. Natural selection acts on the different mutations in different populations depending on the selection pressures.

Founders effect may have caused some of the speciation of olive shells in NZ. For example a small population of shells may have established a population in Spirits bay. This leads to fixed alleles or alleles that are not representative of the main population. As the olive shells cannot move easily, there is no gene

Flow so over time the two Spirits Bay species may have become reproductively isolated from the other species in NZ, diverging to form their own species. Founders effect may also have occurred to form the Chatham Island species.

Sympatric speciation may have occurred in Spirits Bay as there are 2 species present in the same area. The 2 species may occupy slightly different niches and may have developed RIMS over time to diverge into different species. These RIMS may be temporal, breeding at different times of the year, or structural as the two species shells are of significantly different sizes. This led to the speciation seen in Spirits Bay.

Allopatric speciation may also have occurred to form the New Zealand species. A species of Olive Shell from Australia may have been washed over to New Zealand during a storm or other extreme weather event. The populations were now geographically isolated by the barrier of the ocean between New Zealand and Australia (Tasman Sea). There was no gene flow so over time, mutations built up and RIMS developed and the Australian and New Zealand species diverged. This may have been the common ancestor of all the New Zealand species.

mtDNA can be used to determine a common ancestor and when divergence between species occurred. mtDNA is passed down the maternal line and is not affected by recombination so the only changes in the base sequence are because of mutations. Mutations occur at a regular rate so a molecular clock can be established to determine when Olive Shell species diverged in New Zealand.

Punctuated equilibrium is a pattern of evolution where there are long periods of stasis with no evolutionary change, followed by short periods of rapid biological change, usually due to ~~an~~ or significant change in the environment.

The DNA evidence supports punctuated equilibrium model as it can track all species in New Zealand back to a recent common ancestor ~~at approximately 11.5-8 million years ago~~ 11.5-8 million years ago. Therefore all the New Zealand species must have diverged once in New Zealand from this common ancestor.

It appears that adaptive radiation occurred as the common ancestor entered New Zealand and filled the available niches. This would have led to New Sp species in NZ and supports punctuated equilibrium as both tend to occur when there is significant environmental change.

The fossil record in New Zealand demonstrates the long periods of stasis with little morphological change which supports punctuated equilibrium.

Figure 9 shows that divergence events ~~or~~ can be traced back using DNA evidence to have occurred at similar times to ~~the~~ changes in New Zealand's geological stages. Approximately 1 divergence event occurs ~~at~~ at each change of geological stage. This supports that the olive shell species diverged within New Zealand as the timings match up with major environmental changes in New Zealand. These environmental changes will have created new niches, habitats and selection pressures that led to the formation of a new Olive Shell species. This DNA evidence therefore supports the punctuated equilibrium model. This evidence rejects the alternative model as there would be no reason for ~~the~~ The alternative model is rejected as the DNA evidence timing lines up with New Zealand's environmental changes perfectly. The alternative model would suggest new species from overseas were washed up/transported to New Zealand and coincidentally happened to occur during environmental change in NZ, which is highly unlikely for these exact timings to occur,  $\therefore$  the alternative model is rejected.

Fossil evidence of the recent common ancestor of Olive

Shells in New Zealand either may not exist as fossilisation is a rare event, or may not have been discovered yet. Therefore the lack of evidence of one common ancestor of NZ species of Olive Shells is not enough to support the alternative model or disprove the punctuated equilibrium model.

### Question 3: The Woolly Rhinoceros

An ecological niche is a species role within its environment. The ~~walk~~ woolly Rhino inhabited mammoth-steppe areas that were cold and dry. These areas were in Western Europe to North-eastern Siberia. There would have been selection pressures for cold resistance and thermoregulation in cold environments.

Woolly rhinos had thick hair on the neck and shoulders to provide insulation between cold environment to keep them warm. ~~The~~ This helped their survival in their mammoth-steppe biome. The shorter hair on limbs may be to stop snow from collecting on limbs during winter or to maintain a range of motion.

Woolly rhinos had small ears compared to modern rhinos. This may be because it was a herbivore and therefore didn't require good hearing to find prey. Or ~~that~~ it had few predators or was protected by its large size so had no need for good hearing to avoid predators.

Woolly Rhinos had two large horns. The smaller horn between the eyes may be for protection when fighting. The larger horn shows sexual dimorphism with males having longer front horns. This may allow males to better defend females and

young. The front horns were worn down on either side, indicating they were used for fighting and wore down when rubbed against other horns. These horns may have been a display of dominance with females choosing rhinos with larger horns, indicating a fitter male, better able to defend the female. This sexual selection would have increased the fitness of offspring.

~~Woolly rhinos~~ Woolly rhinos had relatively short legs compared to modern rhinos. This may be due to thermoregulation as being closer to the ground decreases cooling from airflow, therefore keeping the rhino warm during winter.

The short legs, ~~may~~ along with downward facing position, and enlarged neck muscles may help the rhino to access low lying grasses and shrubs to graze on. The neck muscles support the large head and heavy horn when in a downwards position when grazing on short grasses or plants.

The large hump of the woolly rhino acts as a fat reserve. This fat reserve would allow the rhino to survive the harsh winters when the ground was completely covered in snow and there was few plants available to eat. The fat reserve could be used for energy during winter to sustain the rhino, allowing it to survive until warmer seasons where

plants were a more abundant food source. ↩

The ~~the~~ dentition and enamel indicate a plant diet. Woolly rhinos have three premolars and three molars, all with thick enamel which is needed to break down tough plant material. This, ~~indicates that~~ along with them being hind-gut fermenters, indicates the rhino was a herbivore and grazed on the grasses, herbs and shrubs in the mammoth-steppes. through chewing ↩

The evidence of trauma on younger fossil specimens indicates increased ~~interspecific~~ ~~into~~ intraspecific competition between rhinos. The skull impact damage from rhino horns indicates that as the ice age ended, the rhino's environment changed, leading to a reduction in the ~~the~~ plants that it ate. This increased competition, leading to ~~man~~ fighting between rhinos as food became scarce. ↩

Jaws and ribs showed signs of being broken and reformed which indicates that ~~many~~ rhinos were able to survive and heal broken bones, without significant impact to their ~~the~~ survival. ↩

Skulls that show evidence of feline attack, eg. claw marks, indicate that the ~~mammoth~~ & rhino had feline predators. It was in a predator/prey relationship with these feline species, where the feline

gained a food source ~~water~~ and nutrients and the rhino died.

Fossil evidence of woolly rhinos shows they existed until at least 14,000 years ago, which overlaps with the existence of Homo sapiens. This ~~means that~~ Cut marks on bones show that H. sapiens ~~and~~ (and/or other hominin species) co-existed with woolly rhinos for a time.

Bones with markings indicate the use of stone tools. Cut marks and percussion ~~cut~~ marks show evidence of upper paleolithic tool culture. This shows that H. sapiens hunted and ate the meat of woolly ~~mammals~~ rhinos. To take down an animal as large as a woolly rhino, would have involved a team of hunters indicating that H. sapiens had some form of developed frontal lobe at the time for planning, coordination and forward thinking. Hunting a woolly rhino would have required communication between hunters, so H. sapiens would have had some form of language and therefore brocas and wernickes areas present in the brain.

The evidence of spears made from woolly rhino horns show that the hominins had an advanced tool culture and hunted the woolly rhino for both meat and resources (horns).

Fashioning a spear from a rhino horn would require other specialised tools, indicating the advanced tool culture of H. sapiens.

H. sapiens would have been able to injure/kill prey from a greater distance by using spears as opposed to short-range, hand-held weapons. This decreases the chance of injury when hunting and allowed H. sapiens to hunt larger prey such as woolly rhinos.

Carvings on woolly rhinoceros bones and cave paintings of woolly rhinos fighting show evidence of art. Art shows abstract thought and symbolism, showing that H. sapiens had undergone some cultural evolution.

Cave paintings of woolly rhinos are also evidence that H. sapiens at the time that woolly rhinos were alive, dwelled in caves. H. sapiens lived in caves and hadn't yet discovered how to create man-made shelters.

Charred bones are potential evidence that the hominins at the time, H. sapiens, had controlled use of fire. This meant the hominins were cooking woolly ~~meat~~ rhino meat. The ability to control fire allows daylight hours to be extended, meaning knowledge of how to make tools and other crafts can

be passed down and taught to future generations. The use of fire also increases the nutrition of meat and kills ~~bacteria~~ harmful bacteria, increasing the overall health of the *H. sapiens* population.

Evidence of a woolly rhino ~~statue~~ statuette made of clay & shows that the hominins at the time were capable of many crafts. This statuette may be an art form with symbolic meaning showing abstract thought. It shows that *H. sapiens* at the time could use many different materials to craft items such as clay, bones, horns and stone. Evidence of material possessions such as this statuette could indicate that there was some form of trade established between individuals or groups of *H. sapiens*.

The statuette shows that *H. sapiens* had more specialised roles and skills to be able to make items of art like the woolly rhino statuette.

The presence of hominins in the mammoth-steppes could have contributed to the extinction of the woolly rhino. *H. sapiens* may have hunted woolly ~~mammoths~~ Rhinos to extinction or may have decreased their population numbers by a significant amount so that genetic diversity was reduced and woolly ~~ma~~ rhinos could not adapt to the changing environment at the end of the last ice age, therefore going extinct.

Female Woolly ~~ma~~ rhinos had an udder with two teats. This indicates they were K-strategists and raised few children with a lot of energy put in to parental care. Only two teats indicate 1-2 offspring born at one time, which were given milk as nutrients to feed them. This increases reproductive success as rhino youth were likely to survive to adulthood because of the parental care.

## Outstanding Scholarship

**Subject:** Biology

**Standard:** 93101

**Total score:** 20

| Q | Score | Marker commentary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | 05    | <p>This candidate discusses the K-selected reproductive strategy and the impact of having few offspring, which requires significant energy investment, on small population size. Late sexual maturity and the formation of single-sex small groups are also described, referencing the challenges to successful breeding.</p> <p>The external threats to dolphins, such as small populations susceptible to genetic drift, the low genetic diversity of the Māui dolphin population, and seismic surveying that interferes with echolocation and finding prey, are discussed in terms of dolphin deaths and reduced population numbers. Seabed mining causing habitat destruction and plastic pollution leading to dolphin deaths and population decrease are also described.</p> <p>The candidate describes the interventions of extending the gillnet / trawl-net fishing ban to include more of the dolphin habitat range.</p> |
| 2 | 07    | <p>The candidate integrates an understanding of allopatric speciation and adaptive radiation to discuss olive shell speciation, describing natural selection and the different selection pressures in each niche, including the role of mutations in each area.</p> <p>DNA analysis and mitochondrial DNA as a molecular clock are discussed in terms of establishing the time of divergence due to the known rate of mutation.</p> <p>The candidate describes punctuated equilibrium, linking rapid speciation to environmental and geological change.</p>                                                                                                                                                                                                                                                                                                                                                                       |
| 3 | 08    | <p>The candidate's discussion of the woolly rhinoceros horn indicates sexual selection due to superior genetics and fitness, with larger horns including a description of sexual dimorphism. Damage to the skeleton is linked to intraspecific competition for resources and mates.</p> <p>The candidate's evidence suggesting that the woolly rhinoceros was herbivorous includes the downward-facing head with large neck muscles to hold the head up, as well as the teeth structure. Breeding behaviour, in terms of few calves produced and parental care invested (K-strategy), is discussed and evidenced by the two teats on the udder of the female.</p> <p>A comprehensive discussion about the way of life of the hominins that interacted with the woolly rhinoceros includes the co-existence of <i>Homo sapiens</i>, their Upper Palaeolithic tool culture, and their ability to hunt</p>                           |

| Q | Score | Marker commentary                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   |       | <p>woolly rhinoceros using tools made from bones, thus enabling the high protein in the meat diet to support brain enlargement.</p> <p>As these mammals were very large, an analysis of the communication needed to carry out cooperative hunting is provided in the response. Other aspects of hominin way of life are discussed, including the creation of art and the controlled use of fire to cook food, making it more digestible.</p> |