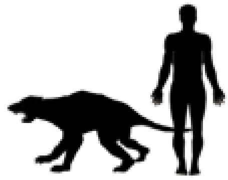
# Animals and Fossils

## Extinct Animals: Thylacoleo carnifex

### Thylacoleo carnifex



**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Thylacoleonidae
**Genus & Species:** *Thylacoleo carnifex*


*Thylacoleo carnifex* is commonly referred to as a 'Marsupial Lion', largely because of the cat-like nature of its skull and its carnivorous habit.

Described in 1858 by Sir Richard Owen as "the fellest of all predatory beasts", this animal weighed around 120 kg and was the largest mammalian predator on the Australian continent. It hunted in forest areas. *Thylacoleo* was capable of grasping or slashing its prey with the long sharp claws on its semi-opposable thumb, then stabbing or strangling with its large incisor teeth. Finally the hapless prey would be cut into bite-size pieces with the blade-like cheek teeth.

The evolutionary history of the Marsupial Lions can be traced back to the ancient rainforests of Riversleigh in Queensland, some 25 million years ago.

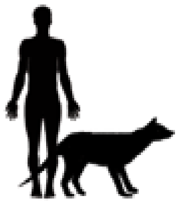
These animals were relatively common across most of Australia during the Pleistocene period. They became extinct about 50,000 years ago.


Skull and jaw bones of Thylacoleo showing its stabbing incisors and slicing blade.


Bones of hand showing 4 fingers and thumb which could grasp and hold prey

## Extinct Animals: Thylacinus cynocephalus

### Thylacinus cynocephalus



**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Dasyuromorphia
**Family:** Thylacinidae
**Genus & Species:** *Thylacinus cynocephalus*


*Thylacinus cynocephalus* is more commonly known as the Thylacine or Tasmanian Tiger, although a better name may be the 'marsupial wolf' because of the wolf-like nature of its skull, teeth and body.

Its principal habitat was open forest and woodlands where its major source of food, kangaroos and wallabies, could be found.

The fossil record shows the Thylacine was once common over much of Australia. However like the Devil, its disappearance on the mainland coincided with the time Dingoes were introduced to Australia around 3,500 years ago. It survived in Tasmania relatively recently.

The *Thylacine* was hunted to extinction following European settlement as farmers were convinced that *Thylacines* were killing their sheep. A bounty was granted by the government and the animals were exterminated, with the last one dying in the Hobart Zoo in 1936.

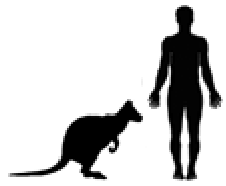
Sadly, people had finally realised their mistake by 1936 and had moved to protect the species, however by that stage it was too late and this magnificent marsupial carnivore was gone.

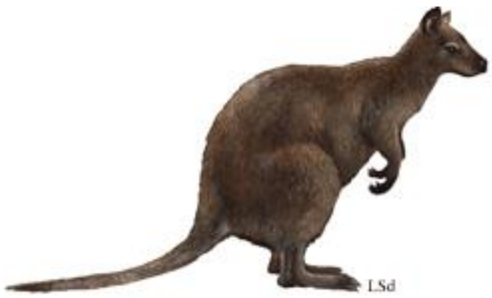

Fossil jaw bone of Thylacine, found in Victoria Fossil Cave, is over 200,000 years old


Skeleton of Thylacine

## Red-necked Wallaby

**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Macropodidae
**Genus & Species:** *Macropus rufogriseus*






The Red-necked Wallaby *Macropus rufogriseus* is a common, large wallaby that is found primarily along the eastern and south eastern regions of mainland Australia and northern Tasmania. These wallabies occupy open eucalypt forests with a moderate shrub understorey or coastal heath areas.

They graze in openings in the forest but require shrubby areas for shelter during the day.

Macropus rufogriseus are generally solitary, although they may come together in groups of 30 or more when grazing.

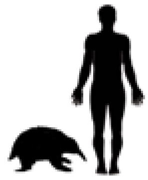
If disturbed they behave as individuals or pairs, scattering in all directions. It is this flighty nature that probably contributes to their high representation in pitfall cave deposits.


Fossil skull of the Red-necked Wallaby

## Extinct Animals : Megalibgwilia ramsayi

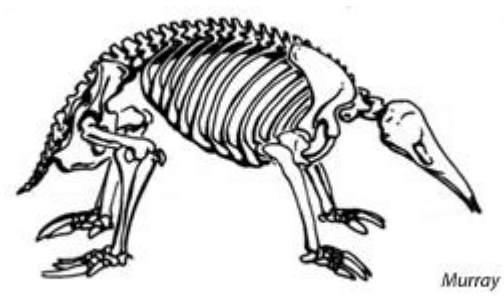
### *Megalibgwilia ramsayi*

**Class:** Mammalia
**Order:** Monotremata
**Family:** Tachyglossidae
**Genus & Species:** *Megalibgwilia ramsayi*




*Megalibgwilia ramsayi* was similar in appearance to the living Long-beaked Echidna of Papua New Guinea, *Zaglossus bruijnii*, although much larger.

Megalibgwilia lived during the Pleistocene, becoming extinct about 50,000 years ago.




Artist's drawing of the skeleton of Megalibgwilia ramsayi

Unlike the modern echidna, which lives mostly on ants and termites, *Megalibgwilia* were able to consume larger food items such as grubs, beetles and worms.

Its robust forelimbs and their long sturdy snouts assisted in the search for food. Both of these features are indicative of great strength for digging and probing amongst rocks and logs.


Skull of Megalibgwilia ramsayi with long sturdy snout, used for digging for grubs, beetles and worms


View of skull from below, showing the groove in the palate along with the tongue extended

## Extinct Animals : Zygomaturus trilobus

### *Zygomaturus trilobus*

**Class:** Mammalia
**Supercohort:**Marsupialia
**Order:** Diprotodontia
**Family:** Diprotodontidae
**Genus & Species:** *Zygomaturus trilobus*

*Zygomaturus trilobus* had a size and build similar to a pygmy hippopotamus, weighing around 300 to 500 kg.

Model of Zygomaturus trilobus

The scientific name refers to the broad zygomatic arches (cheek bones) and the three prominent lobes of the premolar teeth.

Cast of fossil skull of Zygomaturus trilobus

Some of the features of its skeleton suggest it may have preferred swampy habitats.

It possibly lived in small herds around the wetter, coastal margins of Australia and occasionally may have extended its range along the watercourses into central Australia.

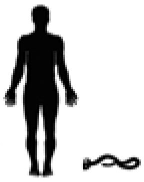
As a ground dweller, it moved on all four limbs.

Fossil jaws of Zygomaturus trilobus, showing fork-like lower incisors and strong grinding molars

## Living Animals : Red-bellied Black Snake

### *Red-bellied Black Snake*

**Class:** Reptilia
**Subclass:** Lepidosauria
**Order:** Squamata
**Family:** Elapidae
**Genus & Species:** *Pseudechis porphyriacus*



This snake is known as the Red-bellied Black Snake because of the distinctive bright red scales along the side of its belly.

The remainder of the back scales are an iridescent black except for the head which may be a lighter brown.

The Red-bellied Black Snake grows to around 1.2 metres long.
The principal habitat of this diurnal snake is around streams, swamps and lagoons where it can easily access its preferred food source, frogs.


Fossil ribs and vertebrae of the snake

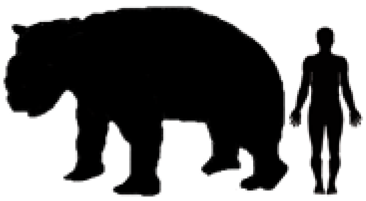

Snake skull and jaws

The Red-bellied Black Snake gives birth to live young, numbering up to 40 at a time. The young are usually born in membranous sacs from which they emerge within minutes of the birth. Although the bite of the red-bellied snake is venomous, it rarely results in the death of a human. It is commonly found in the eastern and south-eastern areas of Australia.

## Extinct Animals : Diprotodon optatum

### *Diprotodon optatum*

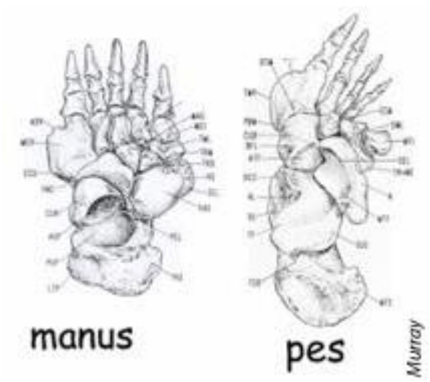
**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Diprotodontidae
**Genus & Species:** *Diprotodon optatum*




Diprotodon optatum  was the largest marsupial to ever live. It was once widespread and relatively common over much of Australia.

Its name 'Diprotodon' literally means "two forward teeth", referring to the paired tusk-like incisors which it may have used to root out small shrubs and bite through tough vegetation.
The molar teeth were as large as a human fist, and were designed for slicing and crushing coarse vegetation.

A large Diprotodon weighed 1.5 - 2.5 tonnes, and in spite of its bulk could move almost as fast as a camel on its relatively long legs and wombat-like feet.

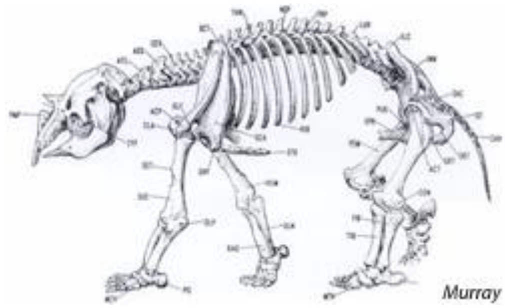



Bones of Diprotodon's front (manus) and back (pes) feet

Fossilised track-ways of this enormous beast have been found in the dry beds of Lake Callabonna in northern South Australia, where hundreds of entire skeletons of Diprotodon have been found.

Diprotodon is comparatively rare in the fossil deposits at Naracoorte. This may be related to the size of the cave entrances, which were mostly too small for this giant to fall into.


Skeleton of Diprotodon optatum




Artist's diagram of skeleton of Diprotodon optatum

## Extinct Animals : Procoptodon goliah

### *Procoptodon goliah*

**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Macropodidae
**Subfamily:** Sthenurinae
**Genus & Species:** *Procoptodon goliah*

Procoptodon goliah was the largest of the Pleistocene sthenurine kangaroos.

It weighed as much as 200 kg, which is around two and a half times heavier than the biggest living Red Kangaroo *Macropus rufus* is today.

Procoptodon flourished over much of Australia until its extinction around 50,000 years ago.

It represents the most extreme adaptation of the leaf-eating sthenurine kangaroos.

Balancing on its single, hoof-like hind toes and propped up by its tail, Procoptodon could have reached leaves more than 3 metres above the ground.

Only the extinct sthenurine kangaroos were capable of reaching above their head in this manner.
The short face and deep skull reflect the powerful mechanical advantage they provide to the chewing muscles. Procoptodon was undoubtedly capable of eating very tough leaves and stems.


Procoptodon's short face and deep skull supported strong chewing muscles


Small Koala-like front incisors were used to pluck leaves from stems

It is thought that Procoptodon would have favoured a forest habitat.

Because of its bulk it probably moved fairly slowly, although the mechanics of its hind limbs indicate that it was capable of rather large hops. Animals that hop upright are generally found in areas with a denser understory, as they are able to see over the top of it.


Ornate-crowned molar teeth are typical of browsers


Model of Procoptodon goliah

## Extinct Animals : Megalania

### *Varanus priscus*

**Class:** Reptilia
**Subclass:** Lepidosauria
**Order:** Squamata
**Family:** Varanidae
**Genus & species:** *Varanus priscus*

Megalania belonged to the family that includes the goannas, or monitor lizards, the largest of which today is the Komodo Dragon found in Indonesia.

Fossils of *Megalania* are comparatively rare. No complete skeleton has ever been found.

However several partial skeletons and other elements have allowed scientists to determine the size and structure of the animal.

Skeleton of Megalania

The large skull was equipped with numerous recurved, scimitar-like teeth.

The skeleton suggests *Megalania* was a very sturdily built animal, much more bulky than the Komodo Dragon and probably at least one third longer (4 to 5 metres).

Like its modern counterparts *Megalania* probably scavenged from dead animals, but would have also been able to hunt and kill quite large prey.

Komodo Dragons hunt by ambush and have been known to kill deer, buffalo and even people.

Whether *Megalania* killed *Diprotodon* , the largest of the megafauna is a matter of speculation; however, it was probably capable of doing so.

It would also have competed for prey with other large carnivores such as the Marsupial Lion, *Thylacoleo carnifex*.

The fossil record indicates that the geographic range of *Megalania* was quite broad including sites in Queensland, central Australia and New South Wales.

Until recently this animal was not thought to have inhabited the southern part of the continent. However a fossil found at Naracoorte in 2000 extends its range much further.

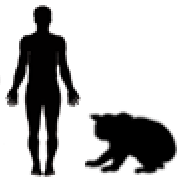

Size comparison of humerus (arm) bones of Megalania (on left) and the Goanna Varanus rosenbergi (on right)


Vertebra of Megalania prisca,compared to one of a lizard

# Extinct Animals : Phascolarctos stirtoni

## *Phascolarctos stirtoni*

**Class:** Mammalia
**Supercohort:**Marsupialia
**Order:** Diprotodontia
**Family:** Phascolarctidae
**Genus & Species:** *Phascolarctos stirtoni*




During the Pleistocene period the Giant Koala *Phascolarctos stirtoni* occupied the same arboreal niche as the modern Koala. As the common name suggests, *Phascolarctos stirtoni* is about one third larger than its modern equivalent.

However, apart from the variation in size, there appear to be fewer other differences between the species and some scientists suggest that the modern Koala is really only a dwarfed form of the Pleistocene species.

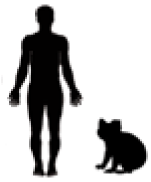

The teeth of the modern Koala (left) and a cast of teeth of the extinct Giant Koala (right) show great similarity

Model of Phascolarctos stirtoni

# Living Animals : Koala

### *Koala*

**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Phascolarctidae
**Genus & Species:** *Phascolarctos cinereus*



The Koala *Phascolarctos cinereus* is a tree dwelling marsupial that feeds almost exclusively on eucalypt leaves.
It occurs in eucalypt forests ranging from the tropical north to the temperate south along the Great Dividing Range of eastern Australia. At the time of European settlement it also may have occurred in the gallery forests flanking many of river systems flowing south westwards from the Range. Introduced populations also occur in South Australia.

Skeleton of the Koala

Fossils of Koalas are rare in the deposits at Naracoorte.
This is probably related to their arboreal lifestyle and the minimal amount of time they spend on the ground, thus reducing their chance of falling into a cave.

The association of the arboreal koala with eucalypt forests relates to their specialised eucalypt leaf diet.

The association of the arboreal koala with eucalypt forests relates to their specialised eucalypt leaf diet.

However Koalas appear to have a preference for different eucalypt species in different areas.

Given the poor dietary quality of the eucalypt leaves it is somewhat of a puzzle why the Koalas rely on it. Not only do eucalypt leaves possess little protein, they also contain high concentrations of indigestible compounds, including lignin and fibre, and potentially toxic phenolics and terpenes.

Part of the answer may relate to the Koala lifestyle where individuals may be inactive for 20 hours a day, significantly reducing their energy requirements.

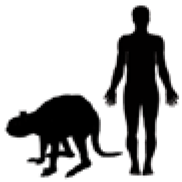

Koala skull with strong teeth to grind leaves

Koalas sleep for up to 20 hours a day

## Extinct Animals : Simosthenurus occidentalis

### *Simosthenurus occidentalis*

**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Macropodidae
**Subfamily:** Sthenurinae
**Genus & Species:** *Simosthenurus occidentalis*



Although Simosthenurines were no taller than most modern species of kangaroo, their robust bones, broad pelvis, long arms and short necks were unique adaptations to their browsing mode of feeding.


Jaw bone of Simosthenurus occidentalis, showing strong grinding teeth

Their single-toed (monodactyl) hind feet had small hoof-like nails more typical of animals adapted to moving over relatively flat terrain.

*Simosthenurus occidentalis* was a leaf-eating kangaroo, about the size of a modern grey kangaroo.

In order to grind tough leaves and shrubs it had powerful jaws and striations (sharp vertical ridges) on its teeth.

The name, 'Sthenurus', Latin for 'strong-tailed', was derived from the first description of this group by Sir Richard Owen in the nineteenth century.


Strong grinding molar teeth of Simosthenurus occidentalis, showing striations

He noted that the bones were undoubtedly kangaroo-like and suggestive of powerful hind limbs and strong tails.

Within the *Pleistocene sthenurines* there were two main genera, the *Simosthenurus* (species with extremely short skulls) and the *Sthenurus* (those species with longer skulls).

As with many other browsing marsupials, the Sthenurine kangaroos became extinct around 50,000 years ago.

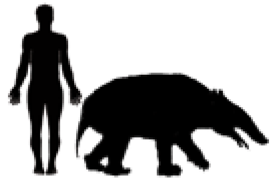
Skeleton of *Simosthenurus occidentalis*


Model of *Simosthenurus occidentalis*

# Extinct Animals : Palorchestes azael

## *Palorchestes azael*

**Class**: Mammalia
**Supercohort:** Marsupialia
**Order:** Diprotodontia
**Family:** Palorchestidae
**Genus & Species:** *Palorchestes azael*

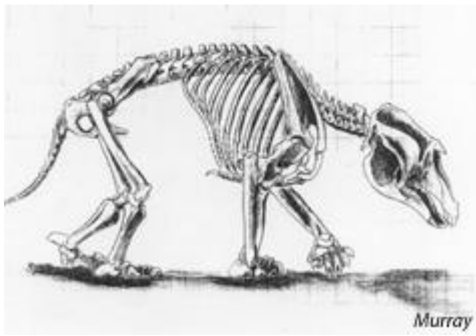



This large marsupial was initially described as a giant kangaroo due to the similarity of its cheek teeth to those of living kangaroos.

Consequently, it was given the scientific name *Palorchestes azael*, which is derived from Latin and means 'ancient leaper'.
As more fossil material of this animal has been discovered, scientists now know that Palorchestes actually resembled a tapir-like animal and had a short trunk attached to the front of the skull.

For this reason, it is sometimes referred to as the Marsupial Tapir.


Jaw bone of Palorchestes azael, with teeth similar to those of kangaroos




Artist's reconstruction of the skeleton of Palorchestes azael

Fossils of *Palorchestes azael* are extremely rare with no complete skeleton known.
However palaeontologists are able to reconstruct this animal by looking at more complete remains of other species within the genus, for example *Palorchestes painei*, which lived during the Miocene period in Central Australia.

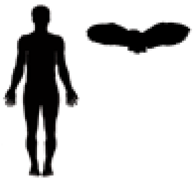
Palorchestes was a ground dwelling marsupial that lived in a woodland habitat.
It possessed powerful forelimbs and razor sharp claws, and was capable of ripping through tough vegetation such as bark on tree trunks in order to obtain food.
The strong, high-crowned teeth provide further evidence that its diet consisted largely of abrasive vegetation.


Model of Palorchestes with her young (on right), with its head in her pouch suckling milk

## Living Animals : Barn Owl

### *Barn Owl*

**Class:** Aves
**Order:** Strigiformes
**Family:** Tytonidae
**Genus & Species:** *Tyto alba*




The Barn Owl *Tyto alba* occurs across much of Australia and is a bird of prey or raptor.
It is easily recognised by the white, heart-shaped facial mask.

Its principal habitats are open forests and woodland areas where its favoured prey can be found. During the day it shelters in caves, tree hollows or thick foliage.

At night, this nocturnal predator hunts for small mammals and reptiles. It has excellent hearing and is capable of silently flying to swoop on its unsuspecting prey, grasping it with its widespread talons.


The Barn Owl has a distinctive white, heart-shaped face


Skull of the Barn Owl, showing its long sharp beak

Once caught, food is digested in its gizzard. The Barn Owl then regurgitates the indigestible remains (eg fur, bones) as pellets. These pellets accumulate as piles of small bones beneath the roost.

Large concentrations of small vertebrate bones found in the caves at Naracoorte were accumulated by owls which once roosted there.

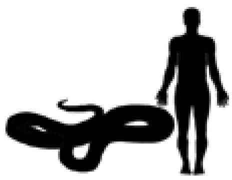

Fossil bones of the small animals eaten by owls


Fossillised pellet of bones regurgitated by an owl

## Extinct Animals : Wonambi naracoortensis

### *Wonambi naracoortensis*

**Class:** Reptilia
**Subclass:** Lepidosauria
**Order:** Squamata
**Family:** Madtsoiidae
**Genus & Species:** *Wonambi naracoortensis*



The 5 metre snake *Wonambi naracoortensis* was first described from fossils at Naracoorte, and was the first extinct snake to be described from Australia.

The name *Wonambi* comes from the Aboriginal name for giant rainbow serpents that inhabited sacred waterholes and enforced sacred law.

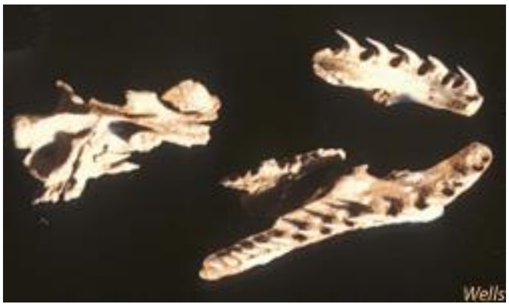
Model of Wonambi naracoortensis crushing a wallaby in its coils

This snake would have killed by wrapping its body around its prey and slowly tightening the coils until the animal suffocated.
Its skull was comparatively small and it would have taken small to medium sized prey, mostly mammals.

Scientists recognised early that Wonambi was related to the more ancient and even larger extinct madtsoiid snakes which had been found in the fossil record of South America and Africa.

More remains of madtsoiids have since been found in Australia, notably at Riversleigh in Queensland including a smaller version of Wonambi.
Fossilised remains of madtsoiid snakes have now been found on nearly every continent that once was part of the supercontinent, Gondwana.
They became extinct on all other continents around 55 million years ago, but continued to diversify in Australia.
*Wonambi naracoortensis* was the last of this ancient lineage and died out within the last 50,000 years ago.

Partially-excavated skeleton

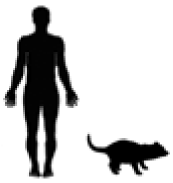


The skull of *Wonambi naracoortensis* was relatively small

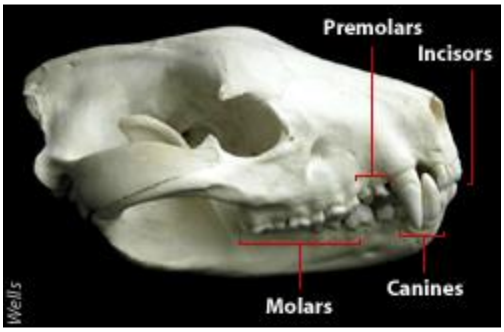
# Living Animals: Tasmanian Devil

## *Tasmanian Devil*

**Class:** Mammalia
**Supercohort:** Marsupialia
**Order:** Dasyuromorphia
**Family:** Dasyuridae
**Genus & Species:** *Sarcophilus harrisii*



The Tasmanian Devil *Sarcophilus harrisii* once roamed widely across Australia, including the Naracoorte region. It became extinct on the mainland around 3,500 years ago. Its disappearance coincided with the introduction of dingoes to Australia. It is thought that competition with these dogs probably led to the demise of devils.



Tasmanian Devils have large, strong teeth, capable of crushing bone

Devils are now found only in the dry, sclerophyll forests and coastal woodlands of Tasmania.

Devils are the largest surviving marsupial carnivores. They are predominantly scavengers of carrion, but are also known to hunt and kill small prey.

Their appetites are voracious and their bone-crushing dentition allows them to eat every part of their victim, including the bones.
Around Australia, many fossil deposits contain bone material that shows signs of ravaging by Tasmanian Devils.

Such bones display tooth marks and fragmentation patterns similar to that produced by Devils today.

It is likely that these animals used some caves as dens, bringing back food and accumulating bone over time.

Fossil bone showing tooth marks from being gnawed by a Tasmanian Devil

Jaws and palate of Sarcophilus harrisii, showing the strong, sharp teeth

Tasmanian Devil

## Living Animals : Lace Monitor or Common Goanna

### *Lace Monitor or Common Goanna*

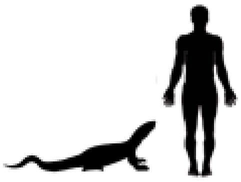
**Class:** Reptilia

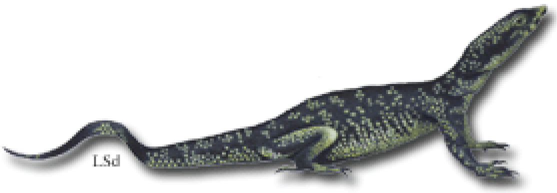
**Subclass:** Lepidosauria

**Order:** Squamata

**Family:** Varanidae

**Genus & Species:** *Varanus varius*





Varanus varius is also known as the Lace Monitor or Common Goanna.
It is found in the coastal areas and ranges of eastern and south-eastern Australia.

Skeleton of a Lace Monitor

The Lace Monitor is a large, mostly arboreal lizard that can grow up to 2 metres in length.
Its diet consists of insects, reptiles, small mammals and nesting birds.

It is also known to feed on carrion, and several Lace Monitors may be seen feeding on the same large carcass.

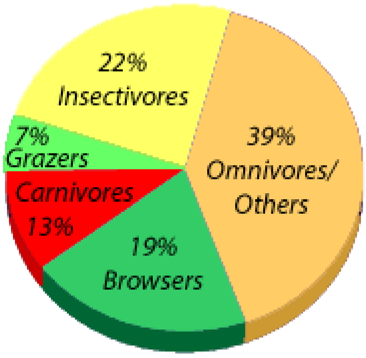
Fossil skull and jaws of a Goanna, showing the typical reptilian teeth

Model of a Lace Monitor

The most common colouration of the Lace Monitor is a dark blue black with scattered white to yellow scales that form spots or blotches. Regional variations to this pattern do occur with the lighter spots forming bands across the back in some individuals.

# Diet

## What did they eat?




Palaeontologists studying Naracoorte's fossil record are gaining valuable insight into how the ancient animals lived and interacted with their environment.

An important part of this is determining what these animals ate and hence the dietary niches they filled.
Clues to the diet of extinct animals are to be found in the structure of their teeth and microscopic wear patterns on their tooth enamel. The dietary preferences of living animals can be observed in the wild.

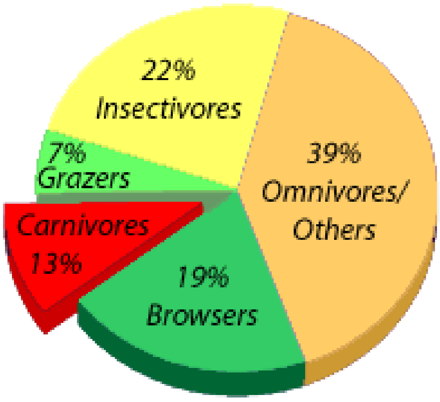
By studying diet, information is gained regarding the feeding behaviour of individual species, the dietary structure of past animal communities, and even clues to the habitat surrounding the caves when the animals became entrapped.

Of the 120 species of amphibians, reptiles, birds and mammals found within the cave deposits, around one third were herbivores, one third carnivores and insectivores, and the remaining third were omnivorous or had other dietary requirements.


Herbivores eat the leaves, stems, fruits and seeds of plants


Fungi are a food source for a number of animals

## Carnivores




Carnivorous animals feed on the flesh of other animals. They can be active predators, meaning they hunt and kill their prey, or they may be scavengers and feed on carrion (dead animals).

Meat-eaters found within the Naracoorte fossil deposits include owls, snakes and goannas, and mammals such as the the Tasmanian Tiger *Thylacinus cynacephalus* Native Cat or Quoll *Dasyurus*, the scavenging Tasmanian Devil *Sarcophilus harrisii* and the extinct Marsupial Lion *Thylacoleo carnifex*.

The Native Cat, or Quoll


Skeleton of the Quoll

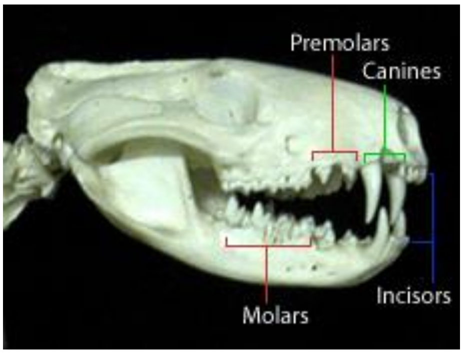
Certain features of meat-eating animals provide clues about how they hunt and eat. For example, owls have huge claws and powerful beaks for catching and devouring prey.


The owl has a sharp beak for devouring prey


The owl's sharp talons allow it to swoop and grasp its prey

Mammalian carnivores have four different kinds of teeth, each with a specific purpose:

- incisors for nipping and biting
- sharp canine teeth for stabbing and holding prey
- premolar teeth for cutting and slicing
- molar teeth for shearing flesh and crushing bone




Skull of the Quoll, showing typical carnivore's teeth

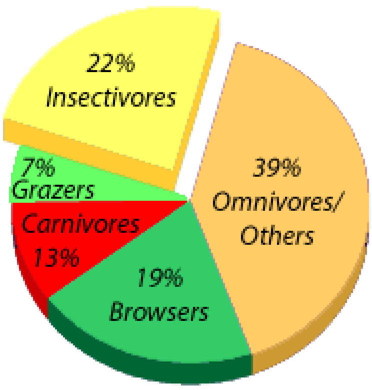
In some animals these features are especially well developed, as in the Tasmanian Devil which has a powerful jaw musculature and molar teeth that can crush bone. The tooth marks from Tasmanian Devils have been found on fossil bones.

The Marsupial Lion took these adaptations even further with the development of an enormous flesh-slicing premolar tooth, and grasping hands with huge claws for catching and holding prey.


The Tasmanian Devil is a scavenger and has molar teeth that can crush bone


Jaw bone of the Marsupial Lion with its unusual stabbing lower incisor and large flesh-slicing premolar

## Insectivores




The amazing abundance and diversity of the insects is mirrored by the large number of animals that use them for food.
Many of the species found at Naracoorte survived on a diet composed mainly of insects and other invertebrates.
Interestingly, the majority of insectivores that lived at Naracoorte thousands of years ago are still to be found in the area today. These animals include frogs and tortoises, lizards, birds, small marsupials, rodents and bats.

Bats are highly adapted insect eaters and catch nocturnal, flying insects using echolocation for hunting. Other insectivores make use of a range of insects and other invertebrates.
Insectivorous mammals have sharp teeth for piercing and crushing the exoskeleton of insects.


Fossilised bones of the Magpie-lark, which feeds on insects, have been found at Naracoorte


Sharp teeth on the fossil jaw bones of insectivorous marsupials Antechinus and Sminthopsis

Some insectivores are highly specialised such as the ant-eating Echidna *Tachyglossus aculeatus* which has a long snout and tongue for collecting ants and termites.


The Echidna eating ants

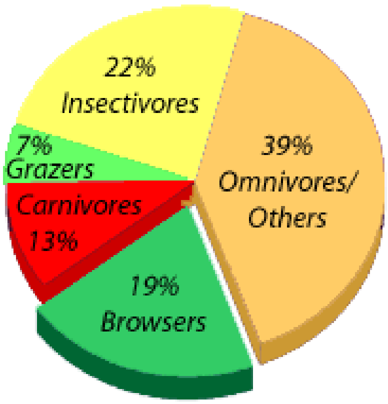

Skeleton of the Echidna Tachyglossus aculeatus

In the woodlands of ancient Naracoorte, the Giant Long-beaked Echidna *Megalibgwilia ramsayi* foraged for grubs and worms.

The long snout is made up of a hollow tube, through which the tongue extended to grasp the prey.


The extinct Giant Long-beaked Echidna used its long nose to forage for grubs and worms

## Browsing Herbivores




Herbivores can be divided into two major groups – grazers (grass eaters) and browsers (leaf eaters). Browsers have a leafy diet which may vary from succulent leaves to large, tough, woody stems.

Their teeth are designed for crushing and grinding this type of food and they generally have relatively short faces and powerful jaw muscles, adaptations to a tough leafy diet. Many of the extinct animals such as the short-faced Sthenurine kangaroos and the large Diprotodon, *Zygomaturus* and *Palorchestes* were browsers.

The disappearance of the giant browsers from the landscape remains a mystery. Perhaps a change in the vegetation in the area in the last 400,000 years from eucalypt forest with a scrub understorey to a more open woodland may be part of the reason. However, browsers such as the Koala *Phascolarctos cinereus* are still found in the Naracoorte area.

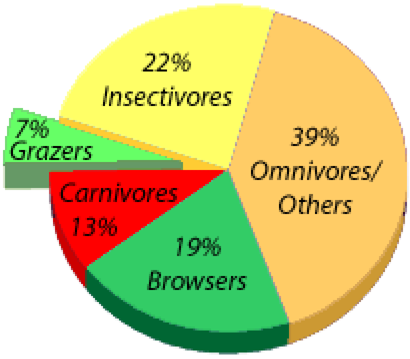

Lower jaw of Sthenurus brownei showing teeth adapted to cutting and grinding vegetation


Sthenurine skull showing its short face and powerful jaws


Skull of a Koala, with a V-shaped array of front incisors for grasping leaves, and 4-cusped molars for cutting and grinding them


The Koala browses only on Eucalypt leaves

# Grazing Herbivores




Grazing animals eat grass and are generally found in open grassland areas or grassy areas within woodlands. Grazing animals at Naracoorte include kangaroos, wallabies and wombats.

Grass cells contain minute amounts of abrasive silica and thus the teeth of grazing animals are subjected to considerable wear. Their teeth have high crowns often with extensive folding of the enamel, but these wear down throughout life.

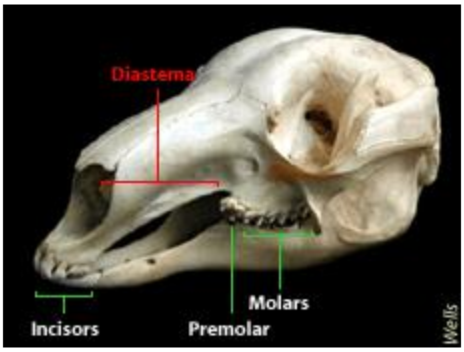
Some grazing animals, such as kangaroos, replace their teeth as they wear. Others, like wombats, have continuously growing teeth.


Wombats have continuously growing teeth to cope with wear

Southern Hairy-nosed Wombat Lasiorhinus latifrons

Many of the grazing animals, like kangaroos, have long slender faces and a pronounced gap (diastema) between the incisor and premolar teeth which allows them to use the tongue to move grass around the mouth for prolonged chewing.


The Kangaroo has a long slender face and continuously growing teeth to facilitate grazing




Kangaroo skull showing the diastema, which provides space for the tongue to move grass around in the mouth

Few grazing animals have become extinct since the ice ages although many, such as the kangaroos and wombats, have diminished in body size from their 'ice-age' ancestors.
Smaller size may be an adaptation to reduction in resources and changing environment.

## Omnivores and Others

Some animals don't fit neatly into a single category because they have wider tastes. These animals feed on a combination of plants and animals and are called Omnivores.

Other animals eat foods that do not fall into any of the previous categories, such as pollen or nectar, roots and tubers, or fungi.

Many animals feed on invertebrates, which are animals which do not have backbones, such as beetles, snails and slugs, and worms.

## Omnivores

Animals as diverse as the Emu *Dromaius novaehollandiae* and the Sleepy Lizard *Tiliqua rugosa* are omnivorous, eating various combinations of animal and plant matter.


Emus feed on plants and invertebrates


The Sleepy Lizard feeds on leaves, flowers, invertebrates and small vertebrates


Jaw of the Sleepy Lizard

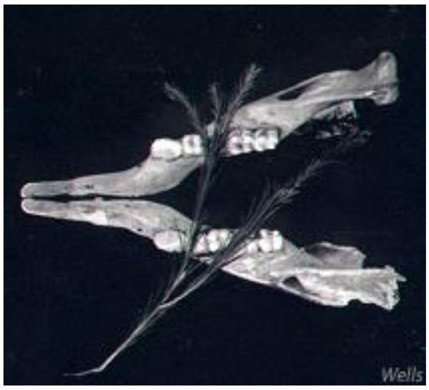

The skull of the Sleepy Lizard

A number of marsupials, such as possums, bandicoots and potoroos, are omnivorous, as was the extinct Giant Rat Kangaroo *Propleopus oscillans*, although some scientists think it was carnivorous.

Many native rodents are also omnivorous, feeding on a wide range of invertebrates, seeds and vegetation.

Mammals which are omnivorous tend to have less specialised teeth than those whose diet consists of just meat or just a particular type of plant material. Their teeth need to perform all of the functions - grasping, cutting, slicing and grinding - but none of these is predominant.


The skull of the Brush-tailed Possum, showing the less-specialised teeth of the omnivore




Jaw of the extinct Giant Rat Kangaroo, which is thought to have eaten plant material and carrion, has long incisors, a large cutting premolar and grinding molars

## Other Diets

Some animals live on one or more food types and are not obviously carnivorous, herbivorous or insectivorous. These include flowers, pollen, fruits, seeds, shoots, roots and tubers, fungi and invertebrates.


Cheiranthera alternifolia

A number of bird species live on the nectar of flowers. Several possum species also drink nectar, as do Sugar Gliders, Squirrel Gliders and Feathertail Gliders.

Flowers are eaten by some lizards and by the Common Ring-tail Possum.

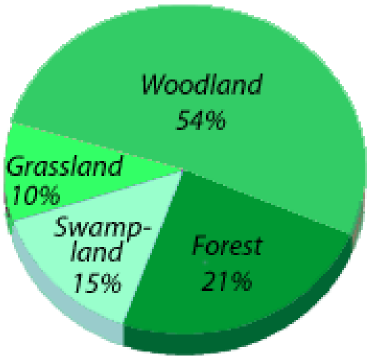
Some animals have quite specialised diets, such as several of the Bettong species, which feed primarily on fungi.


Honeyeaters drink the nectar from flowers


The Rufous Bettong *Aepyprymnus rufescens* feeds primarily on fungi

Fungi are a food source for a range of animals

# Habitat




## The Ancient Habitats

Palaeontologists study cave deposits in order to understand ancient environments.

The types and variety of animal species found provide important clues about what the vegetation and habitats were like during the Pleistocene.

The preferred habitats for living species are known from modern biological research.


Fossils of kangaroos indicate that there were grassland and woodland areas in the past

For extinct species, habitat is inferred by studying the teeth and structure of the skeleton to learn about diet, habit and behaviour. The proportions of the different habitats represented by the animals indicate the range of vegetation types in the past.

For example, if the majority of species found would have preferred an open woodland environment, then this tells us that the major habitat type near the caves was woodland.

Smaller numbers representing other habitats (eg grassland and swampland), tell us that there were patches of other vegetation types in the vicinity.

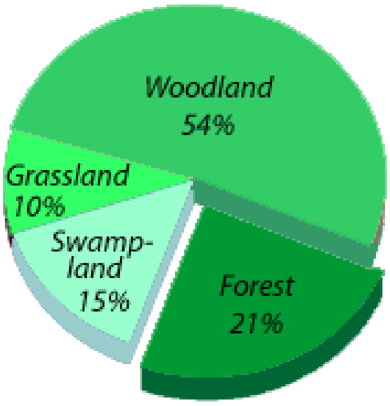
Some animals have broad habitat tolerances, while others are quite specific in their needs.
The Pleistocene deposits at Naracoorte tell us that in the past the vegetation structure was dominated by open eucalypt woodland with patches of thicker forest, grassland and swampy sedgelands.

In addition to the fossil evidence, plant pollen may be preserved in the fossil deposits and provides direct evidence for vegetation types and habitat.


In the Pleistocene open woodland was the most common habitat


Fossils of aquatic animals show that there was swampland in the Naracoorte area

## Animals of the Forests




The forests of ancient Naracoorte probably consisted of tall eucalypts such as the River Red Gum *Eucalyptus camaldulensis* and Hill Gum E. fasciculosa and Acacias (wattles), with a thick understorey of hard-leaved (sclerophyllous) shrubs such as Banksias.

These forests would have been a haven for tree dwelling (arboreal) animals such as possums, bats and Koalas, which spend very little time on the ground.


Forest habitat

Other animals (such as Quolls) are called scansorial, meaning they spend a lot of time in trees, but also forage on the ground. One consequence of living in trees is that your chance of falling into a cave is greatly reduced, and this is evidenced by the low percentages of arboreal animals found in the fossil deposits.


The Swamp Wallaby actually lives in forests

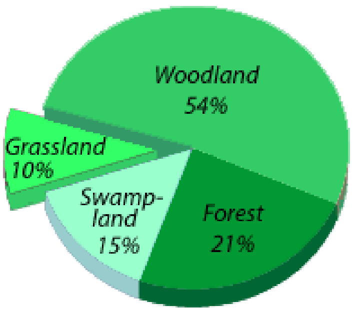
Possum


The arboreal Koala is a skilled tree climber

Many ground-dwelling animals would also have lived in the forests, with smaller marsupials such as bettongs and potoroos sheltering and foraging in the shrubby understorey.

This habitat would have been favoured by the larger of the leaf-eating Sthenurine kangaroos, and the giant extinct snake, Wonambi naracoortensis.

## Animals of the Grasslands




Areas that are dominated by grasses and are more or less treeless are called grasslands.

These may occur as large open expanses or patches within other vegetation types such as open woodland.
Grassy tussocks provide shelter and protection for small vertebrates, nesting sites for birds and food for grazing animals.

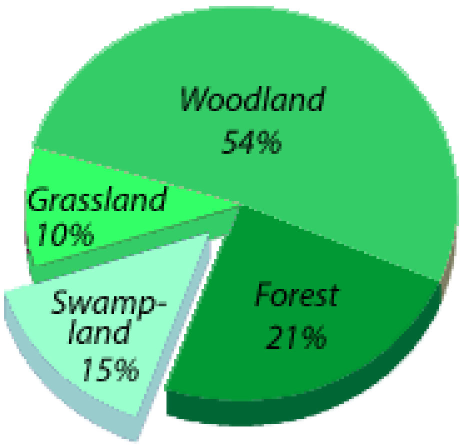
Mitchell's Hopping Mouse lives in grassland


Grassland habitat

In the past, grasslands at Naracoorte would have been used by animals such as Grey Kangaroos, Toolache Wallabies, Red-necked Wallabies, small insectivorous marsupials, birds, reptiles and some rodents.

The presence of grazing animals and those that would prefer grassland habitat within the fossil deposits gives us clues to the variety of habitats and vegetation types surrounding Naracoorte's caves in the past.

## Swampland




Much of the low-lying country in the inter-dune flats near the caves consisted of swampy sedgelands.

These areas would have been subject to inundation by winter rains as they are today.

The vegetation in these areas generally consists of sedges, *Cumbungi* and reed beds, water plants, and shrubs such as various *Melaleuca* species.

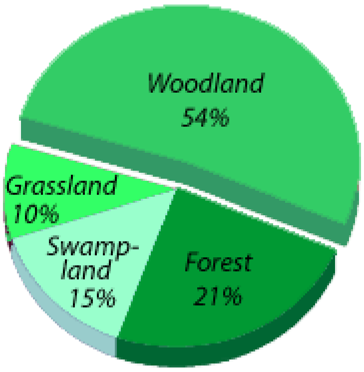
This habitat would have been home to countless species of waterbirds, tortoises, frogs, lizards, snakes and mammals which also browsed in the swamplands.


Swampland habitat

Swampland

During dry times, these animals probably sought refuge along the caves range, where the vegetation was dominated by woodland, with patches of grassland and some remnant swampy areas.

# Animals of the Woodlands




Open eucalypt woodland would have been the dominant vegetation along the Naracoorte Caves range during much of the Pleistocene and would have supported a wide variety of animals.

Areas of woodland such as this still survive today and are mainly composed of Stringybark Eucalyptus obliqua and Silver Banksia *Banksia marginata*, with a low shrubby understorey.

Open Eucalypt woodland was the dominant habitat in the Pleistocene era

A range of shrubs grew below the Eucalypts in the woodland

In the past this understorey would have been home to many of the smaller marsupials, such as the small mouse-like insectivorous marsupials *Antechinus* and *Sminthopsis*, possums, bandicoots, potoroos and wallabies.

In the woodlands wombats would have constructed warrens at the bases of trees, and the scavenging Tasmanian Devils would have scoured the ground for carrion and hunted small animals.

Fossil skeleton of the Brush-tailed Possum Trichosurus vulpecula

Possums spend much of their time in the trees

Possums would have rested in the trees during the day, while a multitude of birds such as honeyeaters, robins and finches foraged in the shrubs and on the ground.


Red-browed Finch


The Kookaburra

Honeyeater

## Reasons for Extinction

### Why did they die out?

We use the term 'extinct' to describe species that no longer exist. Extinctions may be related to a number of factors such as environmental change, catastrophe and more recently, human impact.

Although there are millions of species of organisms existing on the planet today, this is only a minute portion of the total number of species that have existed since the beginnings of multicellular life over 600 million years ago.

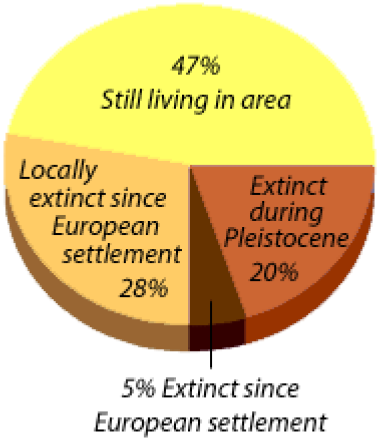
The earth has seen a number of mass extinctions during its history, arguably the most famous of these occurred 65 million years ago when the dinosaurs died out.

More recently, during the latter portion of the Pleistocene Epoch (1.8 million years to 10,000 years ago), another great extinction occurred. Across the globe giant mammals known as the 'Megafauna' became extinct.

In Australia, practically all of the large mammals (and some large reptiles and birds), died out around 45,000 to 50,000 years ago. The big question is why?

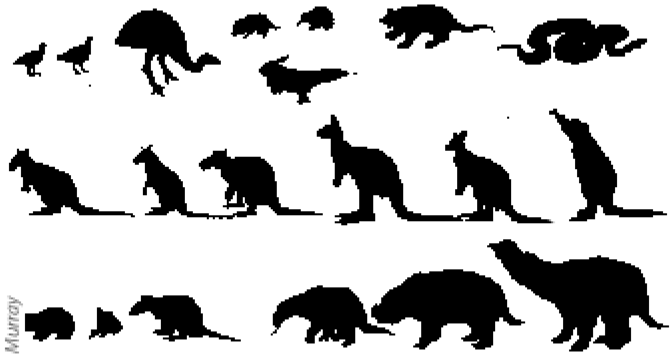
Like many mystery stories, the answer to this problem is not a simple one and scientists have proposed several theories to explain the disappearances. The two major theories are climate change and human intervention.

At Naracoorte, palaeontologists are systematically peeling back the layers of time within the fossil deposits in order to find the answer to this and other questions about the ancient world of the Megafauna.




## Which animals became extinct?

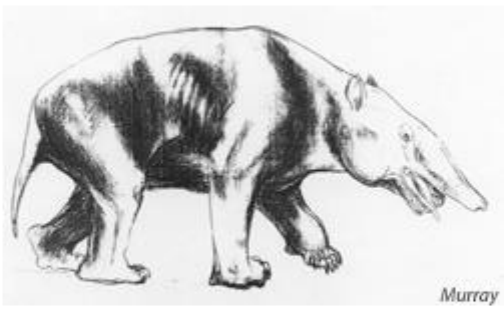
Remarkably, over half of the 120 vertebrate species found within the Pleistocene fossil deposits at Naracoorte are now extinct in the region.




A large number of these species (20%) died out during the Pleistocene, including 80% of the mammals greater than 5 kg in weight. These mammals ranged in size from the 2.5 tonne *Diprotodon* to leaf eating kangaroos the size of wallabies.

Of the remaining species, 5% became totally extinct following European arrival, including the Thylacine *Thylacinus cynocephalus*, the White-footed Tree Rat *Conilurus albipes*, and the Toolache Wallaby *Macropus greyi*.

Other species disappeared from the Naracoorte region following European contact, but survived in other parts of Australia. These included many of the small rodents, potoroos, bettongs, and small to medium-sized carnivorous marsupials *(Dasyurids)*.




Palorchestes azael was one of the Megafauna species that died out during the Pleistocene

The Brush-tailed Bettong is no longer found in the Naracoorte area, but still lives in other parts of Australia

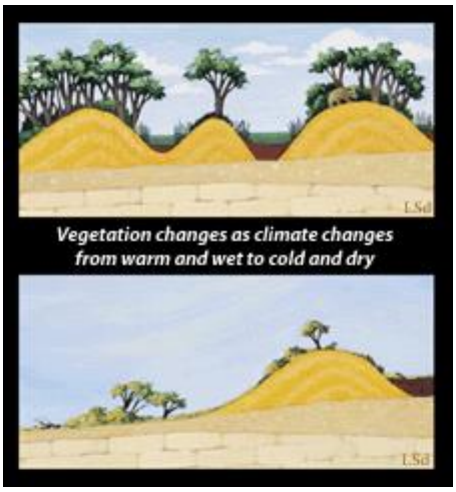
The Grey Kangaroo still lives in the Naracoorte area

Those species still living in the area comprise 47% of the total species found within the fossil deposits. They are predominantly small marsupials, kangaroos, birds, reptiles and amphibians.

# How did the climate change?

## How did the climate change?

Throughout the Pleistocene Epoch, Australia experienced many oscillations in climate which resulted in corresponding changes in vegetation and the animal communities.




Water levels and vegetation changed a number of times as the earth experienced a series of ice-ages followed by inter-glacial periods.

During an ice-age the climate is cold and dry. The inter-glacial periods have a warmer, wetter climate.

In the latter part of the Pleistocene there was a gradual trend toward drier conditions. Some scientists believe these changes led to the extinction of many of Australia's large animals. Others suggest the combined influences of human impact and environmental change led to their demise.

Vegetation varied from rainforest in the wettest periods…

... to sandy dunes during the driest times

# The impact of the Australian Aboriginal people

## The impact of the Australian Aboriginal people

Archaeological evidence suggests that humans first arrived in Australia at least 60,000 years ago.

The impacts that hunting by early Australians had on the animals is still a matter of speculation. However, we do know that many of the extinctions of the Megafauna occurred at around the time that humans spread across Australia. We also know from dating and archaeological material such as rock art, that there was a period of co-existence between Indigenous people and Megafauna.

Dating of fossil sites around Australia suggests that many of these animals were extinct by around 46,000 years ago.

Thus far there is no direct fossil evidence that humans hunted the Australian megafauna. In North America and Europe there is abundant evidence for such activities. In Australia we are yet to find the "smoking gun".

Remnants of Aboriginal stone tool making

Another activity practiced by Aboriginal people was burning, and this would have influenced the vegetation structure. Some scientists have suggested that frequent burning over an extended period of time would have altered the vegetation enough to cause extinctions of animals, particularly the browsers.

# European settlers cleared much of the land

## European settlers cleared much of the land

European settlement has had a profound effect on the environment in Australia and an alarming number of native species have become extinct.

Over the last 200 years many areas have been subject to clearing for agriculture, viticulture and forestry.

In the South East region less than 13% of the natural vegetation is left and it only occurs in isolated pockets and National Parks.

This impact on the vegetation has resulted in the destruction of habitats for many native animals. In the Naracoorte area it has led to the disappearance of some species and severe contractions in the range of many others.

Of those species found in the fossil deposits, almost 30% have become extinct in the area since European arrival.

## Introduction of New Threats

The introduction of feral species such as rabbits, cats and foxes has had a major effect on native animal species.

Pest plant species are also a problem, with many areas of scrub choked out by invasive weeds. This means that there are fewer of the native plants to provide food and shelter for native animals.

Introduced plants such as blackberries choke out the native plants

Feral cats have decimated the population of small native animals

Another contributing factor has been deliberate hunting and persecution of native animals.

The Toolache Wallaby *Macropus greyi* was hunted to extinction for its beautiful fur.

Tragically, the *Thylacine Thylacinus cynocephalus*, Australia's largest marsupial carnivore was wiped out by government-endorsed bounty hunters.


The Thylacine was hunted to extinction by bounty hunters


Skull of the Toolache Wallaby which was hunted to extinction

Many of these threats continue today, and organisations, such as Regional Conservation are striving to protect what little remains.

## The Fossils in the Naracoorte Caves

### How did the fossils come to be in the caves?

The Naracoorte Caves contain bones of thousands of animals that lived here at different times, during the last 500,000 years.

Caves are special fossil sites because, in addition to being death traps, they provide a protected environment in which bones are preserved.

Vertebrate palaeontologists are studying the fossil remains of these animals to understand more about them and the environments in which they once lived. They have studied several aspects of the deposits: the ways in which the layers of sediment formed; the processes involved in the accumulation and preservation of the bones (taphonomy); and the range of animals found (diversity of fauna).

As a first step in our investigation, we must understand how so many bones came to be in the caves.

## How did the bones get into the caves?

### How did the bones get into the caves?

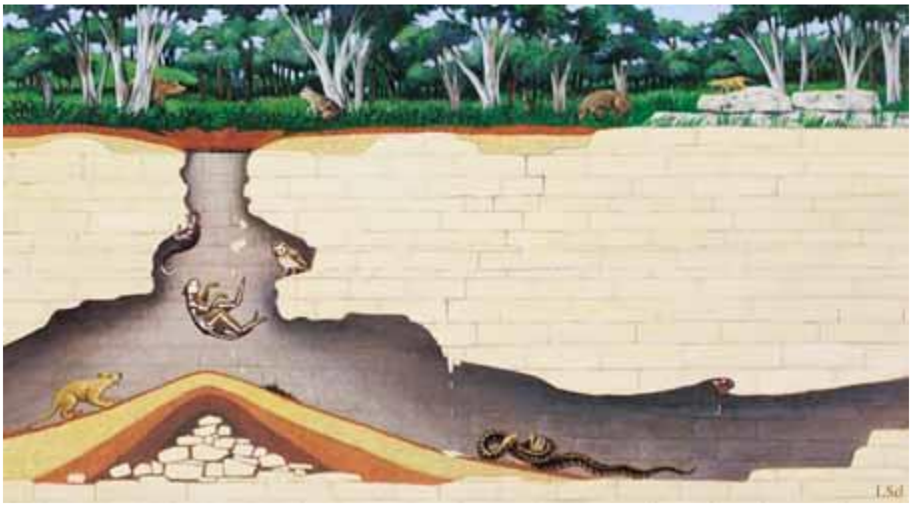
Several entrance holes (solution pipes) formed in the roof of Victoria Fossil Cave more than half a million years ago. The cave began to fill with sediment and bones through these openings.

Bones accumulate in caves by three main processes, which still occur today:

1. Cave dwellers, like possums, rodents, snakes and bats, die in the caves.

2. Pit-fall victims are animals that fall into the cave and cannot climb out. Some may be injured during the fall.

3. Predators, such as owls that roost in caves, may bring in small mammals as part of their diet. In the past, Marsupial Lions *Thylacoleo carnifex* may have used caves as dens.



## Filling the caves with bones and sediments

### Filling the caves with bones and sediments

Over time, layers of bones and sediment build up to form cones under the entrance holes to the caves.

As material continues to fall in, the cones become higher and grow wider at the base. These cones build up gradually, until eventually they block the entrance holes.

The different coloured layers in the cones are due to variations in sediment type. They often relate to changes in the climate and vegetation outside the caves.

Similar cones of sediments are developing under cave entrances today.

The sand cone pictured formed when the vegetation surrounding the cave entrance was cleared in the early 1900s, destabilising the sand.

The image on the left was taken in the 1960s while the one on the right in was taken in 2000. Note the tree roots that have penetrated the cavern seeking water as native vegetation has re-established on the land surface above the cave.

This same process of cone development could also be naturally instigated by a bushfire.



***Different layers of sediment were laid down in different climates***

Different types of sediments surround the bones in the caves. Some sediments include darker clay particles while others are often lighter-coloured and sandier.

Scientists think that the dark layers, which are rich in organic material, formed in wetter climates than exist today.


A palaeontologist excavates layers of sediment in a dig

The pale layers contain mostly sand and are thought to have accumulated under conditions similar to or drier than today.

Consequently, the sediment layers from different caves provide evidence of climate changes over hundreds of thousands of years.

These climate changes influenced the diversity and abundance of vegetation and animals living at the surface.

## Bones and sediments are mixed up over time by water and trampling

Rain falls through open roof entrances, washing sediments from one area to another

Water may collect in circular depressions (dolines) above cave entrances that have become blocked by the tops of sediment cones.

Eventually the upper portion of a cone may collapse under the weight of saturated sediment, thus unplugging a cave entrance.

Sediment then slumps down the sides of the cones to be redeposited further inside the caves.

Once open, subsequent rainfall causes more runoff into the cave, and the gradual slumping of sediment.

Bones within the sediment may be redistributed by this process which leads to mixing of layers and separation of skeletons.

More often though, bones are moved about and disarticulated following trampling by trapped animals that stumble around in the dark looking for escape.

### *Water moves the sediments around*

Water entering the cave may cut deep channels in the sides of sediment cones, scouring out and mixing bones from many levels.

The movement of bones depends on their shape and mass as well as the speed and volume of water flow.

Smaller bones and buoyant bones like skulls are moved more easily, while larger bones, like thigh bones (femurs), require faster flowing water to be transported.

Close to cave walls and further from the entrances, where the effect of water is lessened, some partial skeletons whose bones are still joined (articulated) remain.


Water entering the cave can cut channels through the sediment, and move bones to different locations


The bones of the hand of Thylacoleo carnifex were found still partially joined together


Large limb bones lined up along the direction of the water flow

## The excavation site can be seen on cave tours

### The excavation site can be seen on cave tours

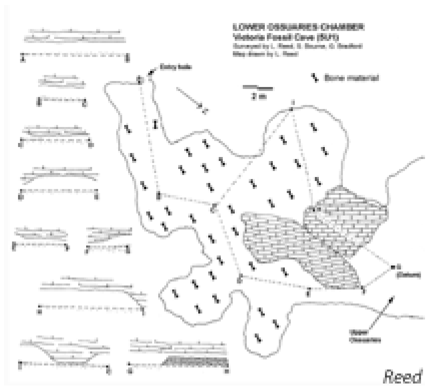
The pitfall entrance to Victoria Fossil Cave was last blocked by sediment around 213,000 years ago, and remain closed today. However, an alternative way in was discovered.

In October 1969, two members of the Cave Exploration Group of South Australia crawled through a tiny passage about 30 centimetres high and found a previously unknown chamber.

One caver was a palaeontologist who immediately recognised the significance of the fossil bones they saw.

Following discovery of the Fossil Chamber, scientists drew detailed maps and took core samples of the sandy floor. This allowed them to determine the size of the deposit, and the depth and layering of the sediments. From their studies they estimated there was 5,000 tonnes of sediment and bones in the chamber. The sediment is as much as 4 metres deep.


Palaeontologists at the collection table in Victoria Fossil Cave in 1970




Map of Lower Osuaries Chamber in Victoria Fossil Cave

Palaeontologists have set up digs at five sites within the chamber. To date they have sifted through around 500 tonnes of sediment, finding many thousands of bones and bone fragments. These fossils have been identified as coming from 118 different animals, many of them now extinct.


Excavation of fossils continues today


Scaffolding provides access to various levels

In one section of the cave, the partially-excavated bones have been left in place in the dig, and can be seen on the guided tour.

On a World Heritage Tour a palaeontologist takes visitors through the current excavation sites and explains the scientific techniques used during excavation (bookings essential).


On a World Heritage Tour a palaeontologist shows visitors around the excavation site


On a guided tour of Victoria Fossil Cave visitors see a dig site and reconstructed skeletons

Throughout the 1970s and 1980s more fossil deposits were discovered in different chambers throughout the cave system. Dating and palaeoclimate studies by researchers from the Australian National University and Flinders University during the 1990s have shown that many of these deposits span different, but often overlapping, time periods; some chambers were sealed tens of thousands of years ago, while others are still accumulating bones today.

Each deposit thus provides a snapshot of the past. Putting together all the 'snapshots' is allowing scientists to reconstruct the history of faunal and climate change at Naracoorte throughout the ice ages and before and after the arrival of both Aboriginal and European peoples. This research is ongoing and has as its primary aim to unravel the cause(s) and timing of extinction of Australia's giant marsupials birds and reptiles, known as Megafauna.

# Reconstructing Animals from Fossils

## What did the animals look like?

Reconstructing the details of once-living animals from their fossil remains is an important task of palaeontology. What did they look like? How did they move? What did they eat?

Our aim is to learn more about the animals that once inhabited the Naracoorte area.

To reconstruct an animal, palaeontologists start by identifying the bones and assembling a skeleton.

From this they can then deduce the nature of soft body parts such as muscles, and build a model of what the animal is likely to have looked like.

They can also suggest where it lived and how it behaved.

# How are the bones dug up and prepared?

Excavating the bones is a complex process requiring time and patience. Careful records are kept at each stage, so that palaeontologists know exactly where each bone was discovered.

The fossil bed is mapped and measured before digging begins.

Fossil bones lie within a segment of the grid, marked out with string

Palaeontologists excavate the bones from a site which has been marked out into grids

Bag-loads of sediment are examined for small fragments

The working site is then divided into small grids so that the position, orientation and inter-relationships of bones can be accurately recorded.

The bones lie within loose, dry sediments which are carefully removed from around the larger bones, using tools such as trowels, paintbrushes and dental picks.

## *Special Techniques*

Many of the fossils are fragile, and care must be taken to avoid damage. The successful recovery of bones may require special methods such as:

### Wet Sieving

The sediment contains thousands of small bones and fragments of larger bones.

These are separated from the sediment by sieving in a trough of gently flowing water.

The water loosens the sediment which passes through the sieve, leaving the small bones behind.

Sieving for small bones

Preparing and applying the plaster

### Plaster Jacketing

Large, fragile or very rare specimens must be stabilised.

A plaster encasement is constructed around the bone and its surrounding sediment.

Once encapsulated the fossil, still buried in sediment, can be safely transported to the laboratory.

In the laboratory the dirt is brushed away and the bones are carefully separated.

Working under bright lights palaeontologists carefully clean the exposed bones. The cast on the right contains bones of *Diprotodon australis*.

A fossil encased in plaster

In the laboratory the plaster cast is cut open, and the bones are carefully exposed by brushing away the surrounding sediment

## *Preparing the Bones in the Laboratory*

In the laboratory the bones are cleaned and treated with a chemical hardener to preserve them.


Specimens are carefully cleaned with brushes and dental instruments

Bones are exposed to changes in temperature and humidity once removed from the caves, and can disintegrate rapidly. This is inhibited by the chemical hardener.

Palaeontologists then proceed to identify and label each specimen.

A microscope is used to examine tiny fossils

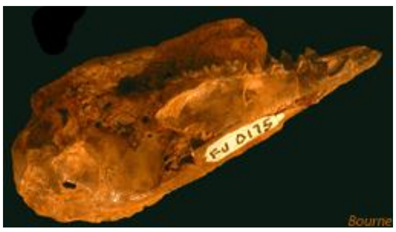
Teeth, jaws and skull fragments are sorted from other bones.

Teeth not much bigger than a pin head are often found by using a microscope.
These tiny specimens are stored in vials awaiting further investigation.

All specimens are labelled with a reference number identifying the grid square from which they were excavated.


Sorting small fragments

The palaeontologists therefore have a detailed record of each bone's original position within the cave sediments.




Each fossil is labelled with a reference number

# How do we know what the skeletons were like?


Bones are often found jumbled together

An intact skeleton is rarely found in the caves.
Faced with a pile of bones, palaeontologists must decide from which type of animal each bone came.
Was it a mammal, a reptile or a bird?

Parts of a skeleton that preserve well, such as jaws, teeth, vertebrae and limbs, are most useful. They possess characteristics unique to an animal group and its way of life.


Cleaning and sorting bones

Animals which look and behave in similar ways generally have similar skeletons.

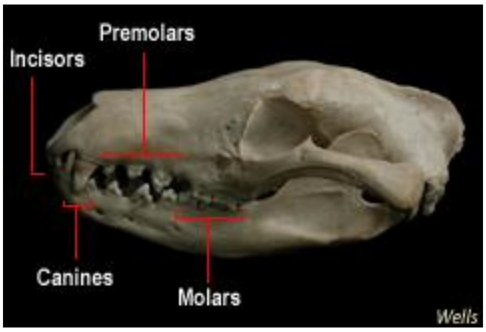
Sorting fossil bones into groups of similar size and form enables palaeontologists to gather the pieces necessary to reconstruct the skeletons.

## *Sorting and Identifying the Bones*

Teeth, jaws and vertebrae have features which allow them to be sorted into different classes of land-based animals: mammals, birds, reptiles and amphibians.

### Teeth

Only mammals have teeth with roots, and their jaws contain different types of teeth: incisors, canines, premolars and molars.
Reptile teeth have no roots and the teeth are all similar in shape, although they may differ in size.




Mammals such as the *Thylacine* have four different types of teeth, and a single jaw bone.

### Jaw Structure


Reptiles, such as the Goanna, have similar-shaped teeth and a lower jaw made up of several bones

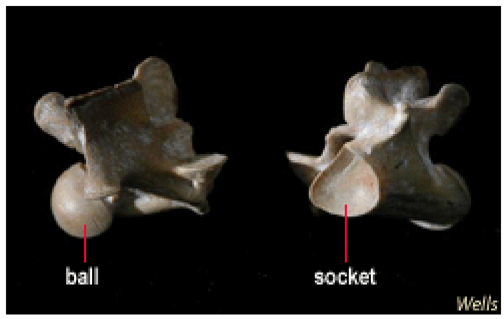
Mammals have only a single bone in the lower jaw, whereas reptiles, birds and amphibians have several bones.

The Goanna has six bones in its lower jaw (dentary, splenial, coronoid, angular, surangular and articular).

**Vetebrae**

The vertebrae of mammals differ from those of other vertebrates. Mammals have flat disks between each vertebra.

Reptiles and amphibians have vertebrae connected by a 'ball and socket' joint.

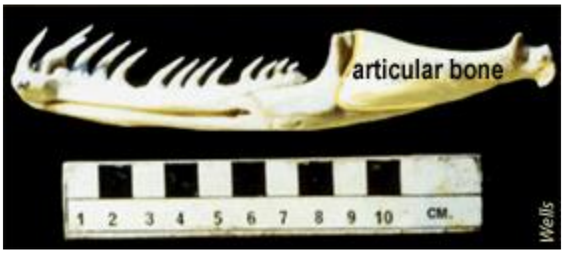

The vertebrae of reptiles, such as the Goanna, fit together with ball and socket joints, which provide flexibility for the spine.
The socket of each vertebra faces forwards, and the ball points backwards

## *Identifying Reptile Bones*

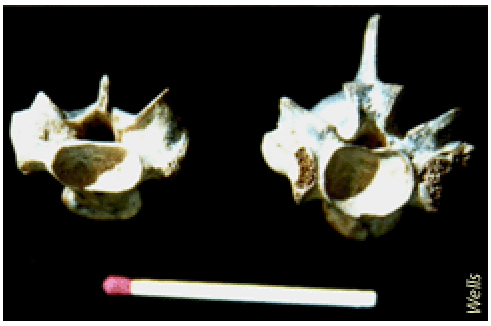
Reptiles can be identified by their vertebrae, teeth and skulls.

### Vertebrae

Reptiles have a 'ball & socket'-like articulation between their vertebrae (bones of the spine).




Reptile jaw showing articular bone




Reptile vertebrae

The cranial (skull) side of a vertebra is concave, whereas its caudal (tail) side is convex.
The processes (projections) on snake vertebrae differ from those of lizards.

### Lower Jaw

The lower jaw of a reptile consists of several bones.
The 'articular bone' at the back of the jaw bone articulates (ie hinges) with the quadrate bone on the side of the skull.

### Teeth

Reptile jaws have peg-like teeth all of the same type, with neither roots nor complex crowns.

This is related to their feeding; reptiles simply bite and swallow, they do not chew their food.
In the image on the right are the fossil jaw bones of three different lizards found at Naracoorte:


Reptile jaws with peg-like teeth

a. Goanna or Lace Monitor *Varanus varius*
b. Shingleback Lizard *Tiliqua rugosa*
c. Eastern Bearded Dragon *Pogona barbata*

## *Identifying Bird Bones*

Limb bones and vertebrae are used to identify birds, because their beaks are rarely preserved and they lack teeth.

### Limb bones

Bird bones are relatively hollow and light with extensive air spaces which reduce their weight for flight.

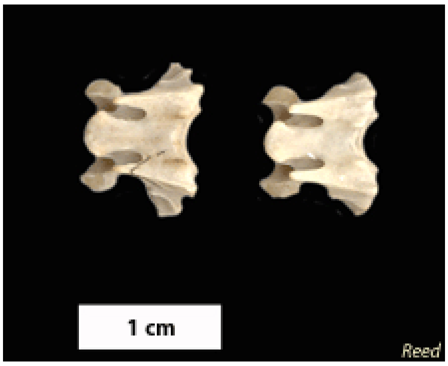
Even though the bones are thin-walled they have to be strong to resist the stresses involved in flight, and they are often preserved as fossils.

Limb bones of the Emu Dromaius novaehollandiae

### Vertebrae

Bird vertebrae are easily identified as their articulations (the joints between them) are 'saddle shaped'.

Each vertebra interlocks with adjacent vertebrae to provide the rigid support necessary for flight.



Neck vertebrae of a bird, showing the saddle shaped articulations

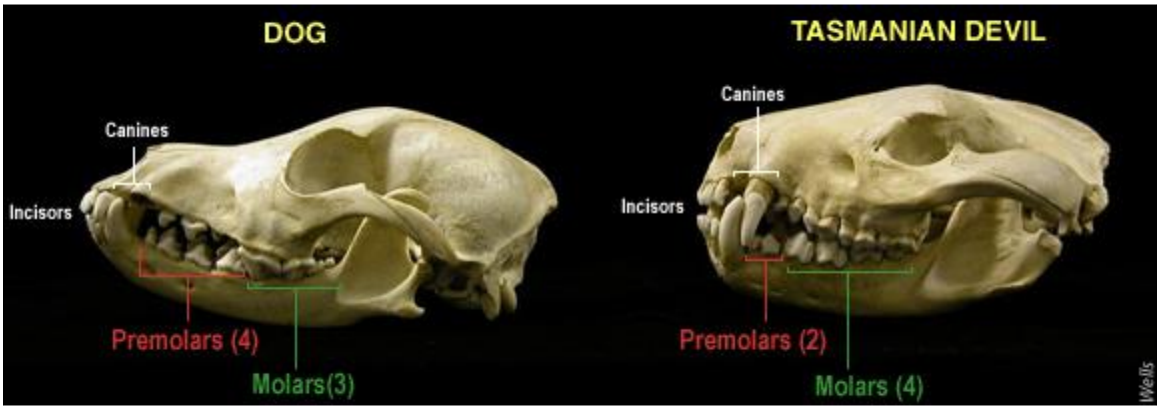
Most of Australia's native mammals are marsupials, eg kangaroos and Koalas.

Marsupials give birth to tiny young, which then mature in the mother's pouch. Placental animals, such as rodents and bats or introduced species like dogs and sheep, give birth to young which are sufficiently mature that they can survive in the outside world with care from the mother.

Features of their teeth and jaws distinguish marsupials from placental mammals.

### Numbers and types of teeth

Most marsupials have a maximum of three premolar and four molar teeth, whereas placental mammals generally have a maximum of four premolar and three molar teeth. In addition the crowns of marsupial teeth have a distinctive form different from that of placental mammals.

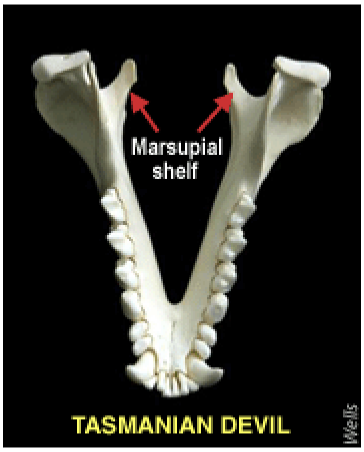


Placental mammals, like the dog, have different numbers of molar and premolar teeth than do marsupial mammals, such as the Tasmanian Devil

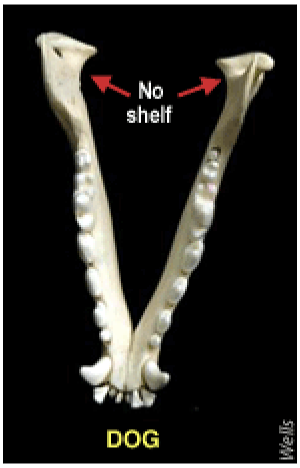
### Jaw shape

The lower jaw of marsupials has a pronounced angular process (often called the marsupial shelf) which is an area where the jaw muscles are attached.

Mammals do not have such a shelf on their lower jaw bones.



Marsupial mammals have a shelf to which the jaw muscles attach



Placental mammals have no shelf on the jaw bone

# How do we know what the muscles were like?

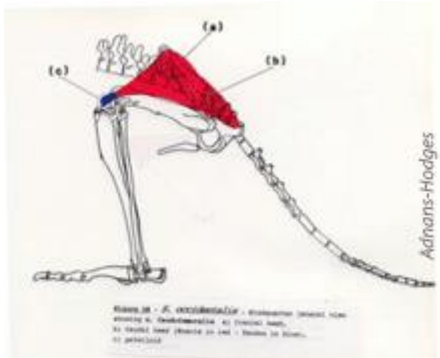
Piecing together the skeleton is the first step in reconstructing an extinct animal, and allows palaeontologists to begin the process of 'fleshing-out'the bones.
All vertebrates share the same basic muscular structure, but this varies according to the form and function of the animal's body. The skeleton holds all of the clues needed to determine the muscle arrangement, and from this the overall shape of the animal.

Grooves and ridges on bone surfaces show where muscles and their tendons were connected to the bone.
The nature of these 'muscle scars' gives an indication of a muscle's size and form.

Palaeontologists can then 'flesh-out' the skeleton muscle by muscle and eventually reconstruct the entire animal.
In many cases palaeontologists use clay models or sketches to assist with this process.


Femur bone with a muscle scar


Clay models demonstrate the reconstructed musculature.




The size and form of each muscle can be deduced from grooves and ridges on the bones and reconstructed graphically

To determine how an animal moved, the articulating surfaces of the joints (eg hinge-like, or ball-and-socket) and the related muscle structure is studied as these factors suggest how the various body parts moved in relation to each other.

Palaeontologists can then suggest how it hopped, used its upper limbs, gathered and chewed its food, and even estimate its speed.

**Rebuilding Jaw Muscles**

The cranial elements (skull and jaws) of an animal provide much information about its overall form and function.

The famous anatomist and palaeontologist Georges Cuvier (1769-1832) was reported to be able to reconstruct an extinct animal from a single tooth or fossil fragment. He was able to do this as he had a deep knowledge of the comparative anatomy of living organisms.

Today, palaeontologists use their knowledge of the musculature of modern animals to compare and contrast between these and extinct species.

The arrangement of the cranial muscles provides palaeontologists with information regarding the range of jaw movement, the diet of the animal and the shape of the head and its soft tissues.

Mammals have 3 main jaw muscles which control chewing motions.

Reconstructing the head of Thylacoleo carnifex

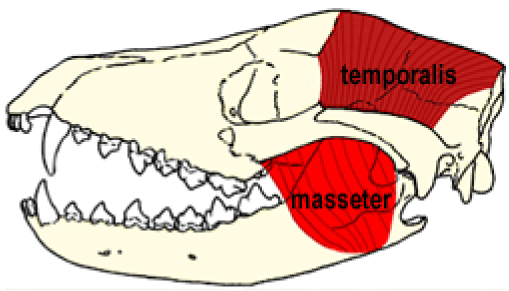
*Masseter* - provides slow, powerful jaw closure with forward/back/side-to-side chewing motions.

*Temporalis* - delivers fast and forceful jaw closure in the up/down plane.

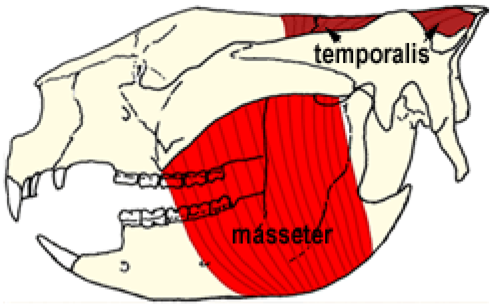
*Pterygoid* - produces sideways jaw movements.

An animal's diet, method of eating, and lifestyle is closely related to the relative size of each of these muscles.

In carnivores the temporalis muscle is well developed, because it must drive the canine teeth forcefully into its prey.



Carnivore Jaw Muscles




Herbivore Jaw Muscles

Herbivores have well-developed masseter and pterygoid muscles because they need to move their jaws in a circular motion to grind and crush plant material.

(The pterygoid muscles are on the inner side of the jaw, and cannot be seen in these diagrams.)

## How do we know what the animals looked like?

Unless time machines become a reality, we will never be able to see an ancient extinct animal first-hand.


Attaching an ear to a model of Diprotodon australis

In very rare cases soft tissues and hair of extinct animals have been preserved, but for the most part palaeontologists must use the only evidence they have, that is, the fossilised bones and other traces of past life.

The shape and structure of the skull provides clues for palaeontologists regarding the size and position of the ears and eyes.

For example the skull of the extinct kangaroo *Simosthenurus occidentalis* shows that unlike other kangaroos its eyes were positioned more forward, giving it almost binocular vision.

Palaeontologists may also make casts of the inside of the brain case or use CT scans to study the structure of the brain of extinct animals.

This enables them to determine which of the senses were the most important to the animal's lifestyle.


Sewing fur onto a model of Procoptodon goliah

For example by studying the brain structure of *Tyrannosaurus rex* scientists have found that its vision was quite poor, but its sense of smell was very good. This has led some to suggest the animal was a scavenger. A similar approach has been used in a study of the brain of *Thylacoleo*, the 'Marsupial Lion'.

Unfortunately bones cannot provide the whole story. The type and colour of an animal's hair and fur is not able to be deduced from bones. In some cases hair has been preserved (eg in dry caves where bodies mummify), but usually no trace is left.

To reconstruct the entire animal palaeontologists have to make educated 'guesses' about what the fur was like and they do this by first determining the function and probable habitat of the animal and then comparing with similar modern forms. For example, if an animal was a predator living in a forest it may have had some sort of camouflaging coat pattern to conceal it from prey.

Constructing a model of Procoptodon goliah

These factors were taken into consideration by the palaeontologists and artists who created the megafauna display in the Wonambi Fossil Centre.

This enabled them to make the models you see in the display as realistic as possible based on current evidence.

Adding skin and scales to a model of Wonambi naracoortensis

## An example of paleontology at work - what was Simosthenurus occidentalis like?

Palaeontologists have excavated bones from *Simosthenurus occidentalis* from the caves, assembled the skeleton, and deduced what the muscles and other features of the animal were likely to have looked like. They have also described its likely behaviour and habitat.

## Simosthenurus - *Reconstructing the Skeleton*

When all the bones had been identified, palaeontologists began constructing a life-sized model.


Simosthenurus bones laid out in order

Laying the bones out in two dimensions gave an initial picture of what the animal might look like.

The fundamental structure of all vertebrates - a backbone with attached ribs, fore and hind limbs, and a skull and jaw bones - guided the arrangement of the bones.

Once laid out, it became clear that the animal had small forelimbs, large strong hind limbs, and a long tail.

Light epoxy-resin casts were made of the original, fragile bones. These were used to construct a 3-dimensional model.

The main parts of the backbone and tail were threaded onto a wire frame and glued together, defining the body shape.

Other bones were then connected to the backbone by wire frames, glue and bolts.
The skeleton's posture is dictated by how the bones fit together (articulate), and its kangaroo-like form is evident.


The model is assembled on a wire frame

Artist's drawing of the skeleton of Simosthenurus occidentalis

**Simosthenurus - *Identifying the Type of Animal***

By looking at the way the bones fit together, it is clear that *Simosthenurus occidentalis* was a kangaroo-like marsupial.

Comparison with the skeletons and skulls of modern marsupials helps us understand its relationship to them, and what missing portions of its skeleton may have looked like.


Skull of the extinct Short-faced Kangaroo

**Similarities to modern marsupials**

The lower jaw of *Simosthenurus occidentalis* has a deep 'U-shaped' pit, called the masseteric fossa. This feature is only found in marsupials of the kangaroo family.
Thus even without knowing what the whole skeleton looked like, the presence of a deep masseteric fossa suggests that *Simosthenurus occidentalis* was related to kangaroos.

This is congruent with the kangaroo-like model of the skeleton.

Differences from modern marsupials
The bones of *Simosthenurus occidentalis* are generally more robust. The shorter and deeper skull has led to its common name, the 'Short-faced Kangaroo'.

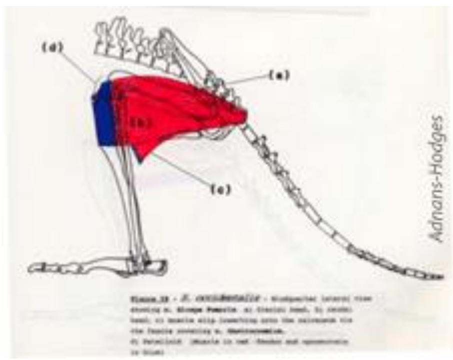

Skull of the modern Grey Kangaroo

## Simosthenurus - *Rebuilding the Muscles*

Once the skeleton had been put together, and the type of animal identified, the focus shifted to reconstructing the musculature of *Simosthenurus occidentalis*.

For example, the hind limbs and feet of *Simosthenurus* have sufficient similarities to modern kangaroos, for us to deduce that it used a similar bipedal (2-footed) hopping motion.


The modern kangaroo moves both feet together, even for small steps. The tail provides support




The muscle scars on the leg bones of Simosthenurus indicate that the leg muscles were large and powerful

However, in contrast to modern kangaroos,the forelimbs of *Simosthenurus occidentalis* were sufficiently long and were articulated in such a way that they would have been able to reach over their heads; modern kangaroos can not do this.

By looking at the shapes of the other bones, and the muscle scars on them, palaeontologists built up a picture of the musculature of the complete animal.

Artist's impression of the musculature of Simosthenurus occidentalis

## Simosthenurus - *Deducing the Appearance*

Palaeontologists developed a picture of how *Simosthenurus occidentalis* might have looked, based on inferences from the skull and bone structure, and on the appearance of related modern-day animals.

Once the musculature had been deduced, the shape of the body was known. Here it is modelled in clay for display in the Wonambi Fossil Centre.

Working on a clay model of Simosthenurus occidentalis

Then the outer features,such as the shape and position of eyes and ears, and the type of skin covering, were decided.
Eyes and ears are critically related to the character of an animal, its habitat and behaviour.

The size and alignment of *Simosthenurus occidentalis* ' eye sockets indicates a degree of stereoscopic vision, providing an ability to judge distance.
This would be important when reaching for vegetation or hopping through dense undergrowth.


The position of the eye sockets suggests that...

The size and alignment of *Simosthenurus occidentalis* ' eye sockets indicates a degree of stereoscopic vision, providing an ability to judge distance.

This would be important when reaching for vegetation or hopping through dense undergrowth.


...the eyes looked forward, providing binocular vision

The size of the ears is not known, but would be sufficient to capture the lowest frequency sounds that transmit well through a forest. *Simosthenurus occidentalis* probably had fur, since fur is a characteristic of almost all marsupials.

Although we cannot determine its precise colouration, it would have been suited to the animal's environment and lifestyle.

Artist's impression of Simosthenurus occidentalis

## Simosthenurus - *Deducing the Posture*

The spine and muscles of *Simosthenurus* were strong enough that it could stand upright to reach leaves

The structures of the pelvis (hip) and vertebrae of the lower back show *Simosthenurus occidentalis* could maintain an erect, upright stance.
The articulations between vertebrae indicate the spine was relatively rigid with limited sideways movement. Strong muscles prevented the hind-limbs from splaying outwards under the weight of the large body. These features are necessary for an animal to remain upright for long periods.

The structure of the shoulder joint, arm bones and muscles, indicate that *Simosthenurus occidentalis* could reach well above its head. Modern ground dwelling kangaroos cannot do this.

These abilities, to remain erect and to reach above its head, are related to the feeding habit of *Simosthenurus occidentalis*.

## Simosthenurus - *Deducing Habits*

*Simosthenurus occidentalis* was an upright browser, inhabiting forest or woodland environments.

By rearing up to the full extent of its hindlimbs and reaching over its head it would grasp high leaves and branches, break them off, or pull them down to the level of its mouth. The powerful jaw muscles and large cheek teeth would enable it to cut and crush vegetation.

Although *Simosthenurus occidentalis* used the 'kangaroo' bipedal hop, its stocky frame and large head imply it was a slow-moving animal. Rapid movement in a straight line would be of less value in a forested area.

In contrast, modern kangaroos are more lightly built, fleet-footed and better adapted to a grazing diet on the open grasslands.

# Glossary

## A

ABRASIVE VEGETABLE MATERIAL

foliage that contains grains of silica that cause tooth wear due to scratching and abrasion.

ACCUMULATION

the process by which bones are introduced into the cave.

ADAPTATION

a biological modification that makes an organism better suited for a particular way of life, for example the sharp talons of a bird of prey are adaptations for killing prey.

AMPHIBIAN

major group of vertebrates which develop gills for breathing in water when young, and have lungs for breathing air as adults (eg frogs).

AQUATIC

living in or spending considerable time in water.

ARBOREAL

living in trees.

ARID

dry region where annual rainfall does not exceed evaporation.

ARTHROPOD

a member of the phylum Arthropoda: animals with segmented bodies, hard exoskeletons and many jointed legs includes insects, spiders, crustaceans, millipedes, centipedes, scorpions.

ARTICULATED

bones that are still attached at the joints as they are in life. See articulated bones of *Thylacoleo* hand

ASSEMBLAGE

a collection of fossils from a single site.

AVEN

cylindrical hole, generally in the cave ceiling, that has been formed via dissolution of limestone by water. See avens in Wet Cave.

## B

BARN OWL

see *Tyto alba*.

BIPEDAL

moving on the 2 hind legs only.

BROWSER

a herbivore that eats mainly leaves, shrubs, trees and ferns. See Browsers page

BRYOZOA

aquatic, colonial organisms which are abundant in marine environments; prevalent in the fossil record and a large component of the limestone at Naracoorte.

## C

CALCAREOUS

containing calcium carbonate.

CANINES

the teeth between the incisors and premolars in mammals; used for piercing and biting.

CARBONATE

mineral compound characterized by C2O3; a precipitate of carbonic acid.

CARNIVORE

a group of mammals that eat meat, possessing well-developed teeth for this diet. See Carnivores page

CARNIVOROUS

an animal that eats the flesh of other animals, but is not necessarily a true carnivore (see above).

CARRION

the flesh of a dead animal.

CATASTROPHE

a sudden and devastating event.

CLASS

high-level taxonomic grouping of similar organisms which contains one or more orders; similar classes form a phylum.

COASTAL HEATH

sandy coastal area with abundant low shrubby vegetation.

COLLAPSE DOME CHAMBER

a cave chamber that has formed via collapse of limestone along bedding planes to form a domed shape.

COMMON BENTWING BAT

see *Miniopterus schreibersii*.

COMMUNITY

populations of living organisms that interact within a particular environment.

CONSTRICTORS

large, non-venomous snakes that coil around their prey and squeeze to kill it.

CREPUSCULAR

active at dawn and dusk, in dim light.

CROWN

the enamel-covered part of the tooth.

CURSORIAL

a running or walking animal.

CUSP

pointed projection on the tooth crown.

## D

DATING

the process by which the age of fossils or rocks is determined; relative dating refers to ageing strata (layers) by their stratigraphic position; absolute dating refers to ageing materials using chemical and physical techniques.

DEN

an area where an animal goes to sleep or eat (eg some animals use caves in this manner).

DENTARY

the lower jaw bone; the combined left and right dentaries form the mandible.

DENTINE

hard and dense material found in the teeth of vertebrates.

DENTITION

term used to describe all of the teeth of an animal combined.

DEPOSIT

rocks, sediments and/or fossils laid down together (eg fossil deposit).

DIAGNOSTIC

characters that can be used to identify a species.

DIASTEMA

the gap between the front teeth (incisors and canines) and the cheek teeth (premolars and molars) used by herbivores for manipulating food in the mouth. See Grazers page.

DIETARY NICHE

the specific position occupied by an organism in the food chain.

DINGO

large dog (*Canis lupus dingo*) introduced to Australia by Indigenous peoples around 3,500 years ago.

*DIPROTODON AUSTRALIS*

largest marsupial to ever live, weighed as much as 2.5 tonnes. See *Diprotodon australis* page.

DIPROTODONT

possessing paired, forward-projecting incisor teeth; characteristic of diprotodontian marsupials (eg possums, kangaroos, wombats, Koalas and extinct groups).

DIPROTODONTIDS

a group of large extinct herbivores belonging to the family Diprotodontidae.

DISARTICULATED

bones that are detached at the joints and separated.

DISTAL

furthest from the body.

DIURNAL

active during the day time.

DNA

Deoxyribonucleic acid, genetic material that determines the inherited characteristics in living organisms.

DORSAL

referring to the uppermost surface.

DUNE

body of sand that is piled up by the action of water or wind.

## E

ECHOLOCATION

analysis of reflected sound waves used to determine the nature and position of objects; aids in maneuvering and hunting; used by bats, whales and dolphins.

ECOLOGY

study of organisms and how they interact with their environment.

ECOSYSTEM

a system involving the interactions between a community and its non-living environment.

ENDEMIC

present within a localized area.

EPIPUBIC BONES

long, slender bones radiating from the pelvis of marsupials that aids in supporting the pouch; diagnostic of marsupial mammals.

EUCALYPT

plants belonging to the genus *Eucalyptus*, the gum trees.

EVOLUTION

the model explaining the origins of life and how pre-existing species change into new species.

EXTANT

a species of plant or animal that is still living.

EXTINCT

a species of plant or animal that no longer exists.

## F

FAMILY

a division of the system for classifying living things that is comprised of related genera (groups).

FAUNA

referring to animals.

FLORA

referring to plants.

FOLIAGE

the leafy parts of plant material.

FORAGE

to actively search for food.

FOREST

an area of vegetation dominated by large trees with a dense shrubby understorey. See Forests page.

FOSSIL

any remains or trace that preserves past life.

FOSSIL DEPOSIT

a naturally accumulated collection of fossils in one area.

FOSSIL RECORD

term used to describe the record of life on Earth as evidenced by fossils.

FOSSILISATION

the process by which organic materials within bones and other remains of organisms are replaced by inorganic materials ie mineralised.

## G

GENUS

a division of the system for classifying living things that is composed of related species.

GEOGRAPHIC RANGE

the area of land that includes all extents of the range that an animal occupies.

GIRTH

the circumference of an animal's abdomen.

GIZZARD

the thick walled part of bird's stomach; also the stomach and entrails generally.

GLACIAL

a cold phase within an ice age when glaciers (mobile ice masses) advance. See also Ice age.

GONDWANA

ancient southern supercontinent that included Australia, New Zealand, Antarctica, South America, South Africa, Madagascar, Arabia and parts of the Middle East and South-east Asia.

GRASSLAND

an area of vegetation that is essentially treeless and dominated by grasses. See Grassland page.

GRAZER

a herbivore that eats grass. See Grazers page.

GUANO

term usually used to describe the faeces (droppings) of bats and birds.

## H

HABITAT

the environment in which an organism lives and exploits resources.

HERBIVORE

an animal that eats plants.

HOLOCENE

the geological time period extending from 10,000 years ago and including the present; also known as the 'Recent' period.

HYDROLOGICAL FLOWS

refers to the natural flows of water from rainfall and streams.

## I

ICE AGE

a period of several million years with alternating warm and cool global climates leading to the development of polar icecaps, glaciers, fluctuating sea levels and climatic changes.

INCISORS

the teeth at the front of the upper and lower jaws of mammals.

INDIGENOUS

originating or occurring naturally in a country or region.

INFRA-RED CAMERAS

cameras installed in the Bat Cave that have infrared diodes that flood the chamber with infrared light enabling photography without visible light.

INSECTIVORE

an animal that eats insects and other arthopods; also a member of the mammal group Insectivora. See Insectivores page.

INTERGLACIAL

the period between glacial maxima in a glacial cycle

INVERTEBRATE

an animal that does not have a backbone.

ISOTOPES

different forms of the same chemical element that possess the same number of protons but different numbers of neutrons in their nuclei. Some isotopes are radioactive (unstable).

## K

KOALA

see *Phascolarctos cinereus*.

## L

LACE MONITOR

see *Varanus varius*.

LAGOON

any small body of water.

LIGNIN

a constituent within cellulose of the cell walls of plant cells; functions in imparting rigidity.

LIMESTONE

sedimentary rock composed primarily of calcium carbonate.

LIMESTONE FORMATIONS

a term used to describe calcite decorations in caves such as stalagmites and stalactites.

## M

MACROPODID

member of the family Macropodidae, the kangaroos.

*MACROPUS RUFOGRISEUS*

extant, medium-sized wallaby known as the Red-necked Wallaby. See *Thylacoleo carnifex*.

MARSUPIAL SHELF

the angular process on the inner surface of the jaw bone that is unique to marsupial mammals.

MARSUPIAL TAPIR

see *Palorchestes azael*.

MASSETER

one of the cranial muscles used for controlling the action of the jaws; major function in sideways movement (chewing). See Jaw muscles page.

MATERNITY CHAMBER

term used to describe a chamber within a cave where bats give birth and raise their young.

MEGAFAUNA

literally means 'large animals' and generally refers to mammals of a body weight greater than 40kg; the Pleistocene megafauna includes large birds and reptiles as well.

MEGALANIA PRISCA

a large extinct goanna. See *Megalania prisca* page.

METABOLIC REQUIREMENTS

basic requirements to sustain the sum of chemical processes that occur in living organisms, thus keeping the animal alive.

MIGRATE

to journey between different habitats at specific times of the year.

*MINIOPTERUS SCHREIBERSII*

small insect-eating and cave-dwelling bat known as the Common Bentwing Bat. See Bentwing Bat page.

MIOCENE

the period of earth history occurring between 23.8 million years ago and 5.3 million years ago.

MOLARS

the teeth behind the premolars in mammals.

MONODACTYL

possessing one primary toe on the hind foot.

MONOTREME

egg-laying mammals including living Platypus and Echidnas.

MORPHOLOGY

of or pertaining to the shape of something.

MUSCLE SCAR

a roughened area on a bone that indicates the point of muscle attachment. See Rebuilding the Muscles page.

## N

NEURAL SPINES

projections from the neural arch of vertebrae. See Reptile skeletons page.

NICHE

the space in the environment occupied by a particular organism.

NOCTURNAL

animals that are active at night.

## O

OLIGOCENE

the period of earth history occurring between 33.7 million years ago and 23.8 million years ago.

OMNIVORE

an animal that eats a range of plants and animals. See Omnivores page.

ORDER

taxonomic category between class and family.

OSCILLATION

a cyclical fluctuation in state eg changes in climate from cold to warm conditions.

## P

PALAEOECOLOGY

the study of fossil organisms in terms of their mode of life and interrelationships with their environment, their manner of death and eventual burial.

PALAEOENVIRONMENT

the environment of the past.

PALAEONTOLOGIST

a scientist who studies fossils and ancient animal life.

*PALORCHESTES AZAEL*

large extinct marsupial that had sharp claws and a short trunk as adaptations to a browsing diet. See *Palorchestes azael* page.

*PERAMELES BOUGAINVILLE*

small, omnivorous marsupial known as the Western Barred Bandicoot. See Western Barred Bandicoot page.

PES

the hind foot.

*PHASCOLARCTOS CINEREUS*

extant browsing, arboreal marsupial known as the 'Koala'. See Koala page.

*PHASCOLARCTOS STIRTONI*

giant extinct Koala. See *Phascolarctos stirtoni* page.

PHENOLICS

large, diverse group of plant secondary metabolites; the phenol group includes lignin, tannins and flavonoids.

PHREATIC PASSAGE

a cave passage that has been formed by the action of ground water.

PITFALL

cave that acts as a natural trap for animals that fall into it.

PLACENTAL

having a placenta, which attaches the unborn baby to the mother's womb.

PLEISTOCENE EPOCH

the period of earth history occurring between 1.8 million years ago and 10,000 years ago.

PLIOCENE

the period of earth history occurring between 5.3 million years ago and 1.8 million years ago.

POLLEN

microscopic pores and grains produced by the male reproductive organs of flowering plants and seed-bearing plants for reproduction.

PREDATOR

carnivorous animal that hunts, kills and eats other animals.

PREMOLARS

the teeth between the canine and molar teeth in mammals.

PREY

animal hunted and killed by predator.

PROXIMAL

closer to the body.

*PSEUDECHIS PORPHYRIACUS*

extant, venomous snake known as the Red-bellied Black Snake. See *Pseudechis porphyriacus* page.

PTERYGOID

one of the cranial muscles used for controlling the action of the jaws; major function in regulating sideways movement. See Jaw muscles page.

PUP

term used to describe a baby bat.

PYTHONIDS

large snakes belonging to the group known as pythons.

## Q

QUADRUPEDAL

moving on all 4 legs.

QUATERNARY

the geological time period spanning from 1.8 million years ago, up to and including the present; includes the Pleistocene and Holocene epochs.

## R

RECURVED

bent or curved backwards.

RED-BELLIED BLACK SNAKE

see *Pseudechis porphyriacus.*

RED-NECKED WALLABY

see *Macropus rufogriseus*.

REGURGITATE

to bring partly digested food back to the mouth.

REPTILE

cold-blooded vertebrate belonging to the class Reptilia includes lizards, crocodiles, snakes, tortoises and turtles.

RIVERSLEIGH

World Heritage fossil site in northern Queensland that contains significant bone-bearing limestone outcrops representing the remains of ancient rainforests.

RODENT

small mammals belonging to the order Rodentia (includes the rats and mice).

## S

SALTATORIAL

a hopping animal.

SARCOPHILUS HARRISII

medium-sized marsupial carnivore, also known as the 'Tasmanian Devil'. See Tasmanian Devil page.

SCANSORIAL

an animal that is capable of climbing and generally shelters in trees and forages on the ground.

SCAVENGER

an animal that feeds on the flesh of dead animals (carrion).

SCLEROPHYLL

pertaining to plants with thick, hard leaves that help reduce water loss (eg eucalypt and heath species).

SECTORIAL

adapted for cutting or slicing.

SEDGE

grasslike plant growing in wet areas such as swamps.

SEDIMENT

material that has been deposited by water, wind or ice (eg sand in a cave).

SEDIMENT CONE

conical pile of sediment formed underneath a cave entrance.

SEMI-OPPOSABLE THUMB

capable of extending across to the opposite side of the hand.

SENSORY SYSTEM

the system of an animal that includes the senses (ie hearing, vision, touch, taste).

*SIMOSTHENURUS*

a genus of extinct leaf-eating, short-faced kangaroos.

SITE

an individual fossil locality or deposit from which fossils have been excavated or collected.

SOLITARY

living independently of other organisms.

SOLUTION PIPE

narrow, cylindrical cave entrance formed when water dissolves limestone along vertical joints within the rock.

SPECIES

any of the taxonomic groups into which a genus is divided, the members of which are incapable of interbreeding and have morphological or genetic traits.

SPELEOTHEM

term given to describe all cave formations such as stalactites, stalagmites, flowstones etc.

STALACTITE

elongated, calcite formation found on the ceiling of caves.

STALAGMITE

elongated, calcite formation found on the floor of caves.

STHENURINE

an extinct kangaroo belonging to the sub-family of kangaroos *Sthenurinae*.

*STHENURUS*

a genus of extinct leaf-eating, long-faced kangaroos.

STRATIGRAPHY

study of the origin of, and relationships between layers or 'strata' of sedimentary rocks and sediments.

SUBFAMILY

taxonomic classification between genus and family which comprises related genera.

SUBSPECIES

animals within the same species but living in different geographic regions, and displaying slight differences in genetic or morphological characteristics.

SUPERFAMILY

taxonomic classification between family and order which contains related families.

SWAMPLAND

an area of low-lying land subject to inundation and dominated by water plants, sedges and reeds. See Swampland page.

SYNDACTYLY

the state where all or some of the toes or fingers are joined together by a web of skin (eg the second and third hind toes of kangaroos).

## T

TAPHONOMY

the study of the processes leading to the accumulation, dispersal and modification of fossil deposits.

TAPIR

large mammal with a elongated nose forming a small trunk; found in Asia and South America; feeds on invertebrates, fruits and plants.

TASMANIAN DEVIL

see *Sarcophilus harrisii*.

TASMANIAN TIGER

see *Thylacinus cynocephalus*.

TAXON

used to describe any taxonomic category.

TAXONOMY

the study of the systematic classification of organisms into various related groups, for example, family, genus and species.

TEMPERATE

having a climate intermediate between tropical and polar; mild or moderate in temperature.

TEMPORALIS

one of the cranial muscles used for controlling the action of the jaws; major function in jaw closure. See Jaw muscles page.

TERPENES

compounds of the formula (C5H8)n the majority of which occur in plants.

TERRESTRIAL

living on the land surface.

TERTIARY

the period in geological time encompassing the period from 65 million years ago until 1.8 million years ago.

TETRAPOD

four-legged vertebrate animals, includes all birds, reptiles, amphibians and mammals (although some have 'lost' or reduced limbs, eg snakes).

*THYLACINUS CYNOCEPHALUS*

extinct marsupial carnivore, also known as the Tasmanian Tiger. See *Thylacinus cynocephalus* page.

*THYLACOLEO CARNIFEX*

extinct marsupial carnivore. See *Thylacoleo carnifex* page.

TORPOR

a short period of dormancy and state of reduced body temperature and metabolism; used by many bats to conserve energy.

TUSSOCK

a dense tuft of vegetation (eg grass).

TYPE LOCALITY

the site from which the first specimen was recorded.

TYPE SPECIMEN

the first specimen of an organism to be scientifically named and recorded.

TYTO ALBA

the Barn Owl, a nocturnal bird of prey. See Barn Owl page.

## U

UNDERSTOREY

the floor of woodlands or forests where ground-dwelling animals live; typically displays a wide range of vegetation.

## V

*VARANUS VARIUS*

large extant goanna (monitor lizard), also known as the Lace Monitor. See Goanna page.

VEGETATION

term used to describe plant material.

VERTEBRAE

the bones of the backbone. Vertebrates have five types - cervical (neck), thoracic (trunk with ribs), lumbar (lower back), sacral (joins with the pelvis) and caudal (tail).

VERTEBRATE

an animal possessing a backbone.

## W

WARREN

a system of burrows constructed by burrowing animals such as wombats.

WESTERN BARRED BANDICOOT

see *Perameles bougainville*.

*WONAMBI NARACOORTENSIS*

a large, extinct madtsoiid snake. See *Wonambi naracoortensis* page.

WOODLAND

an area of vegetation containing more trees than a grassland, but less than a forest, with a thick and diverse understorey of smaller plants. See Woodland page.

## Z

*ZYGOMATURUS TRILOBUS*

large extinct marsupial, around the size of a pygmy hippopotamus. See *Zygomaturus trilobus* page.

# Further Reading

*The references in this section are arranged by headings according to the sections on the web site.*

*Some references are listed in more than one category.*

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