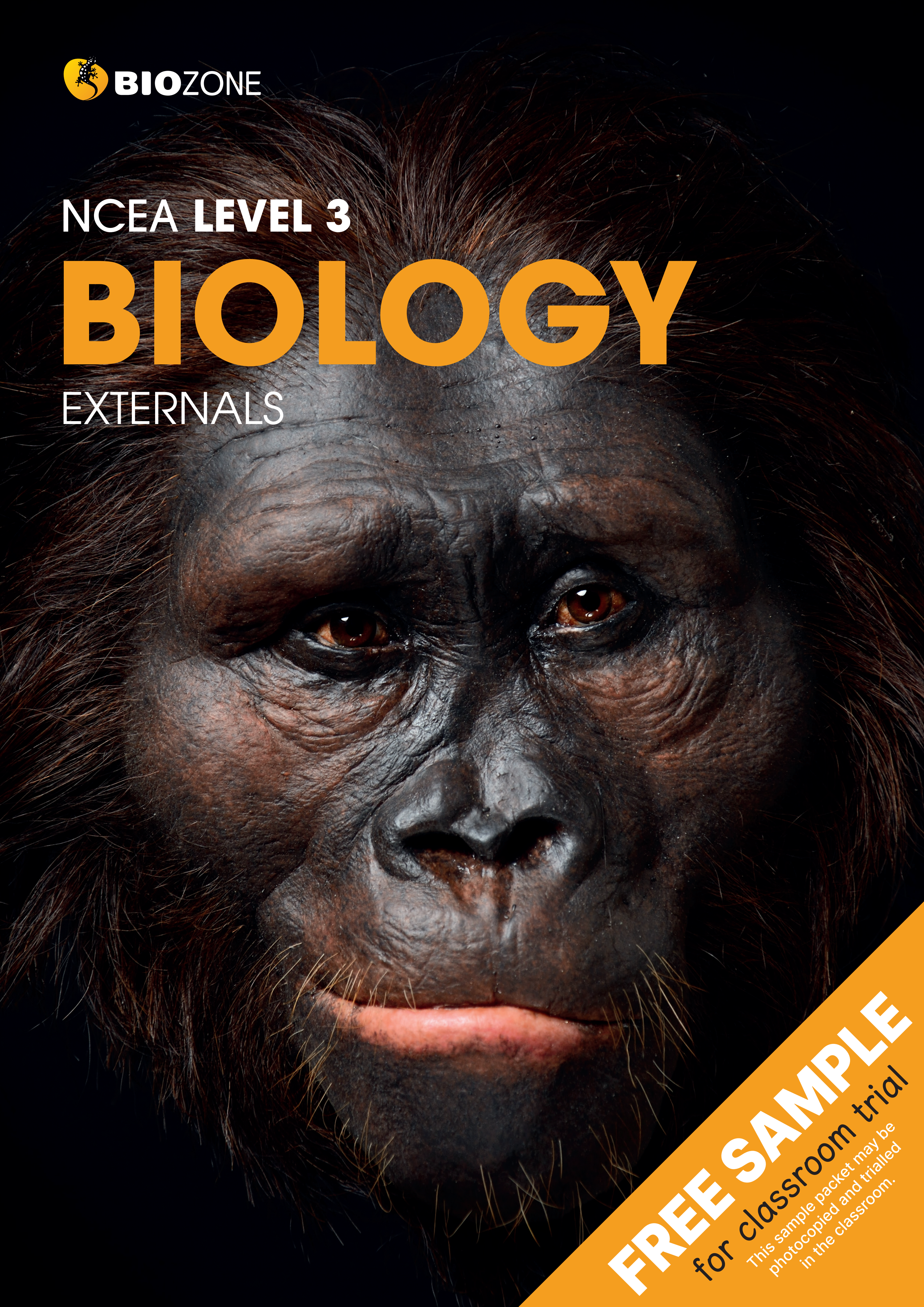
BIOZONE

NCEA LEVEL 3
BIOLOGY
EXTERNALS



Achievement Standard

3.3

Responses to the external environment

Key terms

Common terms

adaptive advantage
environmental cue
innate behaviour
learned behaviour

Orientation in space

dispersal
homing
kinesis (*pl.* kineses)
migration
nastic response
navigation
phytohormone
taxis (*pl.* taxes)
tropism

Orientation in time

actogram
annual rhythm
biological clock
biological rhythm
circadian (daily) rhythm
endogenous
entrainment
exogenous
free running period
lunar rhythm
period (of rhythm)
phase shift
photoperiodism
tidal rhythm
zeitgeber

Species interactions

aggression
agonistic behaviour
altruism
communication
competition
cooperative behaviour
exploitation
hierarchy
kin selection
mutualism
reproductive behaviour
social behaviour
territory

The short and long term responses of plants and animals to their external environment are adaptive, enabling organisms to maximise fitness in their ecological niche. Responses include orientation in space and time as well as responses to other organisms in their environment.

Achievement criteria and explanatory notes

Achievement criteria for achieved, merit, and excellence

☐ A Demonstrate understanding of the responses of plants and animals to their external environment: Describe plant and animal responses to their external environment, including the process(es) within each response and/or the adaptive advantage provided for the organism in relation to its ecological niche.

☐ M Demonstrate in-depth understanding of the responses of plants and animals to their external environment: Use biological ideas to explain how responses occur and why the responses provide an adaptive advantage for the organism in relation to its ecological niche.

☐ E Demonstrate comprehensive understanding of the responses of plants and animals to their external environment: Link biological ideas to explain why the responses provide an adaptive advantage for the organism in relation to its ecological niche. This may involve justifying, relating, evaluating, comparing, contrasting, and analysing the responses of plants and animals to their external environment.

Explanatory notes: Plant and animal responses

Responses are selected from those relating to…

		Activity number
☐	1 Orientation in space to include tropisms and nastic responses in plants, and taxes, kineses, homing, and migration in animals.	**1-20**
☐	2 Orientation in time to include annual, daily, lunar and tidal rhythms.	**25-34**
☐	3 Interspecific relationships to include competition for resources, mutualism, and exploitation (herbivory, predation, and parasitism).	**39-44**
☐	4 Intraspecific relationships to include competition for resources, territoriality, hierarchical behaviour, cooperative interactions, and reproductive behaviour.	**48-70**

The external environment includes both biotic and abiotic factors…

5 Biotic factors are those arising from living things or their activities, e.g. competition.

6 Abiotic factors are factors in the physical environment, e.g. light-dark cycles.

What you need to know for this Achievement Standard

Orientation in space

Activities 1 - 24

By the end of this section you should be able to:

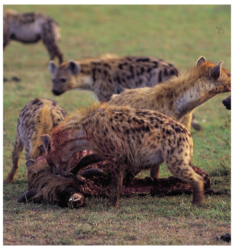
- ☐ Distinguish between taxes and kineses and identify them as innate responses.
- ☐ Describe examples of taxes, the environmental cue involved in each case, and the adaptive advantage of the behaviour in relation to the organism's niche.
- ☐ Describe examples of kineses, the environmental cue involved in each case, and the adaptive advantage of the behaviour in relation to the organism's niche.
- ☐ Describe migratory behaviour, including at least one example from New Zealand. Explain the adaptive advantage of migration, despite its costs. Distinguish migration from dispersal.
- ☐ Describe examples of homing behaviour and distinguish it from migration. Explain the adaptive advantage of the behaviour and its dependence on environmental cues.
- ☐ Using examples, explain how navigation is involved in migratory and homing behaviour.
- ☐ Explain how social insects communicate directional information to enable others to locate resources. Identify the mechanisms involved and the adaptive advantage of the behaviour.

Orientation in time

Activities 25 - 38

By the end of this section you should be able to:

- ☐ Describe and explain how plant and animal behaviours are linked to natural environmental rhythms that occur with a predictable frequency. Define the term biological rhythm.
- ☐ Describe and explain the characteristics of daily, tidal, lunar, and annual rhythms. Explain how an organism's biological rhythms provide an adaptive advantage in its ecological niche.
- ☐ Describe and explain the two mechanisms underlying biological rhythms: the endogenous biological clock and the external zeitgeber (environmental cue).
- ☐ Describe and explain diurnal, nocturnal, and crepuscular activity patterns in animals with circadian rhythms. Explain the adaptive value of these activity patterns in each case.
- ☐ Interpret actograms recording the circadian rhythms of animals. Demonstrate an understanding of the free running period, phase shift, and entrainment.
- ☐ Explain photoperiodism in plants, including the role of phytochrome in measuring daylength by resetting the biological clock (entrainment). Distinguish between long-day and short-day plants.

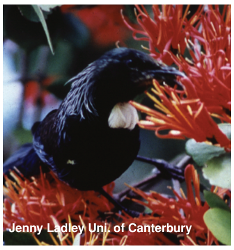


Interspecific relationships

Activities 39 - 47

By the end of this section you should be able to:

- ☐ Describe and explain species interactions, including mutualism, exploitation (herbivory, predation, parasitism), and competition for resources. Identify the adaptive advantages of the relationship to one or both of the parties involved.
- ☐ Explain the evolutionary consequences of interspecific competition (niche differentiation).



Intraspecific relationships

Activities 48 - 73

By the end of this section you should be able to:

- ☐ Distinguish different types of animal organisation, solitary, or groups with or without a social structure. Describe the adaptive advantage of group and social behaviours.
- ☐ Describe how animals communicate. Interpret ethograms and record animal behaviour using an appropriate system to identify the type of behaviour and its intensity.
- ☐ Describe examples of cooperative behaviour and explain its adaptive advantage.
- ☐ Describe intraspecific competition for resources, the behaviours associated with it (e.g. agonistic behaviour), and its consequences (hierarchies, territories, home ranges).
- ☐ Explain the role of territories and hierarchies in allocating resources and reducing aggression.
- ☐ Describe reproductive behaviours in animals and explain their adaptive advantage, including reference to courtship behaviours, mating systems, and parental care.

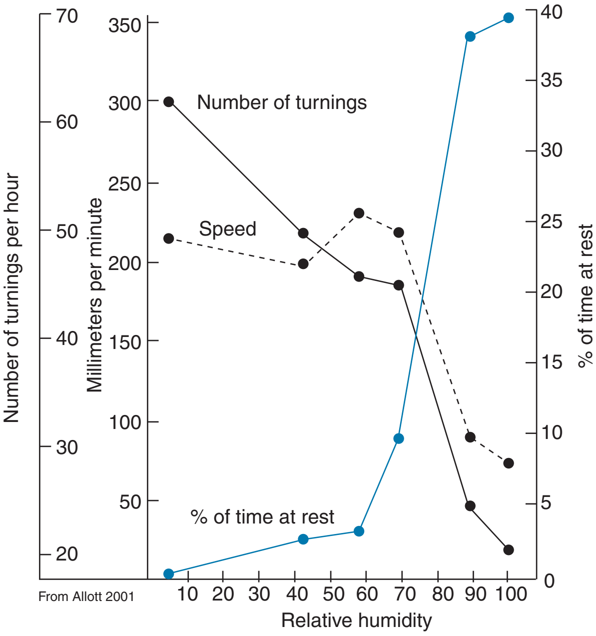
3 Kineses

Key Idea: Kineses are innate locomotory behaviours involving non-directional movements in response to external stimuli.

A **kinesis** (*pl.* kineses) is a non-directional response to a stimulus in which the speed of movement or the rate of turning is proportional to the stimulus intensity. Kineses do not involve orientation directly to the stimulus and are typical of many invertebrates and protozoa. Two main types of kineses can be identified. In an **orthokinesis**, the rate of **movement** is dependent on the stimulus intensity. In a **klinokinesis**, the rate of **turning** is related to the stimulus intensity.

Kinesis in woodlice

Woodlice are commonly found living in damp conditions under logs or bark. Many of the behavioural responses of woodlice are concerned with retaining moisture. Unlike most other terrestrial arthropods, they lack a waterproof cuticle, so water can diffuse through the exoskeleton, making them vulnerable to drying out. When exposed to low humidity, high temperatures, or high light levels, woodlice show a kinesis response to return them to their preferred, high humidity environment.



From Allott 2001

Investigating kinesis in woodlice

Experiment 1

To investigate the effect of a light-dark regime on the orthokinetic behaviour of woodlice.

Method

A petri dish was laid out with 1 cm x 1 cm squares. The investigation was carried out at room temperature (about 21°C). A woodlouse was placed in the petri dish under constant light. The number of squares the woodlouse passed over in five minutes was recorded. This was repeated four times. The woodlouse was then placed in constant dark and the number of squares it passed over in five minutes recorded. Again, this was repeated four times. The results are shown below.

Results

	Number of squares crossed	
Trial	Light	Dark
1	122	15
2	206	68
3	103	57
4	70	59
Mean		

Experiment 2

To investigate the effect of a light-dark regime on the kilinokinetic behaviour of woodlice.

Method

The woodlouse was again placed in the petri dish under constant light. The experiment was carried out at room temperature as in experiment 1. The number of turns the woodlouse performed in five minutes was recorded. This was repeated four times. The woodlouse was then placed in constant dark. Again the number of turns performed in five minutes was recorded. This was also carried out four times. The results are shown below.

Results

	Number of turns	
Trial	Light	Dark
1	80	10
2	165	20
3	110	122
4	90	55
Mean		

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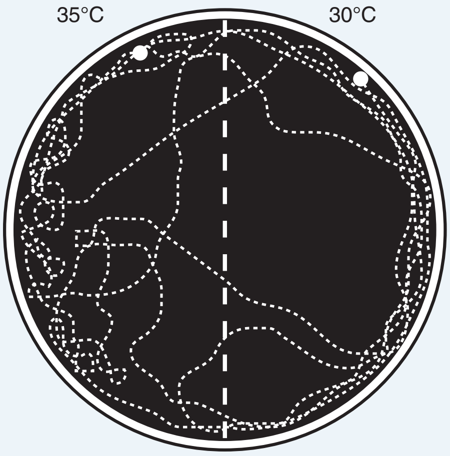
Kinesis in body lice



In a circular chamber, lice make relatively few turns at their preferred temperature of 30°C, but many random turns at 35°C. This response enables the lice to increase their chances of finding favourable conditions and remaining in them once found.

1. Use the graph on woodlice at the top of the previous page to answer the following questions:
   (a) At which relative humidities do the following occur:
      i. Largest number of turnings per hour: ____
      ii. Highest speed of movement: ____
      iii. Largest percentage of time at rest: ____
   (b) Explain the significance of these movements: ____
   (c) What is the preferred range of relative humidity for the woodlice? ____
2. (a) Complete the results tables on the previous page by calculating the mean for each of the experiments.
   (b) Which regime (light or dark) does the woodlice appear to prefer? ____
   (c) Explain your reasoning: ____
   (d) Explain how increasing the number of turns or the speed of movement increases a woodlice's likelihood of survival when in a unfavourable environment.
3. (a) Identify the preferred temperature of a body louse: ____
   (b) The response of the body louse is a klinokinesis / orthokinesis (delete one)
   (c) Contrast the movements of the body louse when within and when outside its preferred temperature environment:

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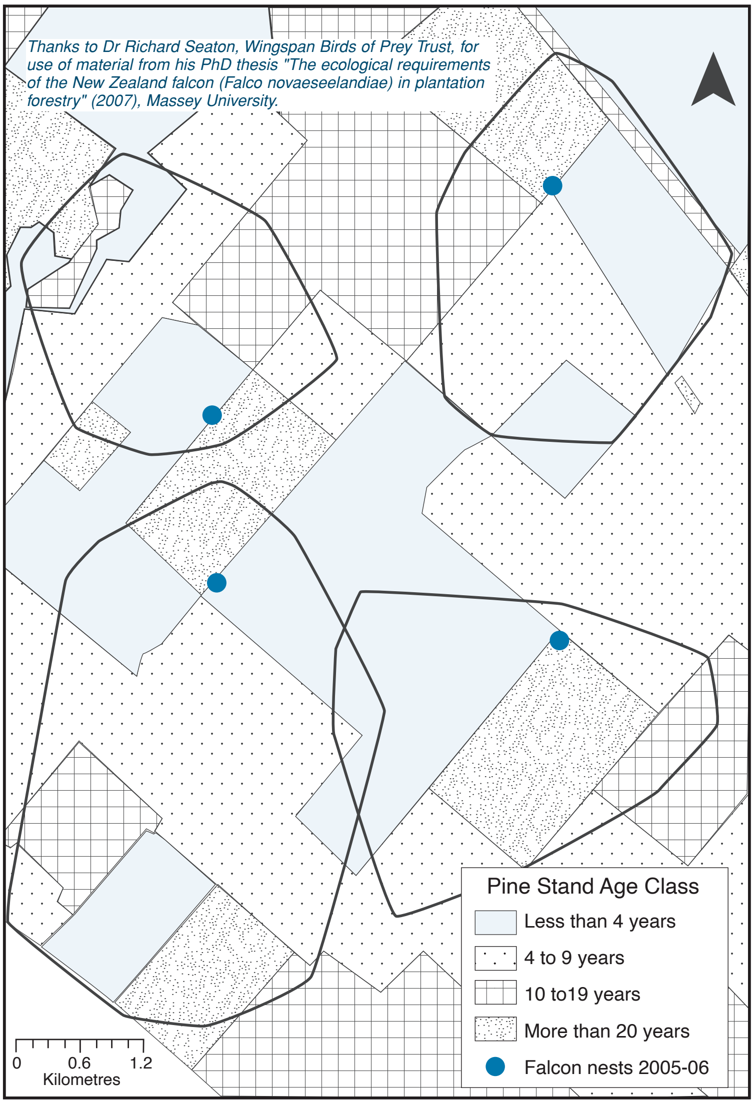
65 Home Ranges in Karearea

Key Idea: The size of a home range depends on the resource density. Home ranges are larger when resources are scarce.



Thanks to Dr Richard Seaton, Wingspan Birds of Prey Trust, for use of material from his PhD thesis "The ecological requirements of the New Zealand falcon (Falco novaeseelandiae) in plantation forestry" (2007), Massey University.

Home ranges of four adult male NZ falcons in the Kaingaroa Forest during the 2005 breeding season (August-March). Forest composition (age of pine stands) is shown in the key. During the breeding season, the entire home range is defended, making it like a large territory.

Defended areas reduce competition

Scott McDougall

The New Zealand falcon or **karearea** is New Zealand's only endemic bird of prey. It catches its prey (mainly small birds) on the wing and rarely eats carrion (dead animals). It is aggressive and territorial, but is vulnerable to introduced predators because it nests on the ground in a simple scrape in the soil.

Research (Seaton, 2007) showed that the reproductive success of NZ falcons is much higher in commercial pine forests with a mix of different aged stands than in native forest. Moreover, territories in pine forests are much smaller than in native forest. This might seem surprising, but the pine forest habitat supports a large number of small bird species as prey.

Summary facts

- The home range size of falcons in the Kaingaroa pine forest (9 km^2) is much smaller than the 75 km^2 recorded for native forest.
- Prey availability is enhanced in pine plantations by high densities of prey congregating along pine stand edges.
- Falcons made the most successful hunting attempts along pine stand edges between stands less than 4 years old and more than 20 years old.
- Prey availability is also high in open stands where prey is more vulnerable to attack.
- Stands less than four years old made up the largest proportion of the falcon home ranges. Old stands provide necessary cover from which to launch attacks over the more open younger stands.

1. Explain how the defence of home ranges by the karearea could reduce competition for resources: ____________________

____

____

2. What evidence is there to suggest that pine forest habitat might be more suitable for karearea than native forest:

____

3. Look at the map of home ranges above.

(a) What habitat feature do all the home ranges have in common that is important to karearea? ____________________

____

(b) Where do the karearea prefer to nest? Can you suggest why? ____________________

____

____

____

4. On a separate page, discuss how you might manage a forest to enhance the conservation of karearea?

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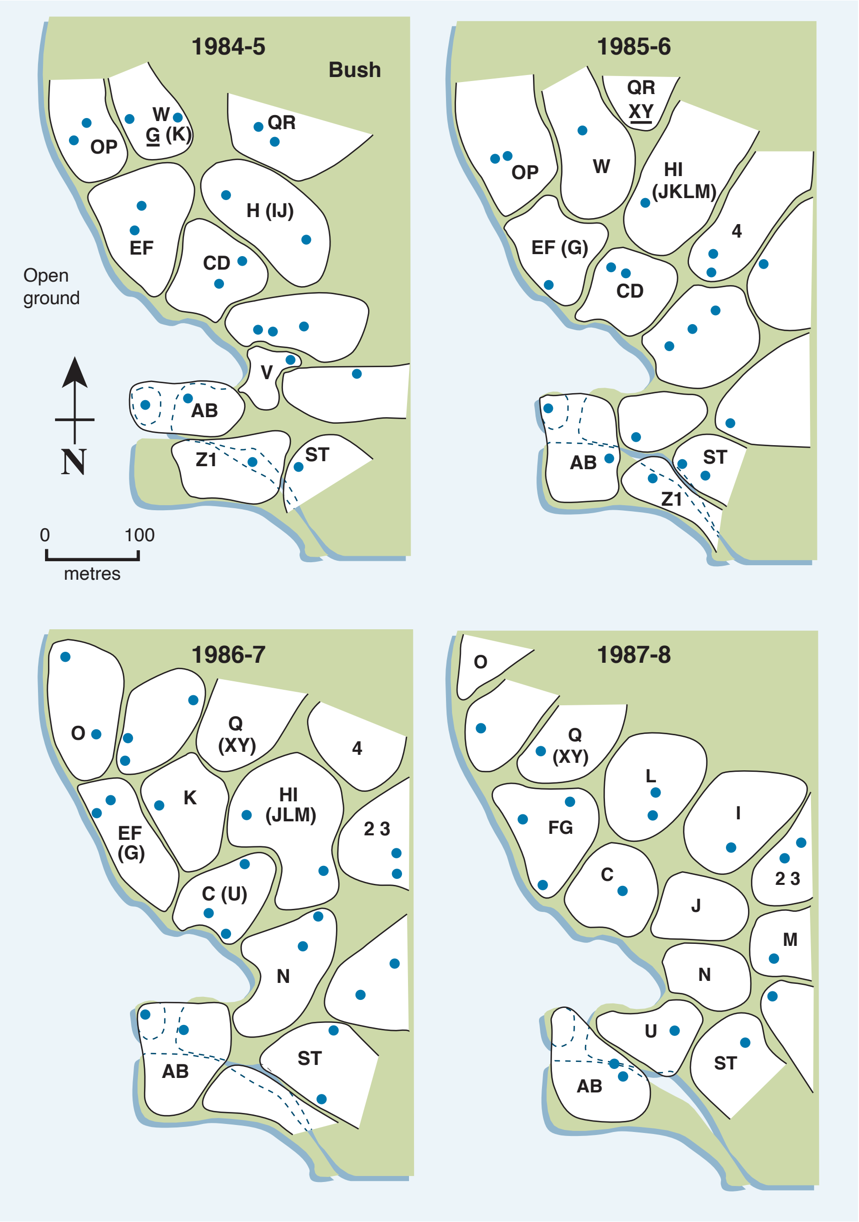
66 Yellowhead Territories

Key Idea: Territories can be occupied by cooperating individuals, which help to support a breeding pair.

Yellowhead
Mohoua ochrocephala

Yellowheads are endemic to New Zealand and are highly territorial in their behaviour. They are **cooperative breeders**, forming breeding groups that occupy a single territory each. Each group contains a **primary pair** that breed, and **secondary birds** that act as nesting helpers. Secondaries do not take part in breeding but provide additional food for the clutch. The diagrams on the right show the changes in locations of yellowhead territories and their occupants in a Fiordland beech forest (at Knobs Flat) over a four year period. The yellowheads occupied all available space and had fairly exclusive territories in which they almost always remained and did almost all their feeding. The letters and numbers are the codes for banded birds.

Source: Graeme Elliott, Ecological Consultant



Key

▢ Territory boundaries

● Nest site

- - - - - Obscured bush margin

Codes for banded birds using **X** as an example

X Member of primary pair

(X) Secondary non-breeding bird

<u>**X**</u> Fledgling (juvenile)

1. Give the approximate dimensions of an 'average' territory (see scale on diagram): ____________________

2. Compare the home range of the yellowhead with its territory: ____________________

3. Secondary birds do not breed. What is the adaptive advantage to them of remaining in the territory of the primary bird?

4. What is the likely cause of bird **N** reducing its territory by about a half in 1987-1988? ____________________

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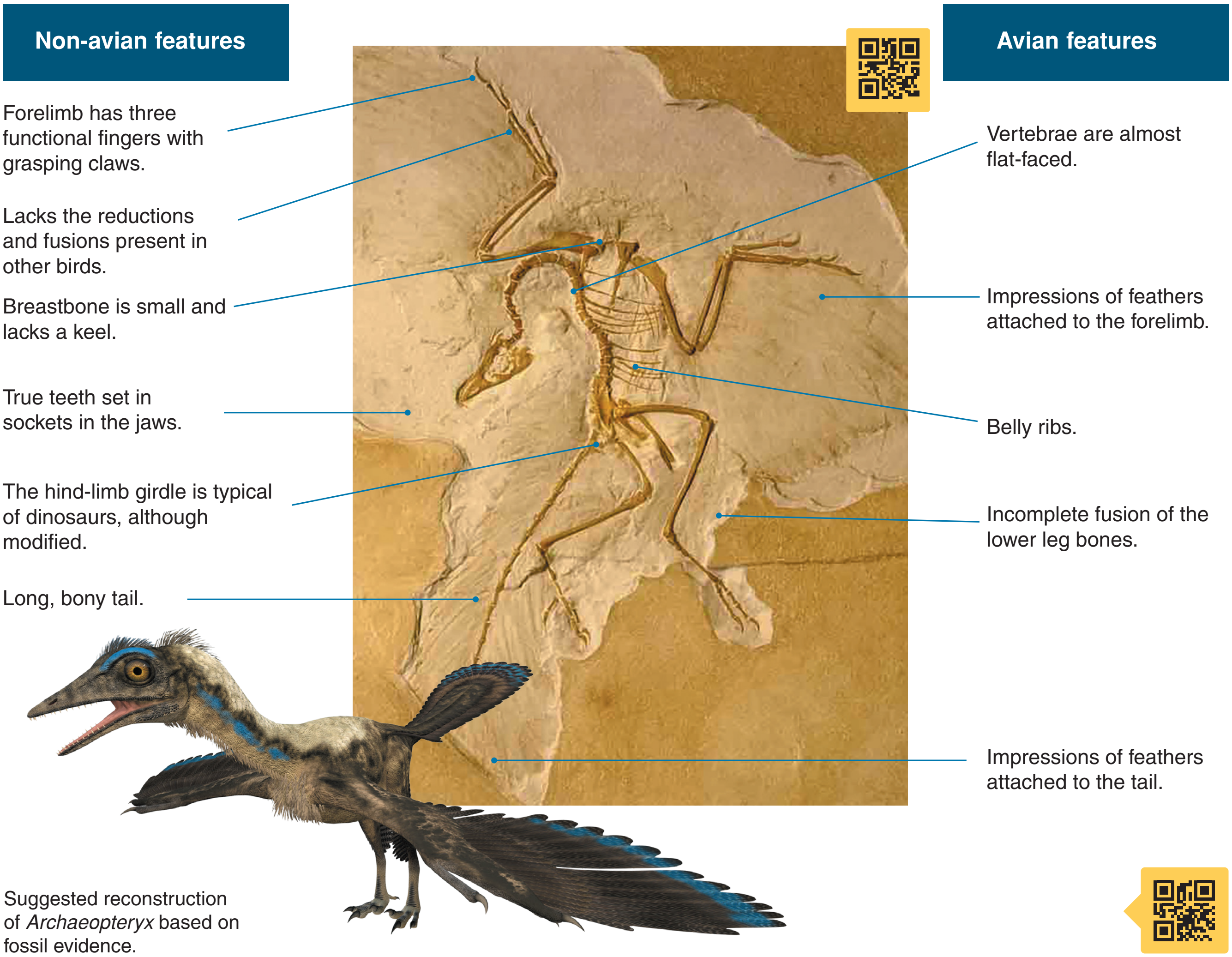
127 Transitional Fossils

Key Idea: Transitional fossils show intermediate states between two different, but related, groups. They provide important links in the fossil record

Transitional fossils are fossils with a mixture of features found in two different, but related, groups. Transitional fossils provide important links in the fossil record and provide evidence to support how one group may have given rise to the other by evolutionary processes. Important examples of transitional fossils include horses, whales, and *Archaeopteryx* and other non-avian feathered dinosaurs (below). *Archaeopteryx* was a transitional form between non-avian dinosaurs and birds. *Archaeopteryx* was crow-sized (50 cm length) and lived about 150 million years ago. It is regarded as the first primitive bird and had a number of birdlike (avian) features, including feathers. However, it also had many non-avian features, which it shared with theropod dinosaurs of the time.



Suggested reconstruction of *Archaeopteryx* based on fossil evidence.

1. (a) What is a transitional fossil? ______________________________

(b) Why are transitional fossils important in understanding evolution? ____________________

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129 The Evolution of Whales

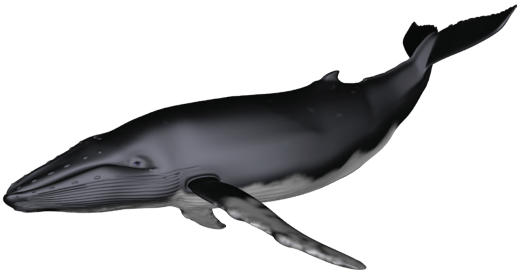
Key Idea: The evolution of whales is well documented in the fossil record, with many transitional forms recording the shift from a terrestrial to an aquatic life.

The evolution of modern whales from an ancestral land mammal is well documented in the fossil record. The fossil record of whales includes many transitional forms, which has enabled scientists to develop an excellent model of whale evolution. The evolution of the whales (below) shows a gradual accumulation of adaptive features that have equipped them for life in the open ocean.

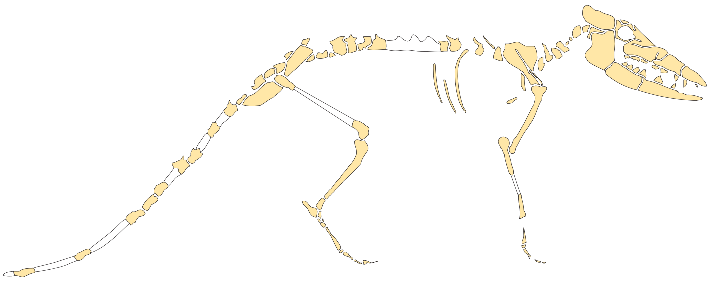
Modern whales are categorised into two broad suborders based on the presence or absence of teeth.

- **Toothed whales**: These have full sets of teeth throughout their lives. Examples: sperm whale and orca.
- **Baleen whales**: Toothless whales, which have a comb-like structure (baleen) in the jaw. Baleen is composed of the protein keratin and is used to filter food from the water. Examples: blue whale, humpback whale.

Robert Pittman - NOAA

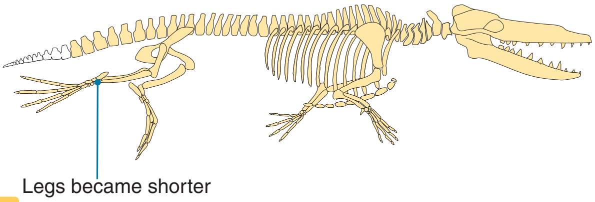


Humpback whale



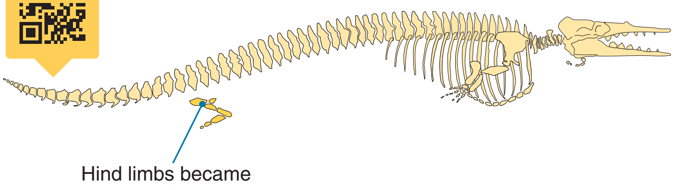
50 mya *Pakicetus*

Pakicetus was a transitional species between carnivorous land mammals and the earliest true whales. It was mainly land dwelling, but foraged for food in water. It had four, long limbs. Its eyes were near the top of the head and its nostrils were at the end of the snout. It had external ears, but they showed features of both terrestrial mammals and fully aquatic mammals.



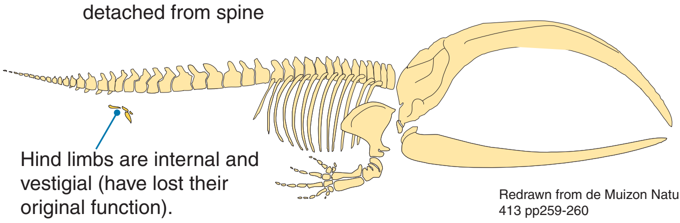
45 mya *Rhodocetus*

Rhodocetus was mainly aquatic (water living). It had adaptations for swimming, including shorter legs and a shorter tail. Its eyes had moved to the side of the skull, and the nostrils were located further up the skull. The ear showed specialisations for hearing in water.



40 mya *Dorudon*

Dorudon was fully aquatic basilosaur. Its adaptations for swimming included a long, streamlined body, a broad powerful muscular tail, the development of flippers and webbing. It had very small hind limbs (not attached to the spine) which would no longer bear weight on land.



Redrawn from de Muizon Nature 2001 413 pp259-260

Balaena (recent whale ancestor)

The hind limbs became fully internal and vestigial. Studies of modern whales show that limb development begins, but is arrested at the limb bud stage. The nostrils became modified as blowholes. This recent ancestor to modern whales diverged into two groups (toothed and baleen) about 36 million years ago. Baleen whales have teeth in their early fetal stage, but lose them before birth.

1. Why does the whale fossil record provide a good example of the evolutionary process? ______________________

____

____

2. Briefly describe the adaptations of whales for swimming that evolved over time: ______________________

____

____

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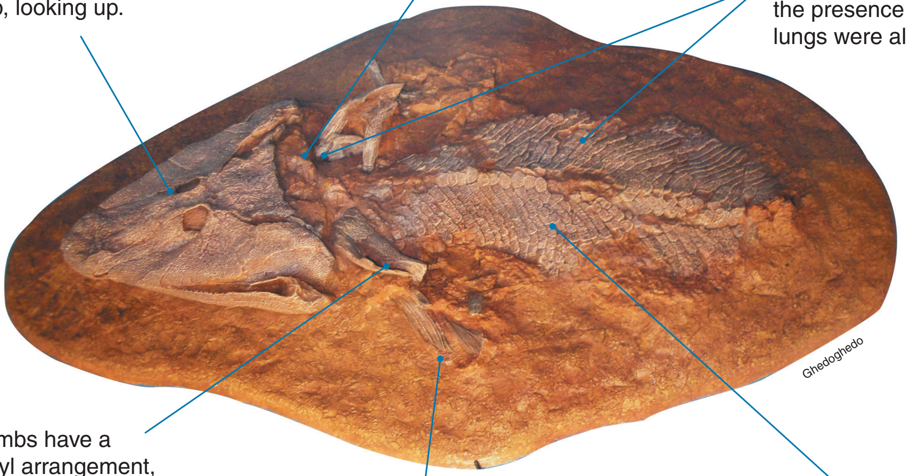
141 NCEA Style Question: Evidence for Evolution

In 2004, a fossil of an unknown vertebrate was discovered in northern Canada and subsequently called *Tiktaalik roseae*. The *Tiktaalik* fossil was quite well preserved and many interesting features could be identified. These are shown on the photograph of the fossil below.



Tiktaalik's head is flattened horizontally like that of a crocodile with the eyes on top, looking up.

The shoulder bones are not attached to the skull, allowing its neck to turn independently of the body.

Rod-like bones that help pump water over gills are present, but the presence of ribs indicates that lungs were also present.

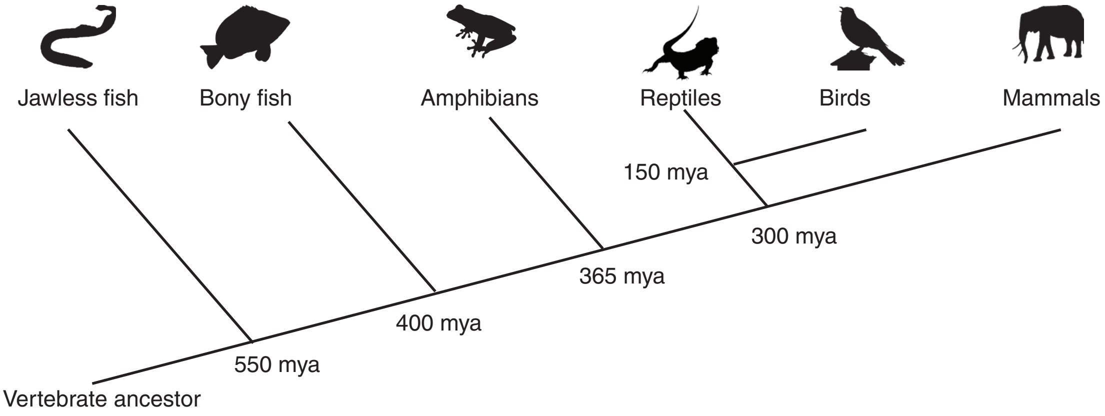
The bones of the limbs have a primitive pentadactyl arrangement, similar to tetrapods, which allowed it to support its body weight.

Fish-like fins are clearly visible.

The fossil of *Tiktaalik* was covered with scales much like those of fish.

Ghedoghedo

1. Use the information above to place *Tiktaalik* on the time line of vertebrate evolution. Discuss the evidence for your decision.



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142 KEY TERMS AND IDEAS: Evidence for Evolution

1. Test your vocabulary by matching each term to its definition, as identified by its preceding letter code.

- fossil
- fossil record
- homologous structure
- phylogenetic tree
- relative dating
- transitional fossil
- vestigial structure

A The science determining the relative order of past events, without necessarily determining their absolute age.

B The fossilised remains of organisms that illustrate an evolutionary transition. They possess both primitive and derived characteristics.

C A structure that has lost its ancestral function but has been retained through evolution in a much reduced form.

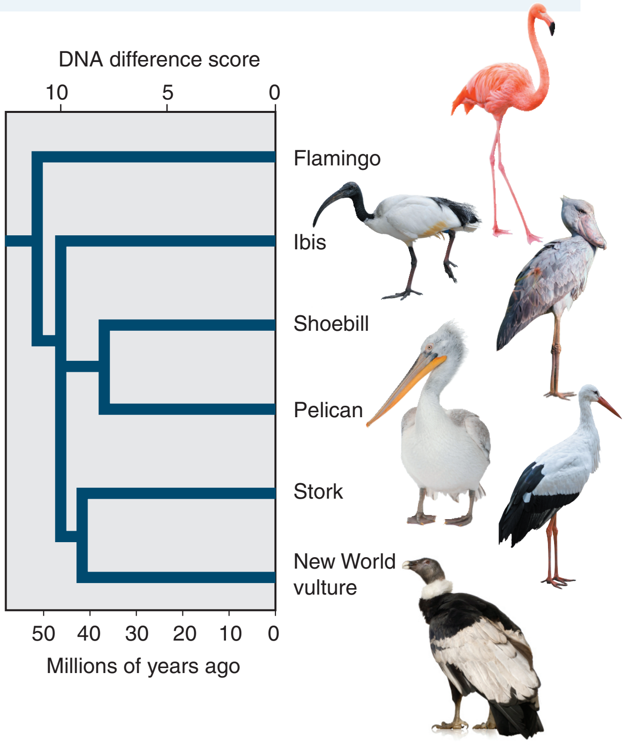
D The preserved remains or traces of a past organism.

E The sum total of current paleontological knowledge. It is all the fossils that have existed throughout life's history, whether they have been found or not.

F Structures in different but related species that are derived from the same ancestral structure but now serve different purposes, e.g. wings in birds and fins in whales.

G The evolutionary history or genealogy of a group of organisms represented as a 'tree' showing descent of new species from the ancestral one.

2. The diagram right shows the evolutionary relationship of a group of birds based on DNA similarities:



(a) Place an X next to the last common ancestor of all the birds:

(b) How many years ago did storks diverge from vultures?

(c) What are the most closely related birds?

(d) What is the difference in DNA (score) between:

i: Storks and vultures:

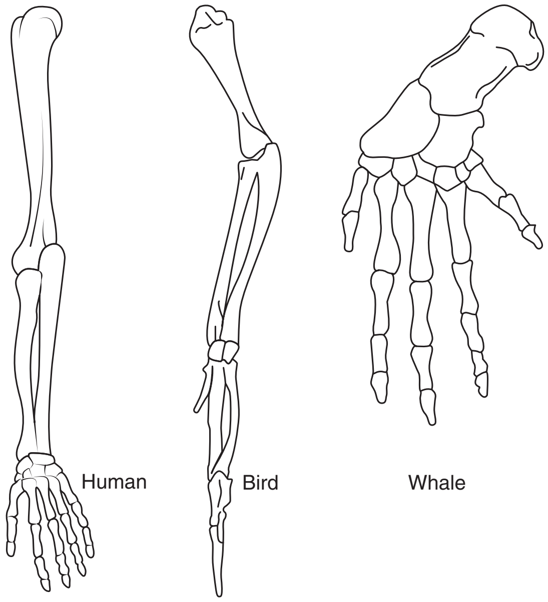
ii: Ibises and shoebills:

(e) Which of the birds is the least related to vultures?

(f) How long ago did ibises and vultures share a common ancestor?

3. (a) The diagrams right show the forelimbs of a whale, bird, and human. Shade the diagram to indicate which bones are homologous. Use the same colour to indicate the equivalent bones in each limb.

(b) What does the homology of these bones indicate?



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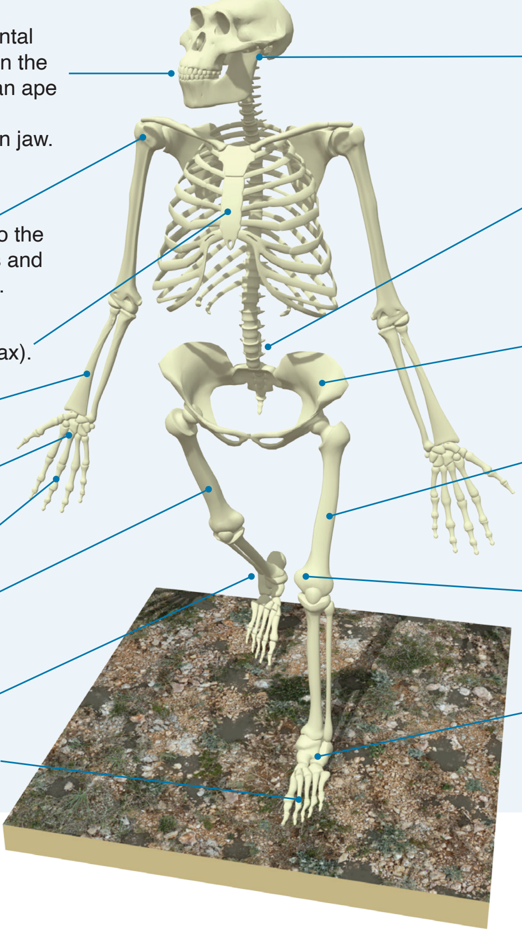
156 Analysis of Lucy's Skeleton

Key Idea: The skeleton of *Australopithecus afarensis* shows both advanced and primitive features.

The reconstruction of Lucy (*Australopithecus afarensis*), below, shows the skeletal features of an early bipedal hominin. Lucy still possessed ape-like features but she was a fully-bipedal hominin with all the adaptations associated with bipedal locomotion. Although there is no doubt that Lucy was habitually bipedal, a number of skeletal features suggest that tree climbing was still an important part of this hominin's niche, perhaps associated with escape, security, or foraging. *A. afarensis* is an important because she shows transitional stages between earlier apes and modern humans.



Lucy's* ape-like characteristics

Shape of the tooth row (dental arcade) is half way between the straight-sided U-shape of an ape jaw and the more rounded, parabolic shape of a human jaw.

Shoulder joint orientated towards the head, similar to the orientation in chimpanzees and other arboreal quadrupeds.

Funnel-shaped chest (thorax).

Arms relatively long compared to legs.

Highly mobile wrist.

Curved finger bones.

Relatively short legs.

Highly mobile ankle joint.

Toes are long and curved.

Lucy's bipedal features

The foramen magnum was much further forward than in apes and much closer to the position in humans.

Lucy's lumbar vertebrae were broad for effective weight transmission from the upper body to the pelvis. The australopithecine spine had an S shaped curvature, similar to that of modern humans.

Lucy's pelvis was broad and basin shaped, similar to a human pelvis. It would have supported the upper body when upright.

Lucy's limbs showed human-like features consistent with bipedalism.
The femoral (valgus) angle was similar to humans, bringing the knees under the body.

Butressing of the knee was more similar to humans than to apes.

Arched feet, wide heels, and big toes aligned with the other toes and not opposable.

*Lucy is the name given to a specimen of ***Australopithecus afarensis***

1. When she was discovered, Lucy was labelled "the missing link" by media, highlighting the fact her skeleton showed both ape-like and human-like features. Describe the features that show Lucy was habitually bipedal and contrast these with features that show her ape ancestry:

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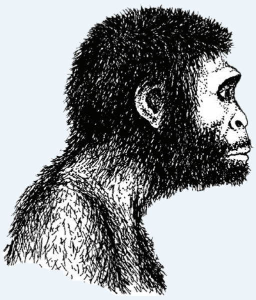
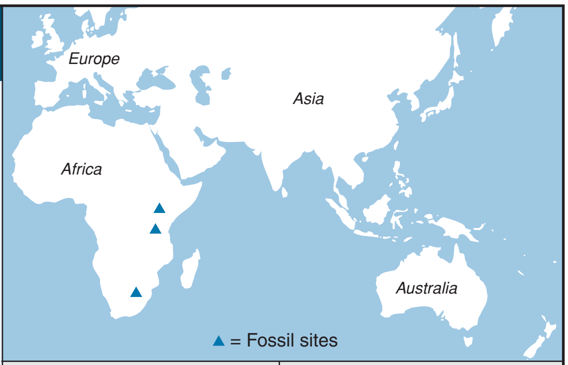
Homo ergaster

Larger brained than previous *Homo* species, with volumes of 850 to 1000 cm^3. Previously considered to be part of *Homo erectus*, but now thought to be a separate species. *Homo ergaster* refers to what used to be called early African forms of *Homo erectus*, existing 1.8 to 1.4 mya. Earliest hominin with human-like body proportions. A nearly complete skeleton of a 9 year old boy was 1.6 m tall (estimated 1.8 m and 60 kg adult size).



Artist's reconstruction



Years: mya

Brain size: cm^3

Height: m

Weight: kg

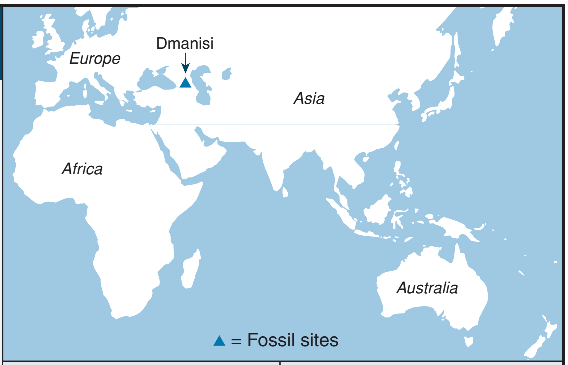
Geographic distribution:

Additional notes:

KMN-ER 3733 skull from Koobi Fora region to the east of Lake Turkana, Kenya

Homo georgicus

Fossils found in Dmanisi, Georgia in 2002 were originally classified as *H. ergaster*, but size differences have since lead to the new classification *Homo georgicus*. The fossils, which include four skulls and several jaw bones have been dated at 1.8 mya. The small size (1.5 m tall and ~50 kg) and cranial capacity (600-780 cm^3) of the fossils place *H. georgicus* as a descendent of *H. habilis* and predecessor of *H. erectus*. Tooth-wear patterns indicate an omnivorous diet. They may have been the earliest hominin to venture out of Africa, some 800,000 years before *H. erectus*. This finding challenges the theories that hominins required a large brain and advanced tool making skills to be able to migrate out of Africa.



Years: mya

Brain size: cm^3

Height: m

Weight: kg

Geographic distribution:

Additional notes:

H. georgicus exhibited strong sexual dimorphism; the males were considerably larger than the females. This is quite a primitive trait, and not observed to the same degree in later more modern hominins such as Homo neanderthalensis.

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D2700 (skull), and **D2735** (lower jaw) of *Homo georgicus* from Dmanisi, Georgia

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