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OUTSTANDING SCHOLARSHIP EXEMPLAR

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Scholarship 2016
Biology

2.00 p.m. Thursday 17 November 2016
Time allowed: Three hours
Total marks: 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 in this booklet.

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

Check that this booklet has pages 2–26 in the correct order. Pages 2–4 are blank and are to be used for planning. Pages 5–26 are lined pages for writing your answers.

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

Question	Mark
ONE	
TWO	
THREE	
TOTAL	/24

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OS Exemplar

Throughout their response the candidate has used perception to analyse the resource material of each question along with their own biological knowledge and then apply it to the questions asked. Each answer is fluently written creating a fully integrated, relevant response. Q1 all aspects of the question have been fully addressed with multiple biological concepts discussed for each of the area areas of discussion. Q2 the candidate failed to give their justified opinion which prevented them gaining a higher grade. Q3 The candidate presented a well written discussion with consideration of possible consequences. A more in-depth response would have gained a higher grade.

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Question One

The black robin has a higher risk of extinction than the Chatham Island tomtit for a number of reasons. Tomtits are able to utilise a wide range of habitats from sea level to subalpine altitude, and including all mature native forest and some non-forested areas. In contrast, black robins are found only in mature forests, particularly those with closed canopies and open understories. This limited range of habitats makes black robins more susceptible to habitat loss, and therefore more likely to go extinct if their habitat is gone, as there are fewer potential habitats for them to relocate to. Chatham Islands are now predominantly used for farming, and this has likely led to deforestation, destroying black robin habitat and making them more likely to go extinct.

Tomtits are able to search for prey in all levels of the forest, and lay their eggs in well-concealed nests. Black robins, however, spend most of their time foraging on the ground, and their nests are in tree cavities only 1.5m above ground. This likely makes them more susceptible to predation than tomtits. The places they live would once have been predator-free, and they free of land mammals, and they have evolved to utilise the ground, but with the introduction of land mammals when humans settled in the Chathams in the 1800s, black robins and their eggs are at a higher risk of being eaten than tomtits, which can simply forage higher in the forest. As a result black robins are at a greater risk of going extinct. In addition to being more likely to be predated on than tomtits, robins have a lower reproductive rate. Tomtits can produce up to 3 broods a year, with 3-4 eggs in each clutch, meaning they could produce 3-12 offspring each year. As their nests are well hidden, most of these offspring will likely survive. Black robins only rear clutches of 1-4 eggs, and as their nests are in tree cavities low to the ground, they are likely to not all survive. They can double-clutch (lay

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more eggs) if the first clutch doesn't survive, but even so they are limited to around 4 offspring a year, much fewer than the tomtit – and even if they double clutch the second lot of offspring may also die. This low reproductive rate will make it comparatively harder for the black robin to maintain population levels, as so many likely die due to predation, and 1-4 eggs a year may not be enough to replace the number of deaths.

The small populations of black robins also makes them susceptible to extinction. ~~[illegible]~~ In such a small population, genetic diversity will be low – the bottleneck effect. An environmental change, eg. a disease, could easily affect all of them and cause extinction. Their genetic diversity is further hindered by the fact that they could not fly to other islands, so all the population was subjected to the same selection pressures. Living on one island would also facilitate the spread of disease. ~~and a disease could easily spread~~ Their lack of flight also forced them to remain on an island with dwindling forest habitats, further increasing their chance of extinction. While both the tomtit and the black robin are endangered, due to factors like the introduction of predators, the black robin is at greater risk of extinction.

Human intervention at first had a negative effect on the black robins' survival, as the introduction of land mammals resulted in predation on the black robins, and settlement and farming would have removed some of the forest habitats the robins need. By the 1880s, only 80 years after European settlement, the robins were thought to be extinct. A very small population of black robins was then found on the predator-free Little Mangere, and humans then intervened to try increase black robin numbers. The birds were moved to Mangere Island, but this did not work – possibly there there was competition with other birds, or conditions were simply the same

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as Little Mangere so the population continued its decline. Researchers tried getting warblers to raise the eggs of a black robin female, Old Blue, but this failed – the type of food provided by the warbler was not right, and thus many young died. Researchers then had success with using tomtits as surrogates. Tomtits are closely related to black robins (both are Petroica species) and they both eat invertebrates, which may explain the success. The removal of Old Blue's eggs would have induced double clutching, and with the tomtits as surrogates, Old Blue could have up to 6 clutches a season and the population began to increase, as more robin young were surviving.

Human intervention affected not only the survival, but the evolution of the black robin. When it was observed that robins were laying eggs on the rims of their nests, researchers would push the eggs back in – without incubation, the eggs would not survive. This behaviour became more common until over 50% of females laid rim eggs. This is because the behaviour is caused by an allele. Without human intervention, it would be selected against, as offspring whose mothers had the allele would be less likely to survive. Through natural selection, the allele would decrease in frequency in the gene pool. Human intervention eliminated this selection pressure as now all eggs would end up in the nest with similar chances of survival. The allele increased in frequency once it was not being selected against – and as it is dominant, both homozygous dominant and heterozygous individuals would exhibit the rim-laying phenotype, making the behaviour very common. Once the population had grown to 200, humans stopped intervening with the eggs, and as such the rim-laying allele was selected against again and decreased in frequency, as robins with it were less likely to have surviving offspring. Now only 9% of females lay rim eggs. The black robin population has grown to 250–300 birds on two islands, showing

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the population is recovering now in predator-free conditions, and thanks to human intervention to raise the robins' reproductive rate. However, a recent study has found some robins have deformed beaks, chicks with are near naked, and have poor bone development. These birds will be unlikely to survive. Deformed beaks could make it hard for them to get food or feed their young, leading to malnourishment - which could be the cause of the chicks' poor bone development. Being near naked will make the birds susceptible to cold and may hinder their ability to fly, while poor bone development could hinder movement also. The evolution of these characteristics could be due to human intervention. The major decline in black robin populations caused by introduced predators and deforestation resulted in only one female, Old Blue, surviving. All black robins alive today must be descended from her. The bottleneck effect means some valuable alleles resulting in healthy robins may have been lost, and deformed robins are now more common. The lack of genetic diversity in the robins and the inbreeding that has likely happened means detrimental recessive alleles may be more likely to be expressed in the phenotype as individuals have a higher chance of inheriting 2 copies. Human intervention to save robins also could have led to some deformed or unhealthy robins surviving surviving when they otherwise wouldn't have and passing on their genes, so these traits were not selected against as they would and thus became more prevalent have been otherwise. Now that human intervention has ended, however, the alleles causing these traits will be selected against, as individuals with these traits are less likely to survive and reproduce. The black robins will continue to face problems due to its low numbers and lack of diversity, but currently the species is recovering.

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Question Two

~~Though resident and transient orca are the same species, ecological processes have resulted~~ Resident and transient orca have evolved to occupy distinct ecological niches. The two types of orca are not known to interbreed and became reproductively isolated around 700,000 years ago. As they are reproductively isolated, they could be considered different species. This is an example of sympatric speciation, or speciation without a geographic barrier, as both types of orca occupy a similar region of the ocean. The two populations occupied slightly different niches, one close to the shore and rivers and one further to sea (and further north + south) and accumulated differences as they adapted to these niches. Each niche would have different selection pressures, and through the process of natural selection, favourable alleles in each population would become more frequent as individuals with those alleles would be more likely to survive and reproduce. Over time, enough differences would accumulate that the two populations would no longer interbreed.

One of the differences between resident and transient orca is their food source. Resident orca live in or near rivers, where migrating salmon are found, and these are their main source of food along with other fish. They hunt by echolocation. Transient orca, however, ~~hunt exclusively~~ prey on other marine mammals, like seals, dolphins, and do not use echolocation as it would be detected by their prey. In resident orca, echolocation has been selected for as it helps them hunt, but in transient orca it would have been selected against as individuals relying on echolocation would be less likely to catch enough prey to get the nutrition they need to survive.

While the social structures of resident and transient orca are similar in that they both have a matrilineal structure, there are several notable differences. Resident orca have very structured groups, sometimes forming

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clans of up to 30 individuals. This may be for a number of reasons, like group defence, group hunting, or protection of individuals or resources. These may be particularly important as there are two groups of resident orca, the northern and southern. Competition between these populations, or a need to maintain boundaries between them, may make a highly structured large social group beneficial. In contrast, transient orca live in smaller groups, with offspring leaving when they mature, and males often roaming alone and only joining groups to mate. Transient orca occupy a large area and there is no competition between groups, so there is less need for a large social group. In addition, while resident orca may benefit from hunting in groups as it could help them catch fish, transient orca may benefit from hunting alone or in small groups as they rely on stealth to catch their prey.

There are also differences in the calls of resident and transient orca, with resident orcas being very vocal and using up to 17 calls, while transient orca are less vocal and have only 4-6 calls. The highly structured, social nature of resident orca may account for the number of calls, as it will enable greater complexity of communication. As transient orca are in smaller groups or alone, such a range of calls is not needed. In addition, resident orca may have some calls used for hunting, or for warning away the other (northern/southern) population. Transient orca are not split into two groups so would not need calls for the latter, and as they hunt using stealth a hunting call would be harmful, not beneficial, to them.

The different ecological niches occupied by resident and transient orca have resulted in a number of differences between them. Some of these differences could be reproductive isolating mechanisms e.g. their different social structures

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and hunting strategies could be behavioural RIMs, preventing interbreeding between them, and have caused/will lead to sympatric speciation.

In the future, the three populations of orca will likely continue to accumulate differences. While the populations are all classed as Orcinus orca, they could already be considered different species as they have become reproductively isolated and are not known to interbreed. Each population occupies a different niche and is subject to different selection pressures and thus will evolve differently and diverge into different species, an example of sympatric speciation. ~~The different niches~~ The three populations already have notable differences, eg. different fin shape, ~~prefer~~ food source, ~~etc~~ etc. They will likely continue to accumulate differences as different traits will be beneficial in each of their niches, e.g. the teeth required to catch sharks may be different than those required to catch salmon. Sympatric Speciation may also occur between the northern and ~~popular~~ southern resident orca, as the two populations have never been found in the same area at the same time, and their respective habitats likely have slightly different selection pressures, e.g. different temperatures or types of fish. If each population accumulates enough differences through natural selection as they adapt to these changes, ~~symp~~ they may become unable to potentially interbreed, and thus be different species.

Each population of orca has an uncertain future due to their low numbers, with 200 northern residents, 90 southern residents, and 250 each of transients and offshore orca. These low numbers are due to whaling last century. ~~An example of the bottl~~ Now that there is no whaling in these areas, the populations could recover, but genetic diversity will be low, an example of the bottleneck effect, and some alleles could have been altogether lost due to whaling. This lack of genetic diversity means an environmental change could affect all, or a large proportion, of the population and further reduce numbers. While orca can breed all

year round, which may increase their reproductive success (if conditions are poor they could still breed later that year once conditions improve), their reproductive rate is relatively low. Females usually only have calves between the ages of 17 and 40, and only breed every 4-8 years. The low populations of orca, their lack of genetic diversity due to the bottleneck effect and their slow reproductive rate may make it difficult for their populations to recover in the future.//

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Question Three

H. naledi could potentially be classed as either an australopithicene or part of the Homo genus.

The naledi fossil shows a mix of Homo and Australopithecus features. The skull shape, hands, legs, and feet are similar to Homo species, and show adaptations for bipedalism, like an increased valgus angle and feet adapted for a long-distance stride. However, naledi also has shoulders and fingers adapted for tree climbing, and a flared pelvis, a primitive trait. This mixture of primitive and modern features suggests naledi should be classed as an australopithicene, as A. sediba and A. afarensis also have adaptations for both bipedalism and tree-climbing.

No stone tools have been associated with H. naledi, but naledi's hands are humanlike, suggesting they had the dexterity associated with tool use. However, this does not indicate they are a Homo species, as A garhi, A or K. platyops, and A afarensis seem to have used tools, and A. africanus has hands indicating tool use.

Furthermore, the brain of naledi is relatively small, at 450-550 cm^3. This is smaller than the brain of H. habilis, which is 610 cm^3, but is a similar range to australopithicenes like A. garhi and A. africanus, suggesting naledi should be classed as an australopithicene. There has been a trend throughout hominin evolution towards larger brains, with H. habilis already having the smallest brain of any Homo species, though larger than those of australopithicenes. The size of naledi's brain is closer to australopithicenes than any of the Homo genus, therefore.

In addition, the size of naledi's brain suggests they were not capable of the same level of thought as H. habilis, nor were they getting the same amount of energy in their diet, which is required for a large, energy-using brain.

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Complex thought, better diets due to a higher proportion of meat, and brain development are all linked in a positive feedback loop. Complex thought enables better tool use, which allows hominins to get more meat (e.g. H. habilis used tools to break open bones and get marrow, or to cut meat), which provides the energy needed for brain development, which enables more complex thought. The small brain case of naledi indicates its tool use and thought were therefore not as developed as H. habilis. The location of the naledi fossils also somewhat supports classifying it as an australopithicene, though not especially strongly. It was found in South Africa, where the fossils of A. sediba and A africanus were also found. To date, all Homo species have been found in East Africa, thousands of kilometres away. ~~This does not necessarily mean~~ Overall, the evidence supports classifying naledi as part of the genus Australopithecus. The location and features of the fossil suggest it has more in common with australopithicenes than with any of the Homo genus, as it retains more primitive features than the earliest Homo species, H. habilis.

H. naledi has not been possible to date, and could be recent (<1 mya), early (2-3 mya) or old (>3 mya).

The other hominins found in South Africa are A. africanus and A. sediba. These both lived around 2-2.8 mya, and both have similarities to naledi. A africanus has a brain a similar size and handl suggesting tool use, and A. sediba, like naledi, has a mix of traits associated with bipedalism and tree climbing. It is quite possible that naledi therefore is 'early', as other hominins in a similar region with similar features existed during that time period. Positioning naledi here would not have new implications for the evolution of humans, as similar species already existed in South Africa at that time.

Were H. naledi classed as 'Old' (>3 mya), however, it would place

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it earlier than either A. sediba or A. africanus, and potentially even early than A. afarensis. A. afarensis has a mix of tree climbing and bipedal adaptations, suggesting this was when bipedalism was first developing. If H. naledi was even older than A. afarensis it could suggest bipedalism was developing even earlier, and notably as H. naledi has a larger brain than A. afarensis, it would suggest a diet containing meat, tool use, and brain development, may have happened earlier than one would expect looking at other australopithecine fossils. Furthermore, if H. naledi is classed as 'Homo' and 'Early', it would be the first member of the Homo genus, and indicate the Homo genus originated not in East Africa, where other Homo fossils are found, but in South Africa. This would be a major change to current scientific thinking about where the Homo genus first evolved. It is unlikely naledi was this old, though, ~~as its brain is bigger than other australopiths~~ it has so many similarities to 'early' hominin fossils found in South Africa.

To class naledi as 'Recent' (<1 mya) would also have major implications for human evolution. It would suggest that ~~it~~ in the same time period as H. erectus, or even Neanderthals or H. sapiens, all of which were fully bipedal, ate meat, and used relatively advanced tools, a hominin species with far more primitive features existed. ~~This would suggest that H. erectus and more recent species did not migrate to South Africa~~ The existence of a species like H. naledi at this time would suggest there were no H. erectus or similar in South Africa at the time, or they were recent arrivals, as otherwise they would likely have outcompeted H. naledi, and H. naledi would not have survived for long.

Overall, the evidence supports the idea that naledi is an australopithecine who lived 2-3 mya, at the same time as other australopithecines in South Africa with similar features.

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