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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2025
Biology

Time allowed: Three hours
Total score: 24

QUESTION BOOKLET

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

Write your answers in Answer Booklet 93101A.

Check that this booklet has pages 2–8 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: Thylacines

The thylacine (*Thylacinus cynocephalus*) of the family Thylacinidae, is an extinct, marsupial (non-placental mammal) species endemic to Australia. They were considered a keystone species (a species that has a large impact on the ecosystem).

The thylacine dug and lived in burrows and, like other marsupials, they gave birth to underdeveloped (about the size of a grain of rice) live young (joeys). The joeys were then nurtured to full development in a pouch (Figure 1). Thylacine hunted and killed possums, rodents, lizards, and birds, and scavenged carcasses. This diet overlapped with that of Tasmanian devils (*Sarcophilus harrisii*), a smaller, extant (not extinct) marsupial that also scavenges carcasses and eats small mammals and birds.

Figure 1: A thylacine female carrying joeys in the pouch

Before the 1800s, thylacines were widely distributed across mainland Australia and Tasmania in forested, grassland, and coastal regions. Their joeys were prey for species native to Australia, such as wedge-tailed eagles (*Aquila audax*) and tiger snakes (*Notechis scutatus*). After European settlement, factors such as hunting by settlers and habitat destruction led to their eventual extinction, with the death of the last captive thylacine in 1936. Europeans also introduced cats and foxes, predators of similar size to the thylacine.

The closest living relatives to thylacine are fat-tailed dunnarts (*Sminthopsis crassicaudata*). Figure 2 shows a phylogenetic tree of the marsupial relatives of thylacines. All are listed as between vulnerable and critically endangered species on the International Union for Conservation of Nature (IUCN) Red List. After the thylacine extinction, there was a rise in devil facial tumour disease (DFTD), a transmissable cancer that affects Tasmanian devils, causing death within a few months of contracting the disease.

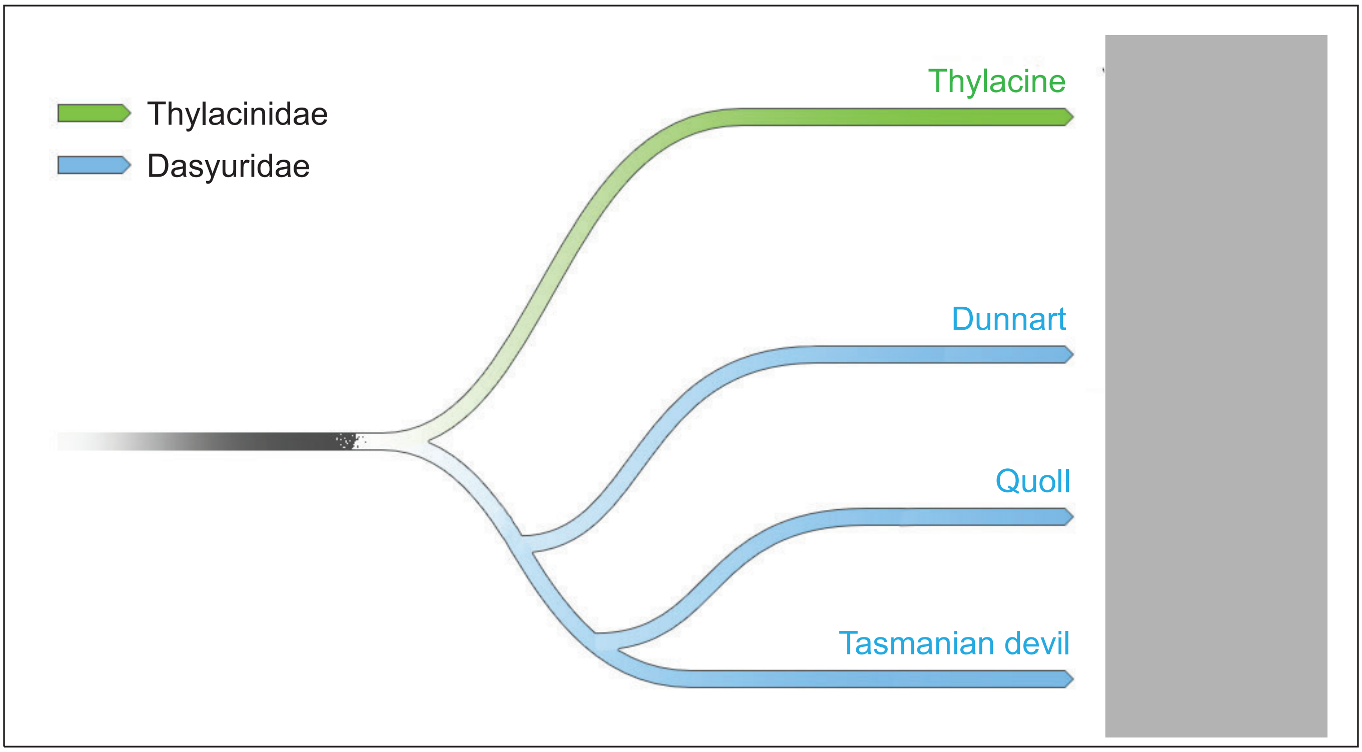


Figure 2: Phylogenetic tree of marsupials related to thylacine

Due to its role as a keystone species, scientists are working to de-extinct the thylacine. De-extinction is the process of using genetic manipulation to generate an organism that either resembles or is an extinct species.

In 1999, the Australian Museum started a rewilding project with the goal of reintroducing thylacine to the wild. Scientists attempted to clone thylacine using DNA extracted from museum specimens, but they were unable to produce a viable embryo. Tasmanian devils and quolls were considered as possible surrogates. Australian Museum ceased attempts in 2005.

Colossal Biosciences, founded in 2021, is a biotechnology and genetic engineering company. They claim to have pieced together a near-complete genome using various thylacine specimens preserved in ethanol. Although there are still gaps in the genome, they aim to fill these gaps using the genome of the fat-tailed dunnart. To date, there have been no successful attempts at cloning marsupials.

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

- the ecological consequences of the thylacine’s extinction on its ecosystem
- how genetic manipulation could be used to de-extinct the thylacine, including possible reasons why the Australian Museum project failed, and your justified opinion on whether Colossal Biosciences will be successful.

QUESTION TWO: The bar-tailed godwit / kuaka

The bar-tailed godwit or kuaka (*Limosa lapponica*) is the most numerous tundra-breeding shorebird species to occur in New Zealand, with around 75 000 visiting each year from the Northern Hemisphere. Virtually all bar-tailed godwits in New Zealand are from the subspecies *L. lapponica baueri* that breeds in western Alaska.

Figure 3: Adult non-breeding bar-tailed godwit

These godwits undertake an annual migration of 29 000 km, from breeding grounds in Alaska to New Zealand, returning again along the coastline (see Figure 4). The leg from Alaska to New Zealand across the Pacific Ocean, which exceeds 11 000 km, is the longest known non-stop flight of any bird. This migration requires significant ecological and evolutionary adaptations for survival.

Bar-tailed godwits breed mostly on the Arctic coasts and tundra of Alaska during the Northern Hemisphere summer. There, they find abundant aquatic invertebrates and shellfish as their primary food source. Following the breeding season, they migrate to Australia and New Zealand, arriving in early September after a non-stop flight of approximately nine days. From September to February, they are relatively common at many harbours and estuaries around New Zealand.

The godwits begin to depart on their return migration north from early March. The flight back to Alaska includes stopovers at staging sites (see Figure 4) to rest, refuel, and prepare for the next stage of their journey, so they arrive in good condition to breed again in May. They do not breed until their third or fourth year so, each southern winter, there are hundreds of non-breeding birds remaining in New Zealand.

Figure 4: The migration route to and from New Zealand

From the fossil record available for bar-tailed godwits, it is known that these migrations have been occurring for a long time. The birds were certainly migrating to New Zealand long before humans arrived. Many of the godwit's features are adaptations for such an extreme migration.

Figure 5: Adaptations of the godwit's anatomy

Bar-tailed godwits are fully protected in New Zealand; however, current count data indicates an annual population decline of nearly 2%. The primary cause of the decline is extensive habitat loss at stopover sites in the Yellow Sea region. Further decline is thought to be likely due to predicted global climate change, including changes in temperature and wind patterns, which may affect the birds at all stages of their annual cycle.

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

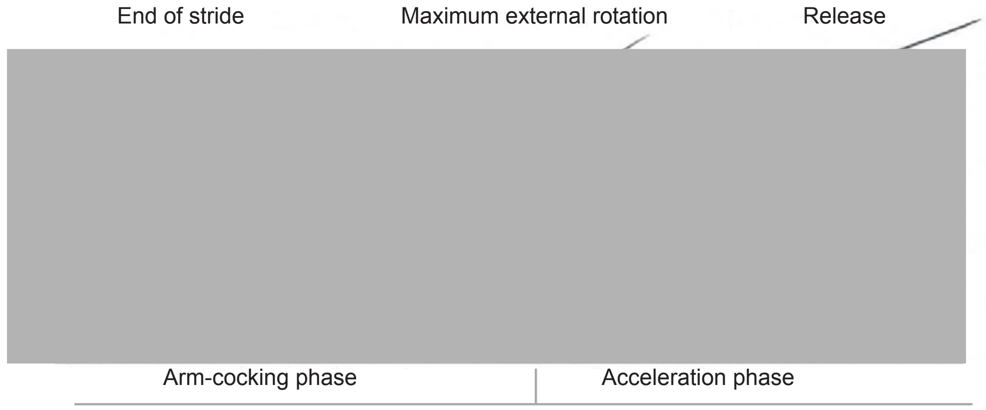
- the adaptations and the key ecological requirements that enable the bar-tailed godwit to successfully undertake such a long and energy-intensive journey
- the potential impacts of climate change on the migration patterns of the bar-tailed godwit, including how alterations in climate may affect their migratory route, resting sites, and the likelihood of successful migration.

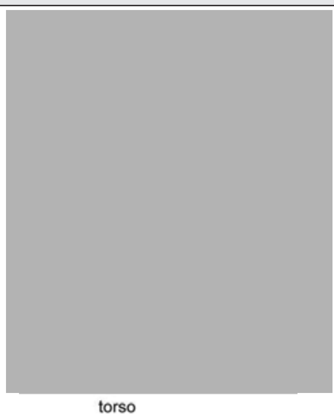
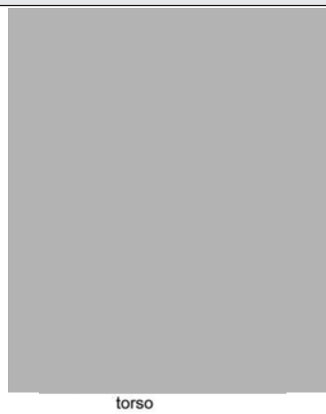
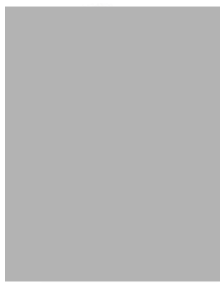
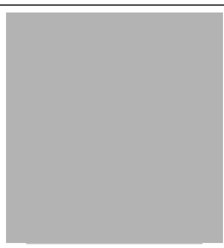
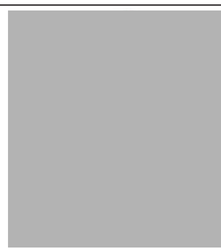
QUESTION THREE: Projectiles

A projectile is an object propelled through the air. Both humans (*Homo sapiens*) and chimpanzees (*Pan troglodytes*) can throw projectiles; however, humans can throw them further and with greater speed. Several adaptations contribute to this ability in humans, including a tall, decoupled waist that allows the torso to rotate independently of the pelvis and head, an adaptation first seen in Australopithecines. Additionally, low, wide shoulders, long legs, and flexible wrists, which appeared in *Homo erectus*, also play a role. It is likely that some of these features were selected for by functions other than throwing.

Table 1: Differences in humans and chimpanzees when throwing

(a) Overhand throw of a projectile.



	Human	Chimpanzee
(b) Arm position during throwing due to difference in shoulder orientation.		
(c) The major line of action of the *Pectoralis major* (pec muscle).		
(d) Orientation of the scapula.		

In addition to physical adaptations for throwing, geneticists have identified gene variants that assist throwing. These gene variants have been identified in the DNA of modern humans and ancient hominins, dating back at least 1 million years, and are not present in chimpanzees. The modern human variant of the GDF5 gene is associated with enhanced rotational range of motion in the shoulder compared to chimpanzees. The modern human variant of the ACTN3 gene, responsible for producing fast twitch muscle fibres that are needed for performing powerful and explosive movements, is more efficient than that of chimpanzees.

Projectiles used by hominins ranged in sophistication from unaltered rocks to spears or arrows, some of which required another tool to throw them, as shown in Table 2 and Figures 6–8 on the following page.

Table 2: Projectiles used by hominins

Projectile type	**Date of evidence of first use**	**Material / manufacture**	**Location found**
Unaltered rocks	Date unknown	Stone	Unknown
Untipped throwing spears (for throwing rather than for thrusting directly into an animal)	400 000 – 300 000 years before present	Wood with at least one sharpened end (Figure 6, page 8)	United Kingdom Germany (Europe)
Stone-tipped, throwing spears	280 000 years before present	Stone tip attached to a wooden javelin (Figure 7, page 8)	Ethiopia (East Africa)
Poison on stone-tipped, throwing spears or arrows	54 000 years before present	Arrow tips are often small when poison is used, not requiring much penetration depth into flesh	France (Europe)
Atlatls (spear throwers)	21 000 to 17 000 years before present	Carved from wood or bone and used to throw a spear (Figure 8, page 8)	France (Europe)
Bow and arrows	11 000 and 12 000 years before present	Bow: wood or bone Strings of the bow: animal sinew (tendon) Arrow: untipped or stone-tipped wood	Germany (Europe)

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

- the adaptations that have enabled *Homo sapiens*, as opposed to chimpanzees, to utilise projectiles successfully, and the advantages these adaptations conferred
- the trends shown in the design and manufacture of projectiles, and justifications for which hominins may or may not have used projectiles.

Continues over page ➤

Figure 6: Wooden throwing spears from Schöningen, Germany, dated to 300 000 years ago

Figure 7: Stone spear tips from Ethiopia, East Africa

Figure 8: Atlatl in use

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Acknowledgements
Material from the following sources has been adapted for use in this assessment:

Page 2
Figure 1: https://colossal.com/wp-content/themes/colossal/img/thylacine-drawing-1.png
Figure 2: https://colossal.com/wp-content/themes/colossal/img/evolution-graph.png

Page 4
Figure 3: https://www.nzbirdsonline.org.nz/species/bar-tailed-godwit
Figure 4: https://teara.govt.nz/en/map/7237/migration-route-eastern-bar-tailed-godwits
https://www.worldatlas.com/seas/yellow-sea.html

Page 5
Figure 5: https://www.allaboutbirds.org/news/wp-content/uploads/2018/09/Anatomy-diagram.jpg

Page 6
Table 1: https://www.ncbi.nlm.nih.gov/core/lw/2.0/html/tileshop_pmc/tileshop_pmc_inline.html?title=Click%20on%20image%20to%20zoom&p=PMC3&id=3785139_emss-53143-f0001.jpg

Page 8
Figure 6: https://www.newscientist.com/article/2469565-ancient-hunters-may-have-used-throwing-spears-300000-years-ago/
Figure 7: https://media.springernature.com/lw685/springer-static/image/chp%3A10.1007%2F978-3-031-20290-2_19/MediaObjects/492828_1_En_19_Fig2_HTML.png
Figure 8: https://en.wikipedia.org/wiki/Spear-thrower