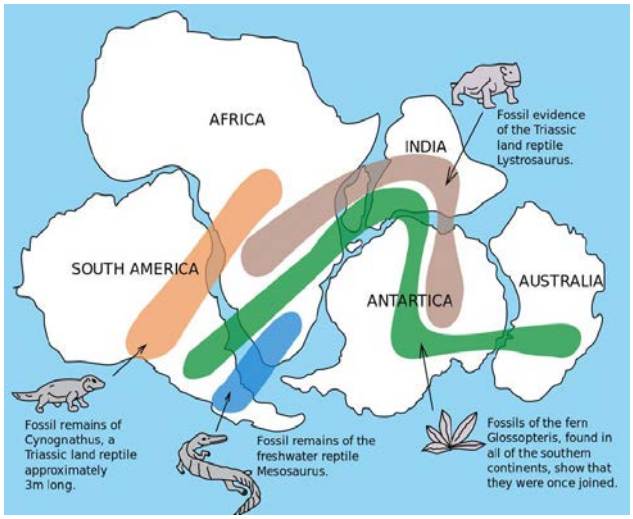
CLASS REPTILIA
SUBCLASS ANAPSIDA

As mentioned earlier, the Anapsida is a subclass within Reptilia, which is characterized by absence of any temporal opening. The most primitive anapsids are known from the early Permian, after which they diversified in the later part of Permian and are known from Africa, Russia, India, China and North America.

PAREIASAURS. These are known from Middle and Late Permian of Africa, western Europe, Russia and China. These were large animals up to 3 m in length, and skulls short and laterally expanded. The pareiasaurs were the first group of vertebrates to adapt to herbivorous diet.

Another group of Anapsida, which require special mention are the **MESOSAURS**. This group had adapted to life in water. They are characterized by a long snout and numerous long slender/fine comb-like teeth suggesting that these were piscivorous (fish-eaters). Their fossil records are known from the Permian of southern Africa and eastern South America, and their occurrence from these two regions only was considered as evidence for the Continental Drift Theory. Their occurrences in the adjacent but widely separated areas suggested that in the geological past, the two continents formed part of a supercontinent called Pangaea.

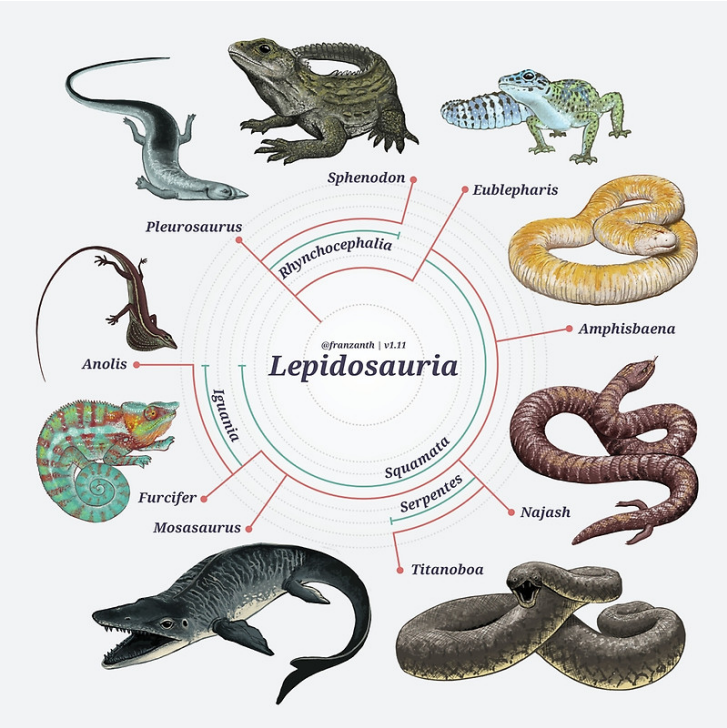


CLASS REPTILIA
SUBCLASS DIAPSIDA

The subclass Diapsida is characterized by the presence of two temporal openings on either side of the skull. The earliest known diapsid reptile is Petrolacosaurus from the late Carboniferous of the USA. Diapsida incorporates various types of living and fossil reptiles, including the dinosaurs. In cladistics, Diapsida is a monophyletic clade that includes the living forms such as snakes, lizards, crocodiles and birds.

Most diapsids can be grouped into two large groups — (1), Lepidosauromorpha and (2), Archosauromorpha.

Lepidosauromorpha



This group includes many fossils and living reptiles such as the lizards and snakes.

The lepidosauromorphs were small animals, characterized by a sprawling posture and use lateral undulation of the trunk for locomotion. Primitive forms are known from the late Permian and early Triassic. The lepidosaurs which include the snakes and lizards are the most diverse of the modern fauna and includes nearly 600 species. The snakes appeared in the Cretaceous, whereas early lizards (very small in size) are known from the Triassic and Jurassic sediments of Africa, Britain and India.

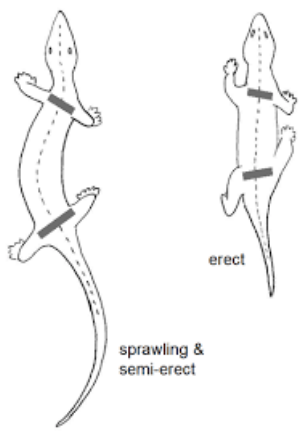
Evolution of posture

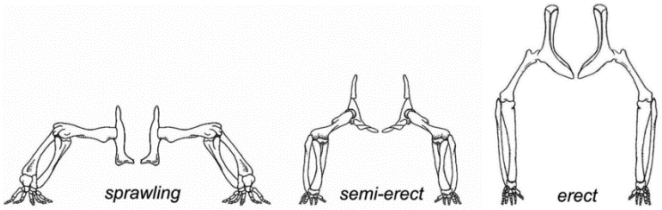
The evolution of Archosauromorpha resulted in an advanced structure of the pelvic girdle and hind limb bones that helped in the appearance of semi-erect (all archosaurmorphs) and erect (dinosaurs) postures from the sprawling posture (lepidosauromorph and other basal tetrapods).

Sprawling posture – when animals have the humerus and femur attached at 90° to the body axis and they move by the lateral undulation of the vertebral column. These animals spend appreciable amount of metabolic energy to move forward as their forward movement has a large lateral or sideways component. Example: lizards and snakes

Semi-erect posture – animals have body held up from the ground, and the humerus and femur are at acute angle to the body axis. Example: crocodiles walking on land and Komodo dragons. In case of the Komodo dragons, the forelimbs are in sprawling posture whereas the hindlimbs are semi-erect.

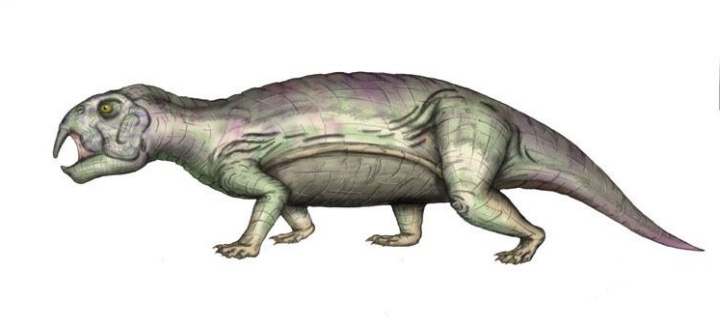
Erect posture – this is found in the mammals and birds. The limbs are arranged beneath the body axis, and the vertebral column does not have lateral motion but have a dorso-ventral movement. Example: horse, lion. Among the reptiles, such erect posture is known in the dinosaurs.





Archosauromorpha

The archosauromorphs first appeared in the Late Permian rocks. Most of these are carnivorous though omnivores/herbivores are also known. They diversified during the Triassic, when all continents were joined together as Pangaea and the tetrapods had a wide dispersion. Triassic climates were warm, with much less variation from the poles to the equator than exists today.

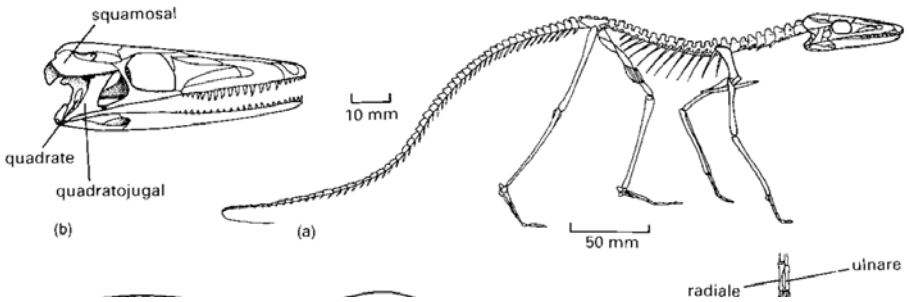


One of the extinct groups of archosauromorphs was the (1), the **rhynchosaurs**, which were terrestrial, quadrupedal, and characterized by a beak, and a specialized dentition of multiple rows of teeth on the upper and lower jaws. The range of this group is from the Middle-Late Triassic. Different genera of the rhynchosaurs are known from Britain, Europe, Africa, and India, South America and North America.

The clade Archosauromorpha includes the clade called Archosauria, which during the Triassic radiated into one line that led to the crocodilians, and the other to the pterosaurs, dinosaurs and birds. Details of some of these groups are as follows:

(2). Crocodylia — True crocodilians arose in the Early Jurassic (see pp. 232–7), but there were a number of close relatives in the Late Triassic. The earliest crocodilean during the Triassic is the genus *Saltoposuchus* known from South Wales, which was a lightly built, delicate animal 0.5 m long. Another crocodylomorph family of the Late Triassic and Early Jurassic, the

Sphenosuchidae, were rather more crocodile-like in appearance. *Sphenosuchus* from the Lower Jurassic of South Africa.



Sphenosuchus

(3). Pterosaurs – these are the flying reptiles. They were characterized by having a thin filamentous wing attached to an elongated fourth finger. All other fingers retained their original proportions. These are mostly known from the Jurassic and Cretaceous sediments. Genus name: *Pterodactyl*.

The diapsids also included several groups of reptiles, which were adapted to water. There were four main groups of reptiles in Triassic seas — the placodonts, pachypleurosaurs, nothosaurs and ichthyosaurs.

(4). Placodonts – were most abundant in the Mid-Triassic of central Europe, Mediterranean areas and southern China, and disappeared during the Late Triassic. The genus *Placodus* looks like a heavily built land animal, but its remains are found in shallow marine beds.

(5). The pachypleurosaurs are elongate animals with small heads, long necks and tails and paddle-like limbs They are best known from the Middle Triassic of central Europe where animals such as *Pachypleurosaurus* have been found abundantly in marine sediments. These were clearly aquatic in adaptations, using wide sweeps of their deep tails to produce swimming thrust. The forelimbs may also have been used to some extent for thrust and steering. The hindlimbs were probably held along the sides of the body most of the time in order to reduce drag.

(6) The larger nothosaurs had elongate head and appeared to be closely related to the plesiosaurs, a group that first appeared in the Mid-Triassic, and radiated dramatically in the Jurassic and Cretaceous.

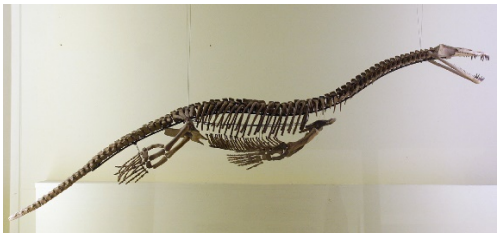
(7). The ichthyosaurs had dolphin-like bodies with no neck, streamlined form, paddles and fish-like tail. They appeared during Early Triassic and continued throughout the Mesozoic Era. The

limbs are shortened and broadened to act as paddles, the orbit is large, jaws are long and narrow and lined with uniform peg-like teeth.

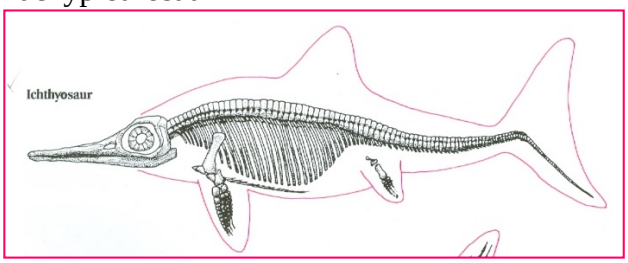
(8). Plesiosaur – These are gigantic forms having a long neck and paddle shaped limbs. Plesiosaurs were highly adapted for submarine locomotion, with powerful paddle-like limbs and heavily reinforced limb girdles. These also first appeared during the Triassic and became extinct during the Cretaceous.

Placodont

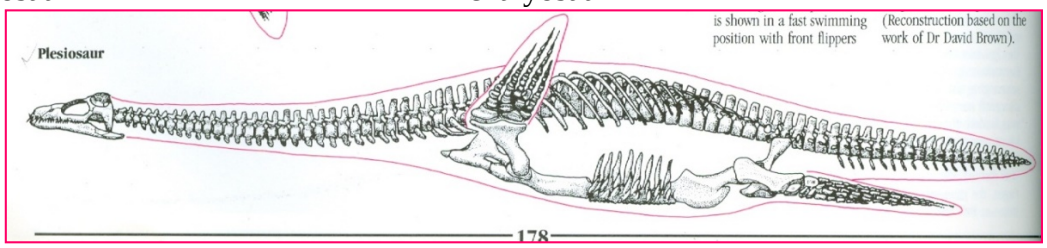
Pachypleurosaur



Nothosaur



Ichthyosaur

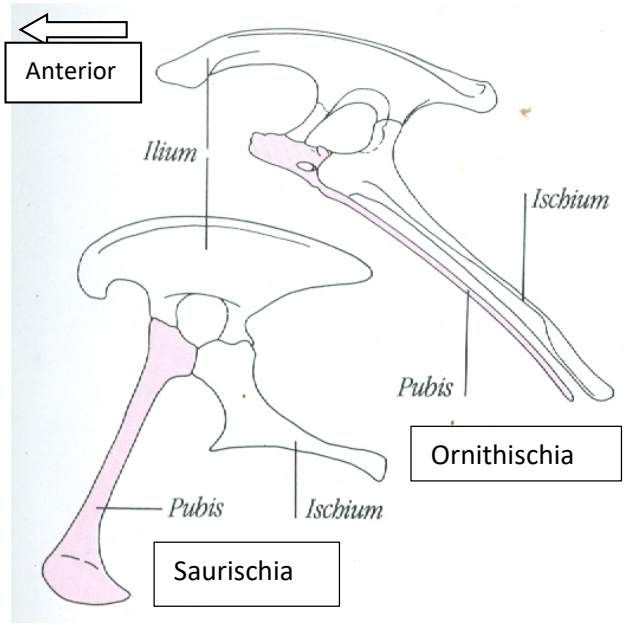


Plesiosaur

(9). Dinosaurs – One of the important groups of Archosauria is the Dinosauria. The name 'Dinosauria' (dino – terrible; sauria – lizard) was given by Richard Owen in 1842 to a group of fossil animals that he recognized as large reptiles. Dinosaurs have many characteristic features, which included an erect posture unlike the other reptiles. The dinosaurs range from Late Triassic to the end of Cretaceous. However, in cladistics, the dinosaur is a clade that also contains its descendent, the birds. The birds are referred to as the avian dinosaurs, which are extant/ living forms and the extinct dinosaurs are known as the non-avian dinosaurs.

Dinosaurs are categorized into two groups based on the structure of their pelvis:

(1) Saurischia – lizard-hipped dinosaurs where the pubis bone is anteriorly directed
(2) Ornithischia – bird-hipped dinosaurs where the pubis is directed posteriorly and parallel to the ischium.



SAURISCHIA

Further subdivided into: 1. Theropoda, and 2. Sauropodomorpha

1. THEROPODA - The theropods include a variety of carnivorous and bipedal dinosaurs. Theropods may be broadly grouped into the coelurosaurs and carnosaurs

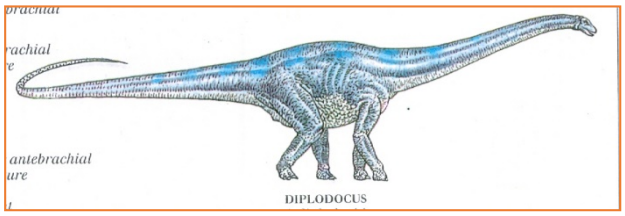
I) Coelurosaur - small size, small head relative to the trunk, large forelimbs, e.g., *Coelophysis* from USA; *Syntarsus* from Jurassic of South Africa.

II) Carnosaurs - large forms with large head relative to the trunk, very short forelimbs. They culminate in the Late Cretaceous in animals about 15 m long and 7000 kg weight. Carnosaurs contain the tyrannosaurids, which are Late Cretaceous forms. Example: *Tyrannosaurus rex*.

Coelophysis

Tyrannosaurus

2. SAUROPODOMORPHA - These are large plant-eating dinosaurs of the Mesozoic and include the partially bipedal prosauropods of the late Triassic and early Jurassic, and the massive quadrupedal sauropods of the later Jurassic and Cretaceous.



The sauropods are characterized by enormous size, weight > 80,000 kg, body length > 30 m, small head, long neck, quadrupedal with upright stance, long tail where the body acts as a fulcrum. Excellent Late Jurassic fossils are known from the Tendaguru Formation, Tanzania, Morrison Formation of the USA. Early Jurassic fossils are relatively rare, though India has a highly fossiliferous Early Jurassic horizon, the Kota Formation of the Pranhita-Godavari Basin. The formation has yielded two sauropod dinosaurs, *Barapasaurus tagorei* and *Kotasaurus haldeni*.

ORNITHISCHIA

These dinosaurs are herbivorous (plant-eating), and characterized by different types of defence mechanisms. These may be subdivided into several groups, which included the following:

(1). **Ornithopods** – These were abundant from Late Triassic onwards until the very end of Cretaceous. Known from North America, Central and South America, Europe, Mongolia, China and Japan.

Some of them had crests on the head, which had a long nasal opening. This helped in making high pitched sound.

(2). **Ceratopians** - Distinctive feature is the presence of facial horns, hooked beak and large frills on the head. These were mainly quadrupedal. Known from Mongolia (early Cretaceous), and North America. E.g., *Triceratops*.

(3). **Pachycephalosaurs** – or thick-headed dinosaurs are relatively rare and puzzling group of dinosaurs. Known from North America, Asia (Mongolia and China), England, Madagascar.

(4). **Stegosaurs** – quadrupedal ornithischians that are characterized by the presence of a double row of long spines, which runs down their back. These are known from the Jurassic sediments of England, North America, Africa, China and Europe.

(5). **Ankylosaurs** - these have broad armoured heads and bony armour-plating with tails having heavy club.

DINOSAURS FROM INDIA

Saurischia

THEROPODS

1. Coelurosaur – ***Alwalkeria maleriensis*** from the Triassic Maleri Formation of Pranhita-Godavari basin in Andhra Pradesh. Small dinosaur with skull length of 9 cm.
2. Abelisaurids (carnosaurs) –***Indosaurus matleyi*** and ***Indosuchus raptorius***. Large animals (skull ~ 1m) with serrated and robust teeth. Recently discovered from Gujarat, ***Rajasaurus narmadaensis***
3. Fragmentary remains of small carnivorous dinosaurs from Jabalpur.

SAUROPODOMORPHA

1. Prosauropods –

   Plateosaurids and some small forms from Late Triassic Dharmaram Formation, PG basin,

   Another taxon similar to ***Massospondylus*** of South Africa is known from Maleri Formation.
2. Sauropods – From Jurassic –

   Barapasaurus tagorei – Jurassic Kota Formation, PG basin. Femur ~ 2m long; collected on the birth centenary of Rabindranath Tagore.

   Kotasaurus – also from the same horizon

   Titanosaurus colberti – skeletal length >25 m, height about 15 m – known from several Cretaceous localities of India.

Ornithischia

1. STEGOSAURIDS – fragmentary remains reported by GSI from Jurassic of Kutch
2. ANKYLOSAURS – a small herbivore with body armour from Kheda district, Gujarat.

EXTINCTION OF THE DINOSAURS

Several theories existed on extinction of dinosaurs –

1. radiation from nearby supernova
2. egg predation by mammals
3. epidemic diseases

Currently combination of two hypotheses are gaining ground. These included:

K-T IMPACT EXTINCTION THEORY

In 1990, a group of geophysicists were looking for oil in the Yucatan region of Mexico. They found a multi-ring structure about 180 km in diameter just off the Gulf of Mexico and submerged in water. This is known as the Chicxulub crater and was dated to be about 65 mys old. It is comparable with a chondritic meteorite of 10 Km diameter.

It is hypothesized that a 10 km meteorite struck earth at a velocity of about 100,000 km/h about 65 mys back that resulted in –

- Destroying everything within a radius of between 400-500 km,
- Large fires and intensive shock waves that traveled long distances
- Enormous tidal waves
- Chain reaction of earthquakes and volcanic activities

That caused a cloud of debris that in turn caused months of darkness and decrease in temperature (impact winter) followed by release of large amount of carbon dioxide caused by global fires and increase in temperature (greenhouse effect). Such effects resulted in destruction of vegetation – death of large herbivores – death of large carnivores (dinosaurs and other such animals). Only small active scavengers such as the birds and mammals with the ability to find food from a wide range of sources would have survived.

Evidences for this meteorite impact are as follows:

(1). Study of rocks at the K-T boundary in Gubbio, Italy showed a thin band of clay layer that have a number of characteristic features. These included –

1. An unusually high amount of iridium - Level of iridium was about 30 times the normal level – two possible sources – 1) from outer space –meteorite impact and 2) from Earth's core – by massive volcanic eruption
2. Spherules of glass –caused by melting
3. Physically altered quartz (quartz with shocked lamellae), - caused by extremely high temperature and pressure, and
4. Soot or ash content – that could have resulted from large global fires.

VOLCANO-GREENHOUSE THEORY

65 million years ago, coinciding with the K-T extinction, volcanism of Deccan Trap lavas erupted onto the earth's surface. It flooded over a million square miles of India and surrounding areas with layers upon layers of basaltic lava flows that is still about 1.5 miles thick in some places of western India.

In the Late Cretaceous, India was an isolated landmass drifting northward towards its collision with Asia. While India was east of Madagascar and just south of the equator, it drifted over the head of a mantle plume or hotspot volcanism on Reunion Island, some 700 km east of Madagascar, which is still active. It is suggested by workers that through the Son Narmada rift, basaltic lava erupted as Deccan Trap.

Earth's core is rich in iridium and Deccan Trap mantle plume is the likely conduit to transport iridium from core to earth's surface. Rapid eruption of the vast Deccan Trap lavas had triggered greenhouse effect resulting in K-T mass extinctions including that of the dinosaurs.

FEATHERED DINOSAURS AND TRANSITION TO BIRDS

Early Cretaceous rocks of Liaoning Province, China, have recovered several different kinds of small theropod dinosaurs, many of which are extremely closely related to modern birds. These dinosaurs were included within the Jehol Biota, which includes varied vertebrates such as fish, mammals, pterosaurs, and a variety of other reptiles, and arthropods, mollusks, and plants. Taphonomic analysis reveals mass mortality suggesting that volcanic activity may have played a role in both their death and preservation. The specimens were buried quickly in a low energy environment at the bottom of lakes, probably by air-fall ash, and were not extensively transported.

Many dinosaur specimens that preserve feathers and other types of integumentary coverings have been recovered. These fossils show a progression of integumentary types from simple fibers to feathers. Phylogenetic analysis shows that these feathered dinosaurs belonged to the theropod dinosaurs, within the coelurosaurs, which show the presence of feathers, or protofeathers.

Sinosauropteryx

CLASS: AVES

Birds originated from the theropod dinosaurs (coelurosaurs). There are many anatomical features, which are similar between the birds and the theropod dinosaurs, especially the feathered dinosaurs known from China.

The class Aves is subdivided into two subclasses, the Archaeornithis and Neornithis.

All the fossil and modern birds fall under Neornithes. Birds are the most diverse of the vertebrates and comprises nearly 9000 species and 27 orders. The skeletons of fossil birds are fragile resulting in their poor preservation and incomplete fossil record. Modern birds appeared in the fossil record at the very end of the Cretaceous.

The earliest fossil bird is *Archaeopteryx*, known from the Upper Jurassic of southern Germany. It falls under the subclass Archaeornithis. There are multiple individuals preserved in the limestone that was deposited in a quiet lagoon environment. These fossils show impressions of feathers attached to the forelimb and tail (Fig.). The skeletal structure of *Archaeopteryx* is similar to that of the modern bird and a theropod dinosaur.