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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

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

Scholarship 2018
Biology

9.30 a.m. Tuesday 20 November 2018
Time allowed: Three hours
Total marks: 24

QUESTION BOOKLET

There are THREE questions in this booklet. Answer ALL questions.

Write your answers in Answer Booklet 93101A.

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

Check that this booklet has pages 2–7 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

QUESTION ONE: FORBES' KĀKĀRIKI

Forbes' kākāriki (*Cyanoramphus forbesi*) is one of the rarest of Aotearoa New Zealand's kākāriki species, and is found only on Mangere Island and Little Mangere Island within the Chatham Island group (Figure 1). The relatively common Chatham Island red-crowned kākāriki (*Cyanoramphus novaezelandiae chathamensis*) are found on the same islands as Forbes' kākāriki, and are also present at Pitt Island, South-East Island, and the southern end of Chatham Island. Chatham Island red-crowned kākāriki are not present at the northern end of Chatham Island where forest remnants remain. Chatham Island itself contains possums and feral cats, whereas these have been eliminated from Mangere Island and are not present on Little Mangere Island.

Figure 1. Location of Mangere Island and Little Mangere Island within the Chatham Islands group

Geographx

In the 1890s the original dense forest was cleared from Mangere Island and replaced by grasses for sheep grazing. Only small patches of coastal scrub and forest were left on the cliffs. Until this time Forbes' kākāriki was the most abundant kākāriki species, but by 1968 less than 30 remained. Farming was stopped in 1968 as Mangere Island was made into a conservation reserve. Ongoing restorative plantings began in 1973 at a rate of approximately 6000 trees per annum.

Forbes' kākāriki prefer forest habitats, while the Chatham Island red-crowned kākāriki prefer open patches of grass, scrub, and herbs.

The current population of Forbes' kākāriki is estimated to be around 900, with approximately 10% of the population being hybrids between Forbes' and Chatham Island red-crowned kākāriki. These resemble Forbes' kākāriki in appearance, and for most hybrids, the only morphological difference is additional red feathers in the crown. However, some hybrids look the same as Forbes' kākāriki. Biologists have observed the tendency for hybrids to backcross with Chatham Island red-crowned kākāriki rather than Forbes' kākāriki.

Biologists tested the immune response of Forbes' kākāriki, Chatham Island red-crowned kākāriki and hybrid kākāriki in order to determine their likely susceptibility to disease. This was done by injecting phytohaemagglutinin (PHA) into wing tissue. PHA stimulates T cells and inflammatory cells, which causes wing tissue thickness to increase, and this can be used as a measure of innate cell-mediated immunity. The results are shown in Figure 2b.

Figure 2a. Kākāriki phenotypes

Clockwise from top left: Forbes' kākāriki, 'slight hybrid', 'distinct hybrid', Chatham Island red-crowned kākāriki.

Tomkins, D.M. *et al*., 'Hybridization increases measures of innate cell-mediated immunity in an endangered bird species.' *Journal of Animal Ecology*, vol 75 (2006), pp 559–564.

Figure 2b. Kākāriki immunity response to PHA challenge with respect to phenotype

The extent of wing tissue thickness quantifies immune response.

Tomkins, D.M. *et al*., 'Hybridization increases measures of innate cell-mediated immunity in an endangered bird species.' *Journal of Animal Ecology*, vol 75 (2006), pp 559–564.

Question

Analyse the information provided in the resource material, and integrate it with your biological knowledge to:

- discuss the evolutionary and ecological processes that may have resulted in the hybrid that formed between the Forbes' kākāriki and Chatham Island red-crowned kākāriki cross, and the possible effects of these hybrids on the future evolution of Forbes' kākāriki
- analyse options for the management of the Forbes' kākāriki to improve their vulnerable status.

QUESTION TWO: MIDAS CICHLIDS

Nicaragua, in Central America, sits on the geologically active Pacific Ring of Fire. The southern part of the country contains a number of freshwater lakes, consisting of two large lakes (Lake Nicaragua and Lake Managua) and a number of small, isolated crater lakes, formed in the calderas of extinct volcanoes. The crater lakes are very recent in origin, with most having been formed in the last 20 000 years (Figure 1).

Figure 1: Topographic map of Nicaragua showing the location of crater lakes, Xiloá and Apoyo.

Elmer, K. *et al., Nature Communications*, vol 5 (2014), p 5168.

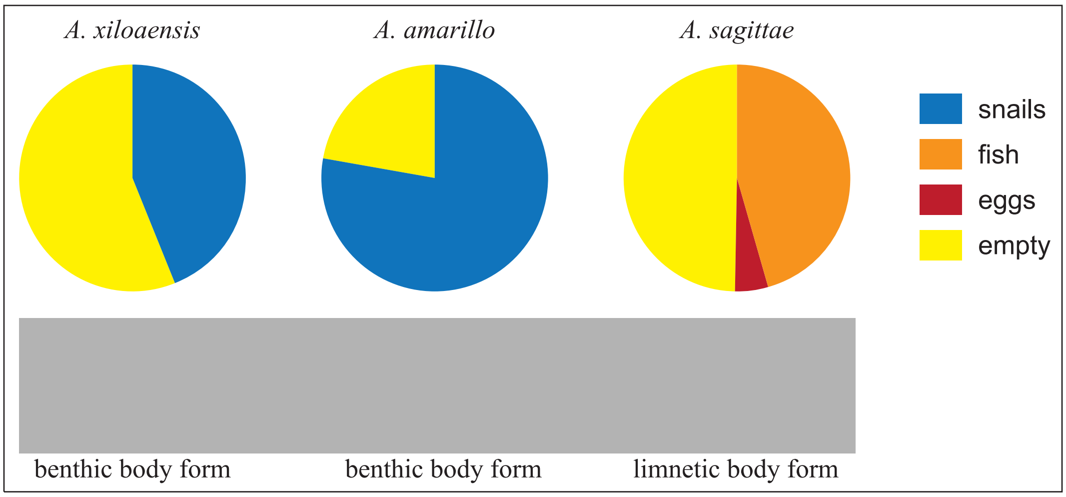
Many of these lakes contain populations of Midas cichlid fishes belonging to the *Amphilophus citrinellus* species complex (a group of very similar, closely related species). Populations in two of the crater lakes, Lake Apoyo and Lake Xiloá, have been extensively studied over the last few decades. Both lakes are very small, but are much deeper than the two large lakes, Lakes Nicaragua and Managua. Lake Apoyo is at most 23 000 years old, is more than 200 m deep, and contains six Midas cichlid species. Lake Xiloá is at most 6 100 years old, is up to 88.5 m deep, and contains four Midas cichlid species.

The presence of Midas cichlid populations in both Lakes Xiloá and Apoyo is thought to be the result of two separate colonisation events, one for each lake (5 400 years ago from Lake Managua in the case of Xiloá and 10 000 years ago from Lake Nicaragua for Apoyo).

Cichlid species in the lakes generally show either benthic or limnetic body forms. Limnetic fish live in more open water and are generally piscivorous (feeding on other fish species). They have a more elongated and streamlined body form. Benthic fish are bottom dwellers that forage in the shallows and have a wider and deeper body shape.

Studies of three of the cichlid species in Lake Xiloá have found differences in their diet (Figure 2), breeding depth (Figure 3), and habitat preference of breeding pairs (Figure 4).

Figure 2: Feeding preferences of three species of cichlid from Lake Xiloá, as determined by stomach content analysis.



Adapted from: McKaye, K. *et al*., *Cuadernos de Investigación de la U.C.A*, vol 12 (2002), pp 19–47.

Figure 3: Breeding depth of three cichlid species in Lake Xiloá

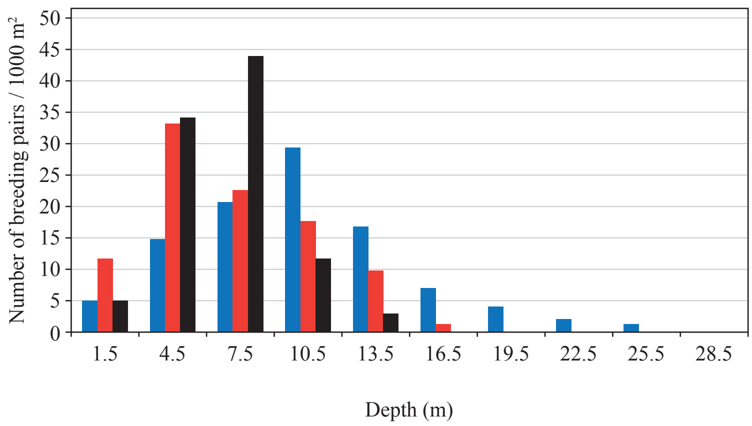
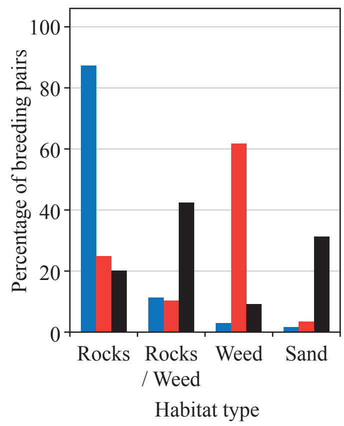
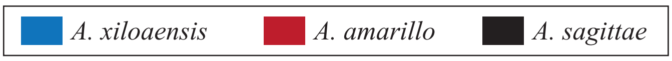


Figure 4: Habitat preference of three cichlid species in Lake Xiloá





Adapted from: McKaye, K. *et al*., *Cuadernos de Investigación de la U.C.A*, vol 12 (2002), pp 19–47.

Researchers have also investigated Midas cichlid species in Lake Apoyo. They have found that one of the species present (*A. zaliosus*) is a limnetic fish, while the other species in the lake are benthic dwellers. As with the situation in Lake Xiloá, studies have shown differences in diet and habitat preference between the benthic and limnetic species in Lake Apoyo, and while interspecific pairs do occasionally form, they are unsuccessful at breeding, possibly due to differences in courtship behaviours.

Genetic studies have shown that the species within each lake are more closely related to each other than to those in other lakes.

Question

Analyse the information provided in the resource material and integrate it with your biological knowledge to discuss the evolutionary processes and patterns that have resulted in the diversity of the Midas cichlid species complex in Lakes Xiloá and Apoyo.

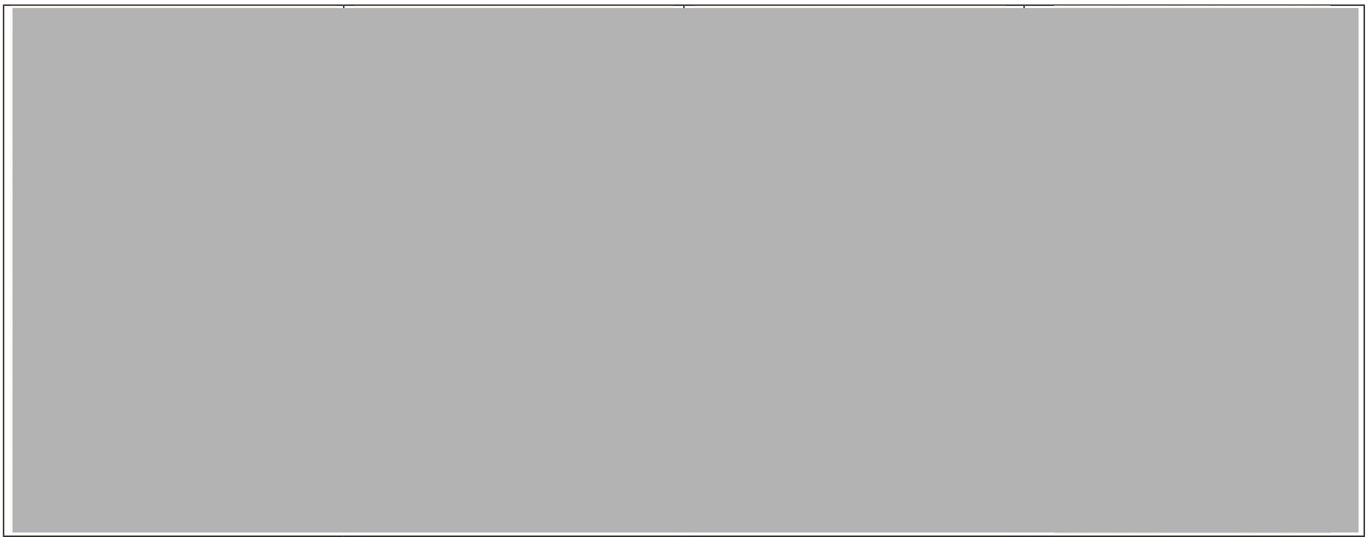
QUESTION THREE: JEBEL IRHOUD FOSSILS

The timing and location of the emergence of *Homo sapiens* is an important aid in the understanding of human evolution.

Genetic models suggest *H. sapiens*, Neanderthals, and Denisovans diverged from a common ancestor approximately 500 000 years ago.

Hominin fossils have recently been discovered from Jebel Irhoud in Morocco. The remains, include a skull (Figure 1c), mandible, maxilla, femur, and teeth. A tooth has been dated to between 254 000 and 318 000 years old.

Figure 1: Skull-shape differences over time



~430 000 year-old skull found in Sima de los Huesos, Spain, considered to represent early Neanderthal.	~50 000 year-old skull from La Ferrassie, France, an example of a late Neanderthal.	~315 000 year-old skull from Jebel Irhoud in Morocco.	~20 000 year-old *H. sapiens* fossil from Abri Pataud, France.

Stringer, C. & Galway-Withham, J., *Nature*, vol 546 (2017), pp 212–214.

Found in the same layer as the Jebel Irhoud fossils are charcoal and Middle Stone Age tools (similar to Eurasian Middle Palaeolithic tools) dominated by Levallois technology (Figure 3). No Acheulean technology has been found. These tools have been dated to between 281 000 and 349 000 years old. Most of the tools are flint from a site over 20 km away. Animal remains are mainly gazelle, but also include zebra, wildebeest, hartebeest, leopards, lions, and coprolites from hyena. These species are also found in east Africa. Approximately a quarter of the bones have been burnt. Some gazelle bones contain cut-marks and have percussion notches.

The features of the Jebel Irhoud skull resemble those of other skulls of similar age such as the ~259 000 ± 35 000 years-old Florisbad skull from South Africa (Figure 2), which was also associated with Middle Stone Age tools.

The age reported for *Homo naledi* (Figure 2) is between 236 000 and 335 000 years old.

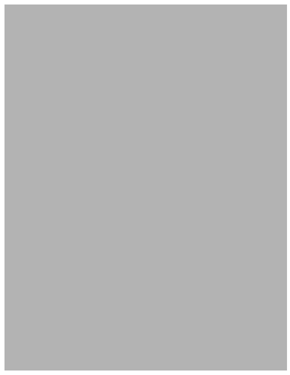
Around 330 000 years ago, the Saharan desert in Africa briefly became vegetated due to climate change.

A different group of researchers has sequenced the genome of a juvenile male named Ballito Bay boy who lived in South Africa approximately 2 000 years ago. They determined that his ancestors on the *H. sapiens* lineage split from those of some other present-day African populations approximately 350 000 to 260 000 years ago.

Figure 2: Location and approximate age in years of Jebel Irhoud fossils and other significant hominin skulls found in Africa. Sahara desert shown in yellow.

Gibbons, A., *Science*, vol 356 (2017), pp 993–994.

Figure 3: Single scraper with some edge damage on a Levallois flake



Richter, D. *et al*., *Nature,* vol 546 (2017), pp 293–96.

Table 1. Endocranial volumes of selected hominins over time.

Hominin	**Age (ky)**	**Endocranial volume (mL)**
Jebel Irhoud 1	315	1375 ± 6 mL
H. erectus (Sambungmacan 3)	200	902 ± 4 mL
H. sapiens (Omo 2)	195	1491 ± 4 mL
H. sapiens (Skhul V)	115	1363 ± 1 mL
H. neanderthalensis (Gibraltar 1)	75	1213 ± 4 mL
H. neanderthalensis (La Chapelle-aux-Saints)	52	1490 ± 3 mL
H. sapiens (Cro-Magnon 1)	31	1574 ± 1 mL
H. sapiens (Dolní Věstonice 16)	30	1542 ± 4 mL
Mean of 89 cranially diverse present-day humans	0	1328 ±164 mL

Neubauer, S. *et al*., ‘The Evolution of Modern Brain Shape’, *Science Advances*, vol 4 (2018), no 1.

Question

Analyse the information provided in the resource material and integrate it with your biological knowledge to:

- give your justified opinion on what hominin species the Jebel Irhoud fossils might represent
- discuss the implications of the Jebel Irhoud findings AND compare these to scientific understanding of the origins of *Homo sapiens* prior to their discovery.