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The Triassic Period and the Beginning of the Mesozoic Era

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THE TRIASSIC PERIOD and the BEGINNING OF THE MESOZOIC ERA

Introduction to the Mesozoic Era: The Triassic Period is the first period of the Mesozoic Era, a span of time from 245 million years ago to 66 million years ago. Although the Mesozoic era commonly known as the "Age of the Dinosaurs", it should be pointed out that there were other important evolutionary developments taking place such as the appearance of the first mammal birds and flowering plans. The onset of the Mesozoic Era, the Triassic Period, was also a time of profound tectonic activity affecting the entire North American craton. In the east, the primary event was the breakup of Pangea and the formation of the Atlantic Ocean. In the west, it was the formation of an Andean-type continental margin as the newly-formed continent of North America rapidly moved westward in response to the opening of the Atlantic Ocean coupled with the addition of **exotic terranes** to the western margin of the continent.. As the Atlantic oceanic ridge rose, the volume of ocean waters that was displaced was sufficient to result in the most extensive flooding of the continent by an epeiric sea since the Paleozoic; a sea whose presence was recorded by the accumulation of extensive carbonates throughout the continental interior.

In the oceans, new life forms evolved to fill the vacancies brought about by the Permian extinction. When life returned, however, most of the old forms were gone and an assemblage comparable to those living in our modern oceans took their place.

Without doubt, the Mesozoic era was the time of the reptiles with reptilian forms dominating nearly every eco-system from the ocean to the land to the air. But it was also the time of significant changes in the plant community with the flowering plants evolving before the end of the Cretaceous along with a tremendous increase in the kinds and numbers of pollinating insects. The Mesozoic Era ends with the a mass extinction, second only to the Permian extinction.

The Breakup of Pangea

Introduction: Without doubt, the breakup of Pangea was one of the most significant historical events of the Mesozoic Era. The breakup occurred in four stages with the first stage beginning in the Triassic and the last occurring in the early Cenozoic.

Stage #1: During the Triassic, tensional forces within Pangea resulted in rifting and extensive vulcanism along zones of normal faulting that record the separation of North America and Gondwana. As the rifting continued, the eastern border of North America pulled away from the Moroccan portion of North Africa. Triassic rocks of both volcanic and clastic origin deposited in down-faulted basins along the eastern margin of North America and the western margin of Morocco record the rift. At the same time, South America separated from Mexico although it remained joined to Africa. Throughout most of the Triassic, the North American-Eurasian landmass remained intact.

Stage #2: During the second stage, rifting resulted in the opening of narrow oceanic basins between southern Africa and the combined Antarctica/Australia continental mass that extended northeastward between Africa and India.

Stage #3: During stage three, the Atlantic rift began to extend northward while, simultaneously, the landmass of Eurasia began to rotate clockwise, initiating the closure of the eastern end of the Tethys Sea, giving rise to the beginnings of the Mediterranean Sea. By the end of Jurassic time, South America began to split away from Africa as a linear ocean was formed in the south and worked its way northward. At this time, Antarctica and Australia were still joined but India had already begun its journey toward its eventual collision with Asia. By late Cretaceous time, South

America had completely separated from Africa and Greenland, although still attached to North America, began to separate from Europe..

Stage #4: The final breakup of what was left of Pangea did not come until the early Cenozoic at which time North America and Eurasia were totally separated. About 45 million years ago with the final separation of Australia and Antarctica, the breakup of Pangea was complete, a breakup that had taken about 150 million years.

The Triassic Period: In Great Britain, where many of the geologic systems were first described and named, a thick sequence of redbeds referred to as the **New Red Sandstone** overlies the Carboniferous rocks; the designation "new" being used to distinguish it from the *Old* Red Sandstone that *underlies* the Carboniferous. In Germany, however, the correlative rock sequence consists of two terrestrial redbed sequences separated by a gray marine sequence. It was this tri-fold division that led Friedrich August von Alberti in 1834 to name the sequence the **Triassic System**. Despite the fact that the three-fold subdivision does not exist throughout most of the world, the original name stuck and is still used world-wide.

The Triassic of North America: Following the Alleghenian Orogeny, the Alleghenian Highlands were located approximately in the middle of the newly-formed super-continent of Pangea. Pangea was to exist for about 50 million years before the onset of the next Wilson Cycle; the one in which we are now involved. During the 50 million years following the culmination of the Alleghenian Orogeny, the Alleghenian Highlands had been worn down to a gently rolling to nearly flat surface. During this period of time, heat began to build under the super-continent due to the insulating properties of the continental crust. As the temperature of the rocks underlying the continent rose, they expanded and became increasingly buoyant. In time, a new convection cell formed in the asthenosphere that subjected Pangea to tensional forces (**Figure 1**). As a result, northeast-southwest trending normal faults began to form throughout what we now identify as the Piedmont. The result of the faulting was the formation of a series of elongate basins that are bordered on one side by a near-vertical normal fault and hinged on the other (**Figure 2**). The northernmost of these basins is located in Nova Scotia while the southernmost is in the Carolinas (**Figure 3**). The tensional forces within the lithosphere resulted in near-continuous movement along the border fault caused the basin to continually subside along the faulted margin. Weathering and erosion immediately began to attack the steep mountainous faulted side of the basin and generated vast volumes of poorly-sorted clastic debris that poured into the basins in the form of alluvial fans building out from the base of the fault scarp (**Figure 4**). Coarse-grained materials accumulated nearest the fault scarp with sands and finer-grained materials being carried into the basin interior. Today, the coarse-grained materials are conglomerates that change laterally into sandstones within the basin interiors. The fact that many of the sediments found in these basins were arkosic attests to the rapidity with the sediments were transported into the basins and buried; little time was available for the feldspars to decompose chemically into clay minerals. The sediments that collected in these fault basins are referred to collectively as the **Newark Supergroup** for exposures near Newark, New Jersey.

In general, the rocks within the upper and lower portion of the Newark Supergroup are redbeds reflecting accumulation of sediments in oxygen-rich waters and, in fact, often exposed to the atmosphere. In contrast, the rocks in the middle of the group are more gray in color reflecting accumulation in less oxidizing conditions such as lakes that formed in the interior of the Triassic basins. Modern examples of such freshwater lakes are Lake Victoria and Lake Albert in the present-day East African Rift Valley. Periodically, basaltic magmas moved upward along the faults and either intruded the sediments as sills and dikes or erupted to the surface as lava flows (**Figure 5**). One of the more well-known examples of a Triassic sill is the Palisades that stretches northward for 50 miles along the Hudson River from New York City. The total thickness of sediments that accumulated in the Triassic basins varies considerably. In Connecticut, the Newark Supergroup has a thickness of about 12,000 to 15,000 feet while in New Jersey, the group reaches a thickness of more than 20,000 feet. In general, the sediments thin in the more southerly basins.

Wherever the base of the Newark Supergroup is exposed, it can be seen that the Triassic sediments were laid down on a low relief erosional surface that cut across highly deformed older rocks. In Nova Scotia, the underlying rocks are Pennsylvanian age and older. In eastern Pennsylvania, the Triassic redbeds rest on deformed Ordovician limestones indicating that all of the Paleozoic rocks younger than Ordovician in that portion of Pangea had been removed by erosion before deposition of the Triassic sediments began. The presence of the low-relief erosional surface underlying the Triassic rocks of the Newark Supergroup clearly indicates that the grand Alleghenian Highland that was created at the end of Permian time had been worn down nearly to sealevel before the Triassic rifting began.

No marine fossils have ever been found in any of the Newark Supergroup sediments, reflecting the fresh water terrestrial origin of the sediments. Except for trace fossils such as dinosaur footprints, fossils are scarce to non-existent in the redbeds; the highly oxidizing conditions under which the original sediments accumulated are not conducive to the preservation of animal or plant remains. Because of the less-oxidizing conditions, and sometime anoxic, conditions present on the bottom of the lakes that formed, fossils of plants and fresh water fish are commonly found in the darker gray lacustrine (lake) beds. The dinosaur tracks were found in what was the shoreline sediments along the margins of lakes and streams. The fossils indicate that the Newark Supergroup was deposited during the later half of the Triassic Period. Fossil evidence also indicates that at least a few of the basins actually continued to subside and accumulate sediment into the Early Jurassic. By Jurassic time, however, the rift valleys that formed to the east of the Triassic basins had begun to flood with marine water to form linear oceans similar to the modern Red Sea as the Atlantic Ocean began to open. With the opening of the ocean, the Triassic basins, filled with the rocks of the Newark Supergroup, moved westward as part of the eastern margin of the newly-formed North American continent.

While North America was separating from Europe and North Africa to form the North Atlantic Ocean, another separation was initiated between North Africa and Europe with the formation of the **Tethys Sea** (**Figure 6**). During Triassic and early Jurassic time while all this was going on, several micro-continents were breaking away from northern Gondwana that would eventually collide with southeastern Asia.

The Triassic of the Cordilleran: While the Triassic tectonic processes that were affecting the eastern portion of North America were relatively quiet, the western margin of the continent was being subjected to much more dynamic events. During the Triassic, most of the craton was covered by an alluvial plain that extended from the eroded remains of the Alleghenian Highland to the present location of the Rocky Mountains (**Figure 7**). To the west of this vast plain, the western margin of the craton was covered by a shallow sea that occupied a **forearc basin** that extended all along the margin of the continent between the western shoreline of the continent and a chain of island arc volcanoes (**Figure 8**). With the craton largely emergent, most of the Triassic sedimentation consisted of non-marine stream and lake deposits. During the early Triassic, for example, throughout what is now Arizona and southern Utah, a formation of fluvial deposits called the **Moenkopi Formation** was laid down by streams that were meandering over a low plain. Cut and fill channel sandstones that record the presence of meandering streams are common in the Moenkopi. Also common are mudcracks on many bedding surfaces that attest to the dry conditions that existed in the region of the time

Although the arid conditions of the Permian carried over into the Triassic, there was enough moisture carried inland by the prevailing winds to allow the growth of forests. For example, in Utah and Arizona, the **Chinle Formation** consists of river and lake sediments that incorporated a rich fossil assemblage of tree remains. In places such as the Petrified Forest National Monument in northeastern Arizona, erosion of the Chinle has exposed the remains of silicified redwood-like tree trunks. The Chinle Formation is also responsible for the highly colored shales and siltstones exposed in the Painted Desert of eastern Arizona. In southwestern Utah, the Chinle is overlain by the **Wingate Sandstone** which consists of "fossilized" sand dunes, again recording the arid climate of the time. Above the Wingate is the **Kayenta Formation** which is a river deposit, all attesting to the changing climate during the Triassic.

The major process going on along the western margin of North America was the combination of subduction and accretion of new terranes. The process actually began with the Late Devonian and Early Mississippian Antler Orogeny during which the collision of the Klamath island arc with the western margin of Laurentia added a sliver of exotic terrane, called the **Roberts Mountain terrane** to the edge of the continent (**Figure 9**). During the Permian, another volcanic arc approached the western margin of the continent, but this time it was a continental arc associated with a micro-continent called **Sonomia. (Figure 10)**. During the Sonoma Orogeny of Early Triassic time, Sonomia collided with and was accreted to the western margin of North America. As Sonomia collided with the margin of the continent, the accretionary wedge that formed ahead of the approaching arc was thrust onto the Roberts Mountain terrane that had been in placed during the Antler Orogeny (**Figure 11**). Sonomia now comprises most of southeastern Oregon and northern California (**Figure 12**)

Before the close of the Triassic, a new zone of subduction formed along the continental margin. The difference between this zone of subduction and those associated with the Antler and Sonoma orogenies is that the former zones dipped *westward* below the oncoming arc (refer to Figures 11 and 12). In contrast, this new zone of subduction dipped *eastward* below the westward moving margin of North America (**Figure 13**). Eventually this zone of subduction would extent all the way from Alaska to Chile and would be the site of major mountain building episodes throughout the Mesozoic that would create a range of mountains similar in every respect to the modern Andes Mountains. Not that the tectonic geology of the Pacific margin of North America wasn't already complicated enough, but during the Mesozoic Era a number of additional zones of subduction would form to the west, each associated with an exotic terrane that would in turn be added to the growing western margin of the continent. We will continue this story in our discussion of the Jurassic and Cretaceous periods.

In light of the widespread continental glaciation of the Permian, it is noteworthy that no Triassic glacial deposits have ever been found. Apparently, by Triassic time, temperatures had become too mild for extensive continental glaciers to exist. The overall warming of Earth by

Triassic time can be inferred by the abundance of Triassic reptile remains which, because of their cold blooded nature, could not have survived if temperatures had dropped to freezing for any length of time.

Life of the Triassic

Marine Life: The mass extinction at the end of the Permian created many vacant environmental niches in the marine environment. Some forms that had suffered significant reductions during the Permian extinction made truly spectacular comebacks, a case in point being the ammonoids.. With only two genera having survived into the Triassic, the ammonoids expanded into at least 100 genera in the Lower Triassic alone; in fact, some paleontologists have referred to the Mesozoic Era as the "Age of Ammonoids". Cephalopods became so numerous that they became useful for world-wide correlation of Mesozoic rocks. Another group of cephalopods that became abundant during the Mesozoic were the squid-like **belemnites**. In fact, the Triassic belemnites may well have been the ancestor to the squids which became numerous during the Jurassic.

With most of the grazers having been wiped out, the stromatolites returned to the shallow subtidal environments around the world. The resurgence would, however, be short lived as the grazers, in particular the gastropods, along with the bivalves quickly became the most prominent groups in the Triassic seas. Sea urchins also made a spectacular return and diversified during the first half of the Mesozoic.

As the continent separated and currents began once again to mix the ocean waters, reefs began to return with the earliest reefs consisting primarily of algae and sponges. Before the end of Triassic time, however, both solitary and colonial **hexacorals** had evolved and by the end of the period were major contributors to the framework of growing reef complexes (**Figure 14**). It is interesting to note that because some of the early reefs apparently grew in deep water, the symbiotic relationship that exists today between algae and coral animals had not yet evolved. However, the appearance of large reefs dominated by hexacorals is taken as evidence that the symbiotic relationship had evolved by late Triassic and early Jurassic time. Missing from the early Triassic seas were the arthropods such as our old friend the trilobite, but it would not be long before arthropods would reappear in the form of crabs and lobsters in Jurassic time.

Although ammonoids and belemnites were the major swimming predators during the Triassic, ray-finned bony fish were diversifying. The Mesozoic fish differed from their modern counterparts in that they lacked overlapping scales, had relatively primitive jaws, had skeletons made partially from cartilage rather than entirely of bone, and exhibited highly asymmetrical tail fins. An important evolutionary development amongst the Mesozoic fish was the swim bladder which allows the fish to change its buoyancy in the water.

Marine reptiles evolved during the Triassic including the **placodont** that had flat-crowned teeth specifically designed to crush shells. Another early marine reptile was the **nothosaur** that resembles modern seals and apparently lived along the shoreline where they fed on fish. Neither the placodont nor the nothosaur survived the Triassic,. However, before the demise of the nothosaur, it gave rise to the **plesiosaur** which, by Cretaceous time, had grown to the size of a modern whale. The plesiosaurs had wing-like limbs that propelled them through the water much like a bird flies through the air **(Figure 15)**. Of the marine reptiles, the most fish-like in appearance was the **ichthyosaur** that resembled a modern dolphin **(Figure 16)**. Most ichthyosaurs were relatively small (10 to 15 feet in length) although the largest ichthyosaur, ***Schonisaurus***, was found in Nevada and measured 45 feet in length and was estimated to have weighed more than 8 tons.

Ichthyosaurs were totally marine and therefore, rather than laying eggs, they bore their young alive. In fact, fossils of ichthysaurs have been found with the skeletons of embryo ichthyosaurs within the female's body.

The last group of Mesozoic marine reptiles to evolve in Triassic time were the early crocodiles. Although the crocodile evolved as a land animal, some became adapted to the marine environment by the late Triassic or early Jurassic.

Terrestrial Plant Life: Plants did not undergo the massive extinction that affected the animal community at the end of the Permian. Most of the plants that had dominated in the Carboniferous swamp environment and that grew on the upland areas had undergone a gradual decline during the close of the Paleozoic with a few rare specimens of Sigillaria being found in Triassic rocks. The major late Paleozoic plant types that did survive into the Triassic were ferns and seed ferns. Although the seed ferns did not survive into the Jurassic, the ferns dominate the Triassic fossil flora and were the dominant understory plants in the Triassic forests. The trees that grew above the ferns were all gymnosperms and included the cycadeoids, the cycads, the ginkgos, and conifers. Of the four, cycadeoids are now extinct, cycads are rare, and only one species of ginkgo exists; it was the conifers that were to survive to become the most dominant land plant of the Mesozoic.

Cycads, commonly called sego palms, look much like modern palm trees except that they are gymnosperms. Today, cycads grow in Florida, Central America, and the Southern Hemisphere. A cycad plant is either male or female with the male cones generating pollen that is carried by the wind to the female cones.

The ginkgos deserve special mention. Ginkgos were abundant up through the Jurassic when they began to decline. Today, only a single species, *Ginkgo biloba*, survives. In fact, until 1690 when living specimens were found growing in a Chinese monastery, they were thought to have gone to extinction. All ginkgos today are direct descendants of those few plants found in China. Ginkgo plants are also either male or female with the male being the one selected for planting in public and private gardens due to the fact that the female fruit begins to take on a vile smell when it ripens.

The conifers that occupied the Triassic forests had the appearance of the modern "monkey puzzle" tree. The fossilized tree trunks found in the Petrified Forest National Monument in Arizona are the remains of these forest conifers.

It might be pointed out that, except for the ferns, nearly all of the remaining Triassic vegetation was unpalatable, if not toxic, to the early Mesozoic herbivores. If they were like most of their modern counterparts, the great majority of Mesozoic plants had fibrous leaves that contained toxins that would have been harmful to any animal that tried to eat them. In addition, because these plants were very slow-growing, they could not have survived the continuous cropping of plant eaters. With most of the Mesozoic trees eliminated as potential food, the diet of most Mesozoic herbivores was limited to the ferns that, fortunately, grew in abundance.

Marine Plants: Because most marine plants either float or are suspended in water, they have neither the vascular system or the semi-rigid tissues (wood) that characterize the land plants. As a result, most marine plants are uni-cellular. The major groups of marine plants are part of the plankton and are therefore referred to as **phytoplankton**. The major difference between the phytoplankton that dominated the seas before the Mesozoic, namely the acritarchs, green algae, and blue-green algae, and those that dominated from the beginning of the Mesozoic to the present day is that the pre-Mesozoic phytoplankton did not have mineralized coatings. The most dominant members of the Mesozoic phytoplankton were the coccolithophorids, dinoflagellates, silicoflagelates, and the diatoms. The rapid expansion of the coccolithophorids and the dinoflagellates began in the Early Jurassic. From the Jurassic on, the dinoflagellates were among the primary producers of the marine food chain. The earliest silicoflagellates and diatoms appear in the Middle Cretaceous.

Reptiles Take Over the Land: In mid-Triassic time, the synapsid-amphibian population that had dominated the land since the late Paleozoic began to give way to advanced reptiles including all living reptilian types except for turtles. There were two groups that took over. One group, the predecessor to the modern lizards and snakes, included the **ichthyosaurs** and **plesiosaurs,** both of which were marine reptiles that had descended from terrestrial forms. The second group, and the one that dominated, was the **archosaurs** or the **thecodonts**, that included crocodiles, dinosaurs, and birds.

The thecodonts evolved into two groups, the first of which is represented by modern crocodiles. Although true crocodiles evolved in the Triassic, they were only about the size of a lizard; their day was yet to come. Other members of the group were much more imposing. During the Triassic, the most common herbiverous thecodont was the **rhynchosaur** whose jaws were equipped with a sharp beak not unlike a modern turtle that allowed the animal to cut through tough plant fibers and seeds. The largest carnivorous thecodont of the day was the **phytosaur** that resembles a modern crocodile except for the fact that its nostrils were on the top of its head rather than at the end of its snout **(Figure 17)**.

The second group of thecodonts were bipeds. The earliest Triassic representatives were about 3 feet long and used their long tail to balance themselves on their hind legs (**Figure 18**). **Dinosaurs** would evolve from this group in the Triassic and before the end of the period would outnumber all other kinds of reptiles, a dominance position that they would occupy to the very end of the Mesozoic Era.

The Dinosaurs Take Over: The word **dinosaur** is from the Greek *deinos*, terrible and **saurus,** reptile. The first dinosaurs were upright bipeds. Unlike the other reptiles whose legs were positioned out to the side in a sprawling stance, the hind legs of the dinosaurs were completely beneath the body (**Figure 19**). Two major groups of dinosaurs emerged, the **saurischians** and the **ornithischians**.

The basic difference between the two groups was in the structure of the pelvis. The saurischians were "***lizard-hipped***" with three bones oriented around the hip socket with the pubic bone that supported the internal organs and to which the muscles were attached that pulled the thigh forward (**Figure 20**). The ornithischians were "***bird-hipped***" in which the pubic bone was rotated backward parallel to the ischium (**Figure 21**). All ornithischians had toothless beaks and well-developed cheeks that would hold vegetation while it was chewed. While there were both herbivorous and carnivorous saurischians, the ornischians were all herbivorous and consisted of a variety of animals including the duckbilled and armored dinosaurs.

One of the early herbivorous sauropods was about 25 to 30 feet long with a long neck that allowed it to brows on the upper limbs of trees. Being relatively small, these animals could move on either two legs or four. By Jurassic time, however, the herbiverous sauropods had become huge, the most well-known being **Brontosaurus** that was about 80 feet long and weighed an estimated 30 tons (**Figure 22**). The largest of all, **Seismosaurus**, was estimated from a few vertebrae and limb bones to be about 110 feet long and weigh nearly 100 tons. One question that is often asked is how such huge animals with such small heads and mouths could have eaten enough food to supply the needs of its enormous body. The best answer is that they must have eaten constantly, devouring anything in their paths.

The carniverous thecodonts were the super predators of the day. Although relatively small in the Triassic (5 feet long and weighing about 45 pounds), by the Cretaceous, they would eventually evolve into ultimate carnivore, **Terrannosaurus rex** that stood nearly 20 feet high and weighed an estimated 3,000 pounds (**Figure 23**). All the evidence indicates that these predators were able to run on their hind legs for considerable distances, indicating that they were actually warm-blooded. Cold-blooded reptiles can only run for relatively short distances before their source of energy is consumed. Warm-blooded animals, on the other hand, have the reserve of energy that allows them to run fast and for extended distances. All the evidence is that the carniverous thecodonts could chase prey to ground. Fossil tracks also suggest that the carnivorous thecodonts hunted in packs and co-operated to run down and kill their prey, not unlike many modern carnivores.

In addition to these large, fearsome creatures, there were other thecodonts that were not nearly as large but were equally as fearsome. One of the most vicious of these was the Cretaceous **Deinonychus** (**Figure 24**). While only about 10 feet long and weighing an estimated 40 pounds, it had strong, grasping front limbs and a huge claw on each hind foot that it used to slash and disembowel its prey

It was from the sauropod dinosaurs that birds were to evolve. If one were to compare the details of the skull, wrist, ankle and general structure of the skeleton of advanced sauropods and those of modern birds, it would be quite difficult to tell them apart. It was for this reason that the first fossil of a Jurassic bird, **Archaeopterix**, was originally mis-identified as a dinosaur until the discovery of feathers and the presence of a breastbone proved it to be a bird. The similarity in the skeletons of the dinosaurs and modern birds is the basis for the argument that birds should be classified as a subgroup of Dinosauria

The ornithosaurs consist of some of the strangest dinosaurs that roamed the land. Many of these animals were heavily armored, perhaps the most well-armored being **ankylosaurus** that was completely covered with thick boney plates as well as being equipped with a tail club for fending off possible predators **(Figure 25)**. Another well-known ornithopod was **stegosaurus** with is row of plates down its back and along its spiked tail.**(Figure 26)**. Most experts believe that the spinal plates were used to control their body temperature in the same fashion that back-finned reptiles control theirs. Another unusual ornithopod was the duck-billed dinosaur, or **hadrosaur**, whose mouth was lined with hundreds of tooth plates that were used to grind vegetable matter **(Figure 27)**. Another dinosaur with a distinctive head were the "boneheads" or **pachycephalasaurs**, whose massive boney head were thought to be used as a defense mechanism to fend off attacks from other pachycephalosaurs. Another familiar group of ornithopods were the Cretaceous **ceratopsians**. whose head was protected by a neck shield, often equipped with spiked edges and one or more horns. The largest, and last, of the ceratopsians was **Triceratops** that was about 25 feet long and tipped the scales at about 2500 pounds **(Figure 28)**.

Aerial Reptiles: Because the first reptiles that took to the air were not capable of sustained flight but rather soared on thermals and glided, we refer to them as "aerial" and not "flying" reptiles.

The ability to glide provided these reptiles with an easy way to cross from tree to tree or to move from tree top to the ground. In fact, the first fossil of what has been interpreted as a gliding reptile was discovered in Permian rocks and named *Daedalosaurus* after the Greek mythological figure, Daedalus, who flew on wings made of feathers and wax. A Triassic reptile, Icarosaurus, named after Icarus, the son of Daedalus who flew too close to the Sun and perished, also glided on wings of thin skin stretched between their appendages. It might be added that this same arrangement is found today in the Draco Lizard in Asia. There appeared in the Triassic a rather bizarre reptile called *Longisquama* that had exceptionally long scales along the front edge of its forelimbs and along its body that could be spread out to either side to serve as a wing. Some paleontologists believe that these over-sized scales could have been the forerunner to feathers. The first reptile considered to be capable of sustained flight was the **pterosaur**. The first pterosaur, Podopteryx, was found in Triassic rocks and had skin membranes that extended between its elbows and knees and from the rear legs to the tail. A fossil pterosaur discovered in Jurassic rocks in Russia was found to have a covering of hair, leading to the interpretation that the animal had developed endothermy and the hair served as insulation needed to maintain the body temperature needed for sustained flight.

The Mammals: Mammals descended from the last of the synapsids in the Late Triassic. For the next 150 million years, mammals remained small (about the size of a mouse) and kept out of the way of the predators of the day by hiding underground during the day and foraging for food at night. Some important structural differences between their synapsid predecessors and the mammals include a single jaw bone to help relieve the stresses of chewing. In contrast to the synapsids that probably swallowed their food whole, the early mammals exhibited the specialization of teeth for stabbing, slicing and chewing, a development that necessitated a stronger jaw structure equipped with more massive jaw muscles. Another development was the formation of a palate that separated the nasal passages from the mouth, allowing the mammals to eat and breathe at the same time. Many of the early mammals were egg-layers, a characteristic that is only present in the duckbilled platypus and spiny anteater of Australia and New Guinea. By the Cretaceous, egg-laying had been largely abandoned as the mammals diverged into two different groups, **the marsupials** and the **placentals.** In marsupials, such as the opossum, kangaroo, wallaby, koala, bandicoot, wombat, and Tasmanian devil, the young are born prematurely as embryos that climb up the mothers stomach and into a pouch where they attach itself to a nipple where they completes their development. Placental animals, on the otherhand, carry their young in the uterus until nearly fully developed and ready for birth. There are advantages disadvantages to both schemes. The advantage of placental development is the the young are protected during the embryonic development and are able to be more fully developed at birth. The disadvantage of placental development is the risks to the mother that are associated with birth, the fact that the infant cannot be aborted without the mother risking her own life, and the fact that both mother and child may perish if subjected to hard times such as the lack of food and water. The advantage of marsupial reproduction is that it is much less dangerous for the mother. For example, the mother can abandon the young with no danger to herself. If the times are good, that is if adequate food and water are available, she can care for multiple young. The disadvantage of the marsupial process is that the young are more vulnerable at a time when they can do little to save their own lives.

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