Vertebrate Palaeontology and Evolution study pack

This resource is designed to familiarise you with the structure, diversity and evolutionary history of vertebrates through analysing images of specimens held at UCL’s [Grant Museum of Zoology](http://www.ucl.ac.uk/museums/zoology). It contains seven chapters: an introduction to vertebrate diversity, Fishes, the fish-tetrapod transition, Amphibians and Amniotes, Lepidosaurs and Chelonians, Archosaurs, and Birds and flight. All images have accompanying text, including information about the specimen plus hints about what to look for and the questions to consider when analysing the images. Please note that this resource does not look at mammals in detail – instead, this fascinating group are given a more thorough treatment in another Object Based Learning for Higher Education (OBL4HE) resource entitled ‘Vertebrate Diversity’ and the Virtual Educational Resource for the Biosciences (VERB) resource ‘Eutherians’.

* Verb Diversity: <https://open-education-repository.ucl.ac.uk/id/eprint/204>
* Eutherians (VERB): <https://open-education-repository.ucl.ac.uk/id/eprint/210>

Scalebars are provided throughout (except for models). Please note that there are two different scale bars used, one with 1cm divisions and one with 0.5cm divisions.

Multiple images of specimens are provided to try to illustrate the various anatomical features. However, please note that the limitations of photography (especially for specimens in cases or bottles) means that some distortion may occur or parts may be concealed or generally hard to determine.

To **download** this resource in its entirety, see the resource's collection page: <https://open-education-repository.ucl.ac.uk/195/>

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# Chapter [6: Archosaurs](http://www.ucl.ac.uk/museums-static/obl4he/vertebratepalaeo/6_archosaurs.html)

This chapter will look at archosaurs. As you look at the various specimens, focus on the fenestration of the skull.

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## 6.1 Hyperodapedon gordoni



This is a cast of the skull and lower jaw of a rhynchosaur. Rhynchosaurs are [basal](#_Basal) archosauromorphs. They are characterised by a beak-like snout. Note the single external nostril at the front of the snout – in life the flesh of the nose probably divided this into two openings.

Although rhynchosaurs are archosauromorphs, they lack the antorbital opening and external mandibular opening. Identify the [orbit](#_Orbit)s and the temporal openings and bars.





## 6.2 Euparkeria

This is a cast of the partial skull of Eurparkeria, an archosauriform reptile from South Africa. Don’t expect to get too many anatomical details from this one as it is disarticulated and incomplete, but it is worth examining.



Here are two web resources for this [taxon](#_taxon). [The first](http://www.ucmp.berkeley.edu/diapsids/euparkeria.html) is a brief review and contains a life reconstruction. [The second](http://www.ucmp.berkeley.edu/taxa/verts/archosaurs/euparkeria.php) includes anatomical reconstructions of the skull and the whole body.

## 6.3 Sphenosaurus

This is a cast of the head, vertebral column and ribs of an extinct eusuchian crocodile from the Late Cretaceous of North America and Europe.



## 6.4 Crocodylus





This is the skull of an [extant](#_extant) crocodile, though a different specimen from that seen in Chapter 1.





Identify as many of the openings in the skull as you can. Note the absence of the antorbital fenestra. Note the complex sculpturing of the external [dermal bone](#_Dermal_bone) surfaces.



Look at the simple tooth shape and note how the upper and lower sets of teeth interdigitate.



Examine the bony secondary palate and consider which bones are involved in its formation. Locate the internal nares and work out where the nasal passages must run in order to link internal and external nares. Where would the major jaw closing and opening muscles be located?

Note that the snout is relatively broad and flat and compare its general shape with that seen in *Tomistoma* later in this practical. Note how the jaw margin undulates along its length – why would this be a useful adaptation?

## 6.5 Tomistoma

This is a typical ‘longirostrine’ form specialised for eating a more exclusively fish-based diet. Elongation of the snout in a manner similar to this seems to have occurred several times during the evolution of crocodiles and today the forms with the longest snouts include the gavial, false gavial (shown here), Johnston’s crocodile, the African long-snouted crocodile and the New Guinea crocodile. Tomistoma is found in south-east Asia and northern Australasia.



Examine the long snout, external and internal nares, tooth crown shape, and the manner in which upper and lower sets of teeth interact.









Photographs of a wide variety of living crocodiles including Tomistoma [are shown here](http://archosaurmusings.wordpress.com/2012/02/18/a-return-to-the-crocdilian-panoply/). Note the differing jaw and skull shapes present.

## 6.6 Scaphognathus crassirostrus

Pterosaurs were flying archosaurs. Their wing membrane was supported by the forelimb, including a long fourth digit on the hand. This small form is known from the Late Jurassic of Europe.



Note the presence of long, forward slanting teeth. The skull is long and low. Study the elements of the forelimb.

## 6.7 Pterodactylus antiquus

Pterosaurs were flying archosaurs. Their wing membrane was supported by the forelimb, including a long fourth digit on the hand. This is a cast of a representative pterodactyloid from the Late Jurassic of Europe.



[This website](http://pterosaur.net/index.php) has a great deal more on pterosaurs and their evolution.

## 6.8 Coelophysis sp.



This is a cast of the skull and mandible of a small theropod dinosaur from the Late Triassic of New Mexico and Arizona. Note the long low shape of the skull, with its numerous small teeth and highly fenestrate construction.





Identify the major openings in the skull. Can you find the choanae (the internal nostrils – on the palate)?





## 6.9 Megalosaurus bucklandi

This is a cast of the premaxilla and maxilla of a large theropod dinosaur from the Middle Jurassic of Oxfordshire.Megalosaurus is a poorly understood form, partly because it is known from a large quantity of fragmentary and disarticulated material. Recent studies suggest that it is a basal tetanuran theropod. Megalosaurus is of considerable historical interest because it is the first dinosaur genus to be named – William Buckland published the name in 1824.



Note the presence of large recurved tooth crowns. Can you identify the ‘ascending process’ of the maxilla, which forms the anterior margin of the antorbital fenestra?

## 6.10 Dinosaur footprint



This is the cast of a footprint from a large theropod dinosaur. Such footprints are usually ‘three-toed’, although their structure is highly variable because of variations in the substrate combined with the way the foot was emplaced during the stepping motion. Ornithopods often produce large three-toed tracks, and it is sometimes difficult to distinguish them from those of theropods.



## 6.11 Theropod egg



This is a cast of part of an oviraptorosaur dinosaur egg. Note the elongate shape of the egg. Egg shape is highly variable in dinosaurs, with some being spherical and others more elongate. This variation may partly reflect the type of dinosaur that produced the egg (e.g. sauropods tend to lay spherical eggs), and may also indicate the way the eggs were stacked in the nest.

There are now several specimens known with an adult animal brooding on the nest of eggs [as seen here](http://archosaurmusings.wordpress.com/2009/05/20/big-mama-%E2%80%93-nesting-dinosaurs/).

## 6.12 Iguanodon sp.

This is a femur of *Iguanodon*, an Early Cretaceous ornithopod dinosaur from southern England and Belgium.





Note the presence of two articular condyles at the end of the femoral shaft, which form part of the knee joint.



## 6.13 Dinosaur skin

This is a cast of the skin impression of a hadrosaur dinosaur.



## 6.14 Other taxa

A number of [taxa](#_taxon) were also covered in this chapter that had appeared in previous chapters.

The dinosaur *Compsognathus.*

The crocodilian *Alligator.*

These are detailed in [Chapter 1](https://open-education-repository.ucl.ac.uk/id/eprint/194).

# [Glossary](http://www.ucl.ac.uk/museums-static/obl4he/vertebratepalaeo/glossary.html)

## A

### akinetic

In anatomy, this refers to a low level of flexibility in a structure due to a lack of moveable joints.

### amniote

Those vertebrates with an amniotic egg. The [extant](#_extant) [clades](#_Clade) are Testudines (turtles), [Diapsida](#_diapsid) (lepidosaurians, crocodilians, and birds), and [Synapsida](#_synapsid) (mammals).

### anapsid

Skull possessing **no** **temporal fenestrae** (NB. an- = without).  
  
[Amniotes](#_amniote) with this skull condition form a [paraphyletic](#_Paraphyletic) group including the Parareptilia (turtles and their extinct relatives), the extinct common ancestor of all [amniotes](#_amniote), and [basal](#_Basal)eureptiles (the extinct precursors of [diapsids](#_diapsid)).  
  
Note that the Testudines (turtles and relatives) have modified the anapsid condition through a reduction (emargination) of the posterior region of the skull.

### Apatite

Calcium phosphate: the crystalline component of bone.

### apomorphy

A derived or specialised character.

### Appendicular skeleton

The endoskeletal element of the fins or limbs of a vertebrate, and their associated girdles (pectoral or pelvic).

### Axial skeleton

All parts of the vertebrate endoskeleton except the limbs or fins and their associated girdles. That is, the cranium, visceral skeleton, notochord, [vertebrae](#_vertebrae), and ribs.

## B

### Basal

Of, relating to, located at, or forming a base.

### Bicuspid

A tooth bearing two [cusps](#_Cusp).

## C

### Calcified cartilage

[Cartilage](#_Cartilage) strengthened with a scattering of [apatite](#_Apatite) crystals (calcium phosphate), as seen in Chondrichthians.

### Cartilage

A tough, elastic, fibrous connective tissue composed of collagen fibres. Used as skeletal tissue in vertebrates, it is non-mineralised and is often the developmental precursor of bone.

### Clade

A phylogenetic lineage comprising a common ancestor and all its descendant species.  
  
Note that the difference between a [taxon](#_taxon) and a clade is that a clade must include all descendant species from a common ancestor, whereas a [taxon](#_taxon) need not.

### cladistic

Relating to the branching sequences of [phylogeny](#_phylogeny).

### cladogram

A branching tree-like diagram representing the phylogenetic relationships (evolutionary history) of a lineage.

### cloaca

The common opening for the reproductive, urinary, and digestive tracts, seen in all vertebrates except therian mammals (marsupials and placental mammals).

The term comes from the Latin for sewer.

### Cursorial

Adapted for running.

### Cusp

The biting point of a tooth.

## D

### Dentary

The anterior bone of the lower jaw which bears the teeth. It forms the whole of the lower jaw in mammals.

### Dentine

A bone-like substance, lacking cell bodies and consisting mainly of calcium phosphate ([apatite](#_Apatite)) in a fibrous matrix.

### Dermal bone

A type of bone forming within the dermis - the deep layer of vertebrate skin cells below the surface layer, the epidermis.

### diapsid

Skull possessing both an **upper and a lower** **temporal fenestra** (NB. di- = two).   
  
[Amniotes](#_amniote) with this skull condition form the [monophyletic](#_monophyletic) [clade](#_Clade) **Diapsida**, which includes the lepidosaurs (lizards, snakes, and tuatara), archosaurs (crocodilians, dinosaurs, and birds), and their other extinct relatives.   
  
Note that some diapsids, such as lizards, have lost the temporal bar separating the fenestrae to form one large window. Others, such as the Aves (birds), have merged both fenestrae with the [orbit](#_Orbit).

## E

### Enamel

The crystalline material covering the crown of a tooth, or certain scales.

### Endopterygota

A [clade](#_Clade) of insects charachterised by their undergoing complete metamorphosis (i.e. [holometabolous](#_Holometabolous)).  
  
See Insect Diversity WebBook for the [clades](#_Clade) within (from Neuroptera down).

### Epidermal

Pertaining to, or originating from, the epidermis - the surface layer of skin cells in vertebrates

### euryapsid

Skull possessing an **upper** [**temporal fenestra**](#_temporal_fenestra) **only**.  
  
However, animals with this skull condition do not represent an important [amniote](#_amniote) lineage, as they are likely to be a [polyphyletic](#_polyphyletic) group, originating a least twice within the [Diapsida](#_diapsid). [Euryapsids](#_euryapsid) include the plesiosaurs and ichthyosaurs - Mesozoic marine reptiles.

### extant

Not extinct.

## F

### fossorial

Specialised for burrowing.

### furcula

The fused clavicle bones of a bird, also known as the wishbone.

## H

### Hemimetabolous

Refers to a type of insect development that is categorised by three distinct, progressive life stages: egg, nymph, imago (adult). Changes are gradual, with no pupal stage.  
  
Some hemimetabolous insects include grasshoppers, cicadas, cockroaches, termites, earwigs, and dragonflies.  
  
Also termed incomplete metamorphosis.

### Holometabolous

Refers to a type of insect development that is categorised by four distinct, progressive life stages: embryo, larva, pupa, imago (adult).  
  
Seen exlusively in the [Endopterygota](#_Endopterygota), which includes beetles, butterflies, wasps, bees, ants, and others.  
  
Also termed complete metamorphosis.

### Horny

Consisting of horn - a tough material composed mainly of keratin.

## I

### ilium

In tetrapods, the dorsal section of the pelvis, which articulates with one or more sacral [vertebrae](#_vertebrae).

## K

### Kinetic

In anatomy, referring to a high level of flexibility afforded by numerous moveable joints.

## L

### Lymph heart

Muscular dilation in a lymph vessel, which pumps lymph (fluid containing white blood cells called lymphocytes important in immune response) around the body of some lungfishes, amphibians and reptiles.

## M

### Metacone

In mammals, the metacone is the distobuccal (rear-most and cheek side) cusp of an upper molar tooth.

### monophyletic

Having a single evolutionary origin. A [taxon](#_taxon) is monophyletic if it contains all the descendants of a common ancestor.

For example, mammals are a monophyletic group, as all species descended from the first known mammal are considered mammals.

See [paraphyletic](#_Paraphyletic) and [polyphyletic](#_polyphyletic) for alternative terms.

### Myrmecophagy

Feeding behaviour categorised by an exclusive (or near exclusive) diet of ants ant termites.

## O

### Orbit

The bony socket of the eye.

### Osteosclerosis

An increase in the density of bone.

## P

### Pachyostosis

A thickening of the bone, often associated with a reduction in the volume of marrow tissue contained within.

### Paracone

In mammals, the paracone is the mesiobuccal (front-most and cheek side) [cusp](#_Cusp) of an upper molar tooth.

### Paraphyletic

A [taxon](#_taxon) including a common ancestor and some but not all of its descendants.   
  
For example, the class Reptilia is paraphyletic, as it does not include birds, who are considered a separate class: Aves. However, birds evolved from theropod dinosaurs, and are therefore reptiles themselves. Similarly, all tetrapods are, evolutionarily speaking, lobe-finned fish.  
  
Importantly, reptiles can be made [monophyletic](#_monophyletic) through the addition of birds to the [taxon](#_taxon).  
  
See [monophyletic](#_monophyletic) and [polyphyletic](#_polyphyletic) for alternative terms.

### Pectoral girdle

In vertebrates, the skeletal structure that provides support for the fore limbs or fins.

### Pelvic girdle

In vertebrates, the skeletal structure that provides support for the hind limbs or fins, which also fuses with the sacral [vertebrae](#_vertebrae).

### phylogeny

The evolutionary history of organismal lineages as they develop through time.

### plesiomorphy

An ancestral character.

### polyphyletic

Referring to a group that does not contain the common ancestor of all the [taxa](#_taxon) within. Therefore, this is not a true taxonomic group, but is often a term used to categorise organisms with a similar ecology, such as insectivorious mammals, or marine mammals.  
  
It is also used when the evolutionary origin of a group, such as snakes, is unsure, and characteristic species within may have originated separately.

### Protocone

In mammals, the protocone is the mesiolingual [cusp](#_Cusp) of an upper molar tooth.

### Pulp cavity

The space within a tooth, or a [dentine](#_Dentine) scale, occupied by blood vessels and nerves.

## S

### symplesiomorphy

A character that is shared between groups but was inherited from an ancestor prior to the last common ancestor.  
  
These are characters that - at the level at which they are referred to as sym[plesiomorphies](#_plesiomorphy) - are not used to form [cladistic](#_cladistic) groupings, or [clades](#_Clade).

### synapomorphy

A derived or specialised character that is shared between two or more groups, and was inherited from the common ancestor in which it originated.  
  
These are the characters that morphological systematists use to support the existence of particular [clades](#_Clade), forming the basis of the field of [**cladistic**](#_cladistic)**s**.

### synapsid

Skull possessing a **lower** [**temporal fenestra**](#_temporal_fenestra) **only**.   
  
[Amniotes](#_amniote) with this skull condition form the [monophyletic](#_monophyletic) [clade](#_Clade) **Synapsida**, which includes the mammals and their extinct ancestors, the non-mammalian reptile-like synapsids.  
  
Note that in the Mammalia, the lower temporal fenestra has merged with the [orbit](#_Orbit).

## T

### taxon

A group of organisms sharing a common ancestry.  
  
Note that the difference between a taxon and a [clade](#_Clade) is that a [clade](#_Clade) must include all descendant species from a common ancestor, whereas a taxon need not.  
  
Pl. taxa.

### temporal fenestra

An opening in the temporal region of the skull seen in [amniotes](#_amniote), providing a flat edge for the attachment of strong lower jaw closing muscles to the skull.  
  
[Amniotes](#_amniote) show **four skull types**, based on the position and number of these temporal fenestrae, two of which define two major lineages of the [amniotes](#_amniote). The skull types and associated groups are as follows:  
  
1) [**Synapsid**](#_synapsid) - Skull possessing a **lower temporal fenestra only**. [Amniotes](#_amniote) with this skull condition form the [monophyletic](#_monophyletic) [clade](#_Clade) [**Synapsida**](#_synapsid), which includes the mammals and their extinct ancestors, the mammal-like reptiles. Note that in the Mammalia, the lower temporal fenestra has merged with the [orbit](#_Orbit).  
  
2) [**Diapsid**](#_diapsid) - Skull possessing both an **upper and a lower** **temporal fenestra** (NB. di- = two). [Amniotes](#_amniote) with this skull condition form the [monophyletic](#_monophyletic) [clade](#_Clade) [**Diapsida**](#_diapsid), which includes the lepidosaurs (lizards, snakes, and tuatara), archosaurs (crocodilians, dinosaurs, and birds), and their other extinct relatives. Note that some groups within the [Diapsida](#_diapsid), such as lizards, have lost the temporal bar separating the fenestrae to form one large window. Others, such as the Aves (birds), have merged both fenestrae with the [orbit](#_Orbit).  
  
3) [**Anapsid**](#_anapsid) - Skull possessing **no** **temporal fenestrae** (NB. an- = without). [Amniotes](#_amniote) with this skull condition form a [paraphyletic](#_Paraphyletic) group including the Parareptilia (turtles and their extinct relatives), the extinct common ancestor of all [amniotes](#_amniote), and [basal](#_Basal) eureptiles (the extinct precursors of [diapsids](#_diapsid)). Note that the Testudines (turtles and relatives) have modified the [anapsid](#_anapsid) condition through a reduction (emargination) of the posteriorregion of the skull.  
  
4) [**Euryapsid**](#_euryapsid) - Skull possessing an **upper temporal fenestra only**. However, animals with this skull condition do not represent an important[amniote](#_amniote) lineage, as they are likely to be a [polyphyletic](#_polyphyletic) group, originating a least twice within the [Diapsida](#_diapsid). [Euryapsids](#_euryapsid) include the plesiosaurs and ichthyosaurs - Mesozoic marine reptiles.

## V

### vertebrae

From anterior to posterior:

Cervical vertebrae: Facilitate the mobility of the head. The first two, the **atlas** and the **axis** are highly specialised, the former articulating with the occipital region of the skull.

Thoracic vertebrae: Articulate with the ribs that fuse with the sternum.

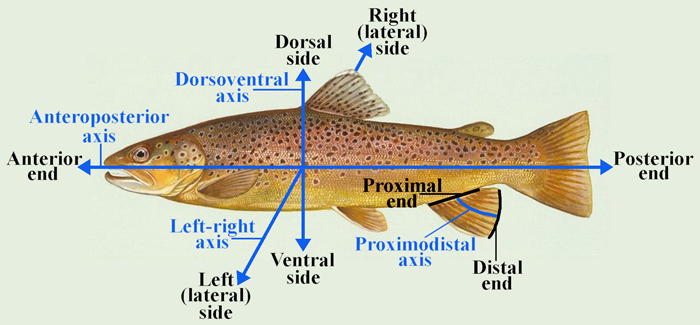
Lumbar vertebrae: Generally larger, with small ribs not attached to the sternum, which support the posterior musculature.

Sacral vertebrae: Fused to the [pelvic girdle](#_Pelvic_girdle), allowing the transfer of force from the [appendicular skeleton](#_Appendicular_skeleton) (limbs) during locomotion.

Caudal vertebrae: Small and less specialised, forming the tail.

### Vertebrate anatomical directions and axes

The image below illustrates the terms used for anatomical directions and axes in vertebrates.



### Vestigial

Occurring as a structure that, once functional (whether during development or in earlier evolutionary forms), is **now reduced** or **degenerate**. An example is the vestigial [pelvic girdle](#_Pelvic_girdle) seen in many snakes, including the boas and pythons, which bears no function.

## Z

### Zygapophysis

Articular process of a vertebra that articulates with the corresponding process of an adjacent vertebra.  
  
Plural = zygapophyses