International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Reptiles and Their Evolutionary Trends

Sachin Changotra

Abstract: ***Reptiles arose about 310–320 million years ago during the Carboniferous period. Reptiles, in the traditional sense of the term, are defined as animals that have scales or scutes, lay land-based hard-shelled eggs, and possess ectothermic metabolisms. So defined, the group is paraphyletic, excluding endothermic animals like birds and mammals that are descended from early reptiles. A definition in accordance with phylogenetic nomenclature which rejects paraphyletic groups, includes birds while excluding mammals and their synapsid ancestors. So defined, Reptilia is identical to Sauropsida.***

Keywords: reptiles

1. Introduction

Reptiles have an extremely diverse evolutionary history that has led to biological successes, such as dinosaurs, pterosaurs, plesiosaurs, mosasaurs, and ichthyosaurs. The origin of the reptiles lies about 320–310 million years ago, in the swamps of the late Carboniferous period, when the first reptiles evolved from advanced reptiliomorph labyrinthodonts. The oldest known animal that may have been an amniote a reptile rather than an amphibian, is *Casineria*

The upper part of the skull of reptiles is modified giving the reptiles a far more efficient and powerful jaw action and making the skull light. The reptiles are classified mainly on the structure of their skulls, in which there are temporal vacuities or fossae or empty spaces in the temporal region.Three different groups of reptiles developed fossae in different places, parapsid, synapsid and diapsid types, and these remained unchanged throughout the evolutionary history of these groups.

Key features of Class REPTILIA

- Body varied in shape, covered with horny epidermal scales, sometimes with dermal plates; integument with few glands.
- Paired limbs, usually with five toes with claws, adapted for climbing, running or paddling; limbs absent in snakes and some lizards.
- Skeleton well ossified; ribs with sternum except in snakes, forming a complete thoracic basket; skull with single occipital condyle.
- Respiration by lungs.
- Three-chambered heart, except in crocodiles which have four-chambered heart.
- Metanephric kidney; uric acid is the main nitrogenous waste.
- Ectothermic animals.
- Nervous system with primitive brain, spinal cord dominant. There are 12 pairs of cranial nerves.
- Sexes separate; fertilization internal, hemipenis as copulatory organ.
- Eggs covered with calcareous or leathery shells. Extra embryonic membranes, amnion, chorion, yolk sac and allantois are present during embryonic life.

2. Subclass ANAPSIDA

Anapsid reptiles are those in which the dermal bones form a complete roof over the skull, with no temporal fossae. Two main groups possess anapsid skull, the extinct Captorhinida and the extant Chelonia.

Modern chelonians are classified into two suborders, according to the method of retracting the head into the shell. The most primitive group are the side-necked turtles (Suborder Pleurodira), which have very long necks to assist in catching fish. In these chelonians, the neck bends sideways in order to fit the head into the shell. Most modern species that belong to this group include the turtles, tortoises and terrapins.

Order CHELONIA

Tortoises and turtles do not have teeth but possess horny beaks. Tortoises are usually herbivorous while sea and fresh water turtles are omnivorous. Body is covered with a shell consisting of two parts – the dorsal carapace and the ventral plastron, which are connected by bridges between front and hind legs. The ribs and backbone are fused with the carapace.

Subclass Parapsida

These are reptiles with one temporal fossa, placed high up on the skull. A number of different forms of aquatic reptile showed this form of skull, such as the Protosaurs, Nothosaurs and Placodonts but we will deal with the two largest groups – the ichthyosaurs and the plesiosaurs. These two lines of reptiles became modified for aquatic life in quite different ways but they share the same basic type of skull organisation, with minor differences. Both Ichthyosaurus and the Plesiosaurus became extinct at the end of the Cretaceous when many other terrestrial reptiles including dinosaurs died out.

Subclass Diapsida

These reptiles possess two temporal fossae in the skull and they have been the most successful and diverse of all the reptiles. They include the dinosaurs and pterosaurs which dominated the land and air during the Mesozoic era and also include the most successful of modern reptiles, such as the crocodiles, snakes and lizards.

The diapsid reptiles are divided into two major goups, the Archosauria and the Lepidosauria, which share the same type of temporal vacuities in the skull, but there are a number of differences in their skull construction which makes it possible that they may have evolved independently from separate cotylosaur ancestors.

Order Rhyncocephalia
The order contains only two species that live on some islands off the coast of New Zealand. They look like lizards but there are differences that set the tuatara apart from lizards. The tuatara spends daytimes in burrows. It comes out in the evening to feed on insects and other invertebrates.

Order Squamata
The order includes Lizards and snakes, which are creepers and inhabit a variety of habitats. Snakes are carnivorous but lizards eat a variety of foods including plants and insects. Snakes have descended from lizards and there are many similarities between them. Some characteristics that distinguish snakes from lizards are:

- Snakes do not have eyelids but lizards have.
- Snakes usually have one row of scales on the belly; lizards have many.
- Snakes do not have legs; most lizards have legs.
- Snakes have jaw bones that disarticulate allowing them to swallow large objects. Lizard jaw bones do not disarticulate.

Order Crocodilia
This order includes alligators, caimans, crocodiles and gharials that are found in and near water in warmer areas of the world. They eat fish, birds, turtles, and mammals.
Members of the crocodile group have legs and feet designed for walking on land and a strong flattened tail used for swimming. The three groups are distinguished from one another by the shape of their heads. Alligators have a broad, rounded snout; while the crocodiles have a triangular head with a more pointed snout and gharials have a very long and narrow snout.

The Dinosaurs

Dinosaurs belonged to three orders:

Order Saurischia
They possessed lizard-like pelvic girdle in which ischium and pubis bones diverge from the base. These dinosaurs were both bipedal and quadrupeds, carnivores as well as herbivores. Examples are, Allosaurus, Tyrannosaurus, Brontosaurus, Diplodocus, Brachiosaurus and Struthiomimus.

Order Ornithischia
They were dinosaurs with bird-like pelvic girdle in which both ischium and pubis are directed backwards. Examples include Iguanodon, Stegosaurus, Triceratops, Camptosaurus and Ankylosaurus.

Order Pterosauria
They were flying reptiles in which forelimbs were modified to support a patagium that stretched from forelimbs to hind limbs. Their size varied from that of sparrow to giants that had wing span of 12 metres.

Subclass Synapsida
These reptiles have one temporal fossa, on the lower side of the remporal region of the skull. They were the most successful and dominant reptiles during the Permian period. In the Mesozoic era they were largely replaced by other lines of reptiles such as dinosaurs, but the surviving synapsids gave rise to the mammals. There is a range of fossil species of these reptiles throughout the Mesozoic. At the start of the era they show typically reptilian characteristics but by the end of the era they became so mammal-like that it is difficult to know whether they should be classified as mammals or reptiles.

The Pelycosauria seem to have died out towards the end of the Permian period since they had more reptilian characters than mammalian characters. The synapsid line of reptiles continued with the radiation of a new group, the Therapsida, which diversified into specialized predators called Cynodonts and the giant herbivores called Dicynodonts. They all died out in Permian and Triassic extinctions, leaving behind small descendents. Throughout the mesozoic era there was a series of successive radiations of these therapsid reptiles to give rise to mammals.

Reptiles: Early Consumers on Land
Evolutionary Novelty: New morphological innovations that define newly established groups:

The amniotic egg: a space capsule for the reptilian embryo. The major evolutionary step to a fully terrestrial existence was accomplished primarily due to innovation in reproduction. As one of their diagnostic features, reptiles have an amniote egg, a reproductive character that eventually allowed them to dominate many available land habits.

Diagnostic features that developed in the gradual evolution of amphibians to reptiles:

Fairly common intermediate forms that combined a blend of typical amphibian and reptilian characters (see figure below).
In general, early reptiles stabilized a particular style of back-bone construction.

The lack of an otic notch in reptiles, the ear being situated at the rear of the skull.
Bones of the back part of the reptilian skull are reduced in number and size, a continuation of the trend present from rhipidistian fish to amphibians.

How to tell early reptiles from others

The most important feature for distinguishing one type of early reptile from another is the structure of the bones in the temple region of the skull, behind the eye, called temporal openings, whichprovide data that is used in subdividing all major reptile groups.

The reptiles of this group are referred to as stem reptiles or anapsidsbecause they are the ones from which the other, more advanced reptiles are thought to have evolved. The only living anapsids are the turtles and tortoises (see figure below)

The synapsids: or mammal-like reptiles have a single temporal opening low on the side of the skull, beneath the postorbital and squamosal bones. They are extinct but very important because mammals evolved from legged stance. By

the end of the Triassic, thecodonts had given rise to both groups of dinosaurs, the Saurischia and Ornithischia this group of reptiles.

The diapsids: or ruling reptiles have two openings, one above the other, separated by a bony connection between the postorbital and squamosal bones. They include the dinosaurs of the Mesozoic Era, as well as most living reptiles-the crocodiles, alligators, snakes, and lizards.

The euryapsids: have a single opening high on the skull, above the postorbital and squamosal bones, a condition derived from their diapsid ancestor. Include the ichthyosaurs and plesiosaurs. Most euryapsids had an aquatic or semiaquatic way of life.

Thecodonts: important diapsid group which gave rise to the groups known as dinosaurs before the close of the Triassic. The thecodonts first appeared during the Early Triassic and became extinct at the close of the system. Some thecodonts ran on all four legs (quadrupedal), others exhibited a new bipedal, or two-

The Saurischia (lizard-hipped): the termcomes from sauria, meaning reptile, and ischia, referring to the ischium bone of the pelvis. These dinosaurs had a pelvis built like that of many other reptiles, hence the name lizard-hipped dinosaurs.From them evolved the other major group of dinosaurs.

The Ornithischia (bird-hipped):which appeared at the end of the Triassic. This group had a birdlike pelvis.

3. Reptiles

Different subclasses are distinguished by skull structure

Anapsids: no holes on side of skull (turtles, extinct primitive [stem] reptiles)

Synapsids: 1 hole on lower side of skull (extinct mammal-like [pelycosaur & therapsid] reptiles). Synapsids ('fused arch'), also known as theropsids ('beast face'), are a class of animals that includes mammals and everything closer to mammals than to other living amniotes.The non-mammalian members were traditionally described as mammal-like reptiles, and are sometimes referred to as "proto-mammals" or "stem-mammals".

Euryapsids: 1 hole on upper side of skull (most extinct marine reptiles. Examples of euryapsids are: icthyosaur, plesiosaur, nothosaur, placodont. This group of reptiles is included in the informal class Euryapsida which is considered to be an unnatural, polyphyletic group, as the various members are not closely related. This group of reptiles is distinguished by a single temporal fenestra, an opening behind the orbit, under which the post-orbital and squamosal bones articulate.

Diapsids: 2 HOLES on side of skull (MOST LIVING REPTILES [lizard, snake, crocodile, tuatara]; extinct DINOSAURS; extinct FLYING [pterosaur] REPTILES, & MOSASAURS [extinct marine reptiles])

DIAPSIDS: 2 HOLES on side of skull (MOST LIVING REPTILES [lizard, snake, crocodile, tuatara]; extinct DINOSAURS; extinct FLYING [pterosaur] REPTILES, & MOSASAURS [extinct marine reptiles])

Many new reptile types appeared in the Triassic
TURTLES (Mesozoic turtles had teeth);
TUATARAS: lizards of New Zealand
CROCODILES (Cretaceous forms got to be as long as 15 m)
LIZARDS & SNAKES (snakes evolved from lizards by the Cretaceous)
MARINE & FLYING REPTILES & DINOSAURS (see below)
THECODONTS (teeth set in sockets) - a MOSTLY BIPEDAL GROUP that GAVE RISE to CROCODILES, LIZARDS, SNAKES, FLYING REPTILES & DINOSAURS

The Triassic land fauna was dominated by therapsids & thecodonts
MARINE REPTILES
Several groups with marine adaptations, including paddle-shaped limbs, streamlined bodies, & reproductive adaptations for birth of young at sea.

Euryapsids:PLACODONTS; NOTHOSAURS;
PLESIOSAURS (long necks; short, tailless bodies; flippers); ICTHYOSAURS (MOST FISH-LIKE MARINE REPTILE [convergent with dolphins])
Anapsids:SEA TURTLES
Diapsids: MARINE CROCODILES OCCURRED MOSTLY DURING JURASSIC; MOSASAURS (SHORT NECKS; LONG BODIES & TAILS)

Therapsids: "mammal-like reptiles" cynodonts : ancestor of Mammalia.

Thecodont ("socket-toothed" reptile), now considered an obsolete term, was formerly used to describe a diverse range of early archosaurs that first appeared in the Latest Permian and flourished until the end of the Triassic period. The group includes the ancestors of dinosaurs (including birds), and ancestors of pterosaurs, and crocodilians, as well as a number of extinct forms that did not give rise to any descendants.

-Theropods - Theropods are a group of bipedal saurischian dinosaurs. Although they were primarily carnivorous, a number of theropod families evolved herbivory during the Cretaceous System. Theropods first appear during the Carnian stage of the Upper Triassic about 220 million years ago (MYA) and were the sole large terrestrial carnivores from the Lower Jurassic until the close of the Cretaceous, about 65 MYA. Today, they are represented by the 9,300 living species of birds, which evolved in the Upper Jurassic from small specialized coelurosaurian dinosaurs.

-Tetrapoda: "four feet" thecodonts
Archosauria (the "ruling reptiles": is a major group of diapsids, differentiated from the other diapsids by the presence of single openings in each side of the skull, in front of the eyes (antorbital fenestrae), among other

characteristics. The ancestral archosaurs probably originated some 250 million years or so ago, in the upper Permian period. Their descendants (such as the dinosaurs) dominated the realm of the terrestrial vertebrates for a majority of the Mesozoic Era. Today, only the birds and crocodilians exist to provide a glimpse into the past glory of archosaurs.

4. The Dinosaurs

1) Evolved in the Triassic & expanded & diversified in the Jurassic & Cretaceous
2) Traditionally divided into two orders based on hip structure: Saurischia (lizard-hipped) & Ornithischia (bird-hipped)
3) Early dinosaurs were mostly Saurichians, which are divided into 2 suborders: (a) Bipedal carnivorous theropods, and (b) giant, 4-footed herbivorous sauropods
4) The Ornithischians are divided into 5 suborders:
5) Stegosaurs, Ankylosaurs, Ceratopsians, Ornithopods, and Pachycephalosauria

All were herbivorous with the front teeth replaced by a beak & cheek teeth adapted for crushing coarse vegetation

Ornithopods, ankylosaours & ceratopsians were low browsers and were the dominant herbivores during the cretaceous

Arguments in favor of warm-bloodedness (Endothermy)

Predator to prey ratios; erect stance; richly vascularized bones; growth rates; social behavior & migration of herds; hair on flying reptiles; complete dominance over mammals

Arguments in favor of cold-bloodedness (Ectothermy)

Dinosaurs were reptiles & modern reptiles are cold-blooded; erect stance & vascularized bones were responses to large size; large size itself

Still an open question

NOTE: it is no longer accepted that dinosaurs were slow & ponderous; dinosaur behavior probably like bird & mammal behavior.

Theropods were quick & agile; large sauropods & ornithischians assembled in social herds; smaller sauropods & ornithischians behaved in a birdlike way.

5. Summary of Dinosaur Taxonomy

Saurischia	Therapoda	Allosa	BipedLate Triassic to end of Cretaceous Size from 0.6 to 15 m Long, 2 or 3 kg to 7.3 metric tons. Some smaller genera may have hunted in packs.
	Sauropoda		Giant Quadrupedal herbivores. Late Triassic to Cretaceous, but most common during Jurassic. Size up to 27 m Long, 75 metric tons. Track ways indicate sauropods lived in herds. Preceded in fossil record by the smaller prosauropods
Ornithischia	Ornithopoda		Some ornithopods, such as Apatosaurus, had a bill-like mouth and are called duck-billed dinosaurs. Size from a few meters Long up to 13 m and 3.6 metric tons. Especially diverse and common during the Cretaceous. Primarily bipedal herbivores, but could also walk on all fours.
	Pachycephalosauria	Stegoceras	Stegoceras only 2 m Long and 55 kg, but larger species known. Thick bones of skull cap might have aided in butting contests for dominance and mates. Bipedal herbivores of Cretaceous.
	Ankylosauria	Ankylosaurus	Ankylosaurus more than 7 m Long and about 2.5 metric tons. Heavily armored with bony plates on top of head, back, and sides. Quadrupedal herbivore.
	Stegosauria	Stegosaurus	A variety of stegosaurs are known, but Stegosaurus, with bony plates on its back and a spiked tail is best known. Plates probably were for absorbing and dissipating heat. Quadrupedal herbivores that were most common during the Jurassic. Stegosaurus 9 m Long, 1.8 metric tons.
	Ceratopsia	Triceratops	Numerous genera known. Some early ones bipedal, but Later Large animals were Quadrupedal herbivores. Much variation in size; Triceratops to 7.6 m Long and 5.4 metric tons, with Large bony frill over top of neck, three horns on skull, and beaklike mouth. Especially common during the Cretaceous.

6. Saurischian Dinosaurs

The saurischians include two distinct groups known as theropods and sauropods(see table above).

Theropods (beast-footed): Typical genus Tyrannosaurus;bipedal carnivores. Upper Triassic to end of Cretaceous.Size from 0.6 to 15 m long, 2 or 3 kg to 7.3 metric tons. Some smaller genera may have hunted in packs. All theropods were carnivorous bipeds that varied from tiny Compsognathus to giants such as Tyrannosaurus and similar but even larger species. Other genera include Allosaurus, Compsognathus, Deinonychus, Velociraptor, and Coelophysis. In 1996, Chinese scientists discovered several theropods with feathers. No one doubts that these dinosaurs had feathers, and molecular evidence indicates they were composed of the same material as bird feathers.

Sauropods (reptile-footed): Typical genus Brachiosaurus; Giant Quadrupedal herbivores. Upper Triassic to Cretaceous, but most common during Jurassic. Size up to 27 m long, 75 metric tons. Track ways indicate sauropods lived in herds. Preceded in fossil record by the smaller prosauropods includes the truly giant, quadrupedal herbivorous dinosaurs such as Apatosaurus, Diplodocus, Apatosaurus,Camarasaurus, and Titanosaurus; the largest

land animals ever. Brachiosaurus, a giant even by sauropod standards, may have weighed 75 metric tons, and partial remains from several areas indicate that even larger sauropods may have existed. Track ways show that sauropods moved in herds. Sauropods were preceded in the fossil record by the smaller Upper Triassic to Lower Jurassic prosauropods, which were undoubtedly related to sauropods but probably not their ancestors. Sauropods were most common during the Jurassic; only a few genera existed during the Cretaceous.

7. Ornithischian Dinosaurs

All were herbivorous with the front teeth replaced by a beak & cheek teeth adapted for crushing coarse vegetation. Ornithopods, ankylosaours and ceratopsians were low browsers and were the dominant herbivores during the cretaceous.

Note: Robert Bakker has suggested that replacement of high browsing sauropods by low browsing ornithischians aided fast growing angiosperms in replacing slow growing gymnosperms as the dominant land plant.

Five Classes of Ornithischians are recognized: Ornithopoda, Pachycephalosauria, Ankylosauria, Stegosauria,
and Ceratopsia (see table above).

Ornithopoda(bird-footed): Typical genus Maiasaura ("good mother dinosaur"). Some ornithopods, such as Apatosaurus, had a bill-like mouth and are called duck-billed dinosaurs. Size from a few meters long up to 13 m and 3.6 metric tons. Especially diverse and common during the Cretaceous. Primarily bipedal herbivores, but could also walk on all fours. Consist of several subgroups, including the familiar duck-billed dinosaurs or hadrosaurs. Hadrosaurs (duck-billed dinosaurs) were especially numerous during the Cretaceous, and several species had head crests that may have been used to amplify bellowing, for sexual display, or for species recognition. All ornithopods were herbivorous and primarily bipedal, but they had well-developed front limbs that allowed them to walk in a quadrupedal fashion, too. The Upper Cretaceous ornithopods Miasaura ("good mother dinosaur") nested in colonies and used the same nesting area repeatedly where 2 m diameter nests were placed 7 m apart or about the length of an adult. Some nests contain juveniles up to 1 m long, which is much larger than when they hatched, so they probably stayed in the nest area where adults protected them and perhaps fed them. The fact that these animals lived in vast herds is demonstrated by the fossils of an estimated 10,000 individuals in a single bone bed in Montana. Apparently they were overcome by toxic gases from a volcano and later buried in flood deposits. Other genera included in this class are Hypsilophodon ('high-ridge tooth'), Iguanodon, and Parasaurolophus View some specimens of Maiasaura

Pachycephalosauria: Typical genus: Stegoceras; only 2 m Long and 55 kg, but larger species known. Thick bones of skull cap might have aided in butting contests for dominance and mates. Bipedal herbivores of Cretaceous.The most distinctive feature of the pachycephalosaurs is their thick-boned, dome-shaped skull. The traditional view of these as animals that butted heads for dominance or mates has been challenged. Now some paleontologists note that the thick skull bones are found only in juveniles but not in adults. In any case, pachycephalosaurs were bipedal herbivores that varied from 1 to 4.5 m long. Their fossils are known only from Late Cretaceous-aged rocks.

Ceratopsia (horned dinosaurs):Typical genus Triceratops. Numerous genera known. Some early ones bipedal, but Later Large animals were Quadrupedal herbivores. Much variation in size; Triceratops to 7.6 m Long and 5.4 metric tons, with Large bony frill over top of neck, three horns on skull, and beaklike mouth. Especially common during the Cretaceous.The fossil record of ceratopsians (horned dinosaurs) shows that small Lower Cretaceous animals were the ancestors of large Upper Cretaceous genera such as Triceratops. Triceratops and related genera with huge heads, a large bony frill over the neck, and a horn or horns on the skull were very common in North America. Fossil track ways show that these large, quadrupedal herbivores moved in herds. Furthermore, bone beds with fossils from a single species indicate that large numbers of ceratopsians perished quickly, probably during river crossings.

Stegosauria: Typical genus Stegosaurus. A variety of stegosaurs are known, but Stegosaurus, with bony plates on its back and a spiked tail is best known. Plates probably were for absorbing and dissipating heat. Quadrupedal herbivores were most common during the Jurassic. Stegosaurus 9 m long, 1.8 metric tons.The most distinctive features of Stegosaurus include being a medium-sized, herbivorous quadruped from the Jurassic System, are a spiked tail, almost certainly used for defense, and plates on its back. The exact arrangement of these plates is uncertain, although they are usually depicted in two rows with the plates on one side offset from those on the other. In any case, most paleontologists think the plates functioned to absorb and dissipate heat.

Ankylosauria: Typical genus Ankylosaurus, more than 7 m Long and about 2.5 metric tons. Heavily armored with bony plates on top of head, back and sides. Quadrupedal herbivore. Were quadrupedal herbivores and more heavily armored than any other dinosaur. Bony armor protected the animal's back, flanks, and top of the head. The tail of some species such as Ankylosaurus ended in a bony club that undoubtedly could deliver a crippling blow to an attacking predator.

8. Flying Reptiles

First flying reptiles - gliders
Pterosaurs - active flyers with maneuvering ability, wings were skin stretched between elongated 4th finger, sides of the body & rear limbs.

Pterosaurs were warm-blooded - fine hair covers well preserved pterosaurs

Paleozoic insects were the first animals to achieve flight, but the first among vertebrates were pterosaurs, or flying reptiles, which were common in the skies from the Upper Triassic until their extinction at the end of the Cretaceous.

Adaptations for flight include a wing membrane supported by an elongated fourth finger, light, hollow bones; and development of those parts of the brain that controlled muscular coordination and sight. Because at least one pterosaur species had a coat of hair or hair like feathers, possibly it, and it is likely that all pterosaurs, were endotherms.

Pterosaurs: Are generally depicted in movies as large, aggressive creatures, but some were no bigger than to day's sparrows, robins, and crows. However, a few species had wingspans of several meters, and the wingspan of one Cretaceous pterosaur was at least 12 m. Nevertheless, even the very largest species probably weighed no more than a few tens of kilograms. Experiments and studies of fossils indicate that the wing bones of large pterosaurs such as Pteranodon were too weak for sustained flapping. These comparatively large animals probably took advantage of rising air currents to stay airborne, mostly by soaring but occasionally flapping their wings for maneuvering. In contrast, smaller pterosaurs probably stayed aloft by vigorously flapping their wings just as present-day small birds do.

PTERODACTYLOIDS - advanced pterosaurs with no tails & some had enormous wingspans: - Pteranodon = 7 m; Quetzalcoatlusnorthropi = 15.5 m

Mesozoic Marine Reptiles
Several types of Mesozoic reptiles adapted to a marine environment, including turtles and some crocodiles, and the Triassic mollusk-crushing placodonts. Best know exaples of marine reptilesareichthyosaurs, plesiosaurs and mosasaurs.

Ichthyosaurs: Used their powerful tail for propulsion and maneuvered with their flipper like forelimbs. They had numerous sharp teeth, and preserved stomach contents reveal a diet of fish, cephalopods, and other marine organisms. It is doubtful that ichthyosaurs could come onto land, so females must have retained eggs within their bodies and given birth to live young. A few fossils with small ichthyosaurs in the appropriate part of the body cavity support this interpretation.

Plesiosaurs: Belonged to one of two subgroups: short-necked and long-necked. Most were modest-sized animals 3.6 to 6 m long, but one species found in Antarctica measures 15 m. Short-necked plesiosaurs might have been bottom feeders, but their long necked cousins may have used their necks in a snakelike fashion, and their numerous sharp teeth, to capture fish. These animals probably came ashore to lay their eggs.

Mosasaurs: They were Upper Cretaceous marine lizards related to the present-day Komodo dragon or monitor lizard. Some species measured no more than 2.5 m long, but a few such as Tylosaurus were large, measuring up to 9 m. Mosasaur limbs resemble paddles and were used mostly for maneuvering, whereas the long tail provided propulsion.

Crocodiles, Turtles, Lizards, and Snakes

Crocodiles: They develop since Jurassic time, crocodiles had become the most common freshwater predators. All crocodiles are amphibious, spending much of their time in water, but they are well equipped for walking on land. Overall, crocodile evolution has been conservative, involving changes mostly in size from a meter or so in Jurassic forms to 15 m in some Cretaceous species.

Turtles: Have been evolutionarily conservative since their appearance during the Triassic. The most remarkable feature of turtles is their heavy, bony armor; turtles are more thoroughly armored than any other vertebrate animal, living or fossil. Turtle ancestry is uncertain. One Permian animal had eight broadly expanded ribs, which may represent the first stages in the development of turtle armor.

Lizards and snakes:Are closely related, and lizards were in fact ancestral to snakes. The limbless condition in snakes (some lizards are limbless, too) and skull modifications that allow snakes to open their mouths very wide are the main difference between these two groups. Lizards are known from Upper Permian strata, but they were not abundant until the Upper Cretaceous. Snakes first appear in the Cretaceous, but the families to which most living snakes belong differentiated since the Early Miocene. One Lower Cretaceous genus from Israel shows characteristics intermediate between snakes and their lizard ancestors