

WEEK 3 BRINGING LIFE TO ITS KNEES

So we've seen that, once the reptiles evolve from the amphibians, they become the dominant animals. And in the Permian we see the big diversification of reptiles. The early reptiles, many of them on land, were large, lumbering animals.

The pareiasaurs were among the earliest of these reptiles that we know of in the fossil record. The pareiasaurs are very interesting. They are these bulky animals, and many of them have these big scutes of bony armour that cover them. Some of them are completely covered in the armour, and some of them have fewer bony scutes than others.

All reptiles, as well as mammals and birds, are considered to be amniotes, since they all have amniotic eggs. Among mammals, only the monotremes lay eggs, whereas other mammals, placentals and marsupials, give birth to live young. So reptiles are regarded as a very significant group of vertebrates. Besides all their modern descendants, they are also the ones that give rise to dinosaurs, which later, about 150 million years ago, we see that they give rise to birds, but we also know that reptiles are the ancestors of mammals. That is the group to which we humans belong.

Another group of reptiles that differ from the pareiasaurs in terms of the number of holes in their skulls are the synapsids. The early history of this group begins with the iconic sail reptiles. Some of you might know these by the name of dimetrodon. They're very unusual in that they have these big sails over their backs of... over their backs. And we see that these sail reptiles are the beginning of the therapsid radiation. This is the group that we know of as the mammal-like reptiles. And this is the group to which mammals belong.

The earliest of the therapsids are the dinocephalians, which were large animals. Some of them were herbivores and others were carnivores. And these therapsids radiated

very early into many different other forms as well. Amongst them are the predatory gorgonopsians, which had big, long, sabre-like teeth on the side of their jaws, and they were vicious predators of the early Permian.

Towards the middle of the Permian, we see another group of carnivorous forms evolving. These are the therocephalians.

But the most abundant herbivores of the time were the dicynodonts. They reached the height of their diversity towards the end of the Permian. During this time, the cynodonts were small, carnivorous forms, and they were really few and far between.

Later this week, we will talk to Dr Mike Day who's a postdoctoral fellow at the Evolutionary Studies Institute at Wits University, and he will talk to us about his research into the decline of the dinocephalians. Now, very early in this course, I told you about background extinctions, and I told you there were sometimes minor extinctions that also occurred besides the big five extinction events. So, Mike works in this Guadeloupean extinction event that occurred just before the big end of the Permian extinction event. And we'll hear about his research into this particular extinction event.

Unlike the previous two extinction events, this time, when the end of the Permian extinction event struck, it had a huge impact on terrestrial biota. Plants, insects, amphibians and reptiles were all affected. Over 70% of vertebrates go extinct. Life in the oceans took an even bigger knock. More than 90% of marine species were annihilated by the end of the Permian extinction event.

What caused this extinction event is still much debated. There are several hypotheses. It could be that, at this time, the continents were merging to form a single large continental mass, called Pangaea. It may have been extreme volcanism in the area that is now Siberia. We see, in the fossil record, in the geological record, actually, basalt outpourings that extend over 300,000 km² and form a huge plateau. There was also a meteorite impact around about this time, and radar images in Eastern Antarctica show a large crater with a diameter of about 480 km, below 1.6 km of ice sheets. So any of these possible events may have triggered the end of the Permian extinction event.

Whatever the cause, we know that the end of the Permian extinction event was a dire time for life on earth. This extinction event is often referred to as the biggest extinction event of all time or, as some people like to say, the one that brought life on earth to its knees. But as we have seen before, life has resilience, and from the very depauperate remaining life forms, new forms begin to establish themselves. From the fossil records of environments that have preserved the end of the Permian and the beginning of the Triassic, we're able to see what kind of diversity was present at these times.

So the fossil records from the shores of the Tethys, or on the edge of boreal in the Northern Arctic Ocean, show that, in the latest Permian, the oceans had rich complex ecosystems, with reef communities having a rich diversity of corals, bryozoans and crinoids, as well as ammonoids and fishes. Even the sea bottom had a rich, complex fauna. There were also a diverse array of fishes. So, in the earliest Triassic, the situation appears rather bleak. After this big extinction event, we see that reefs have disappeared. Only the bivalve *Claraia* survives in the tropical ocean. In the Northern Arctic, *Claraia* and just a few other small fishes and other small components of the biodiversity survives. Star fishes and sea urchins are almost also wiped out. Before this event, we see about 20 to 30 different species of sea urchin. And after the event, just one or two species survives. From these minor groups, we see the diversity of all later sea urchins that we have today.

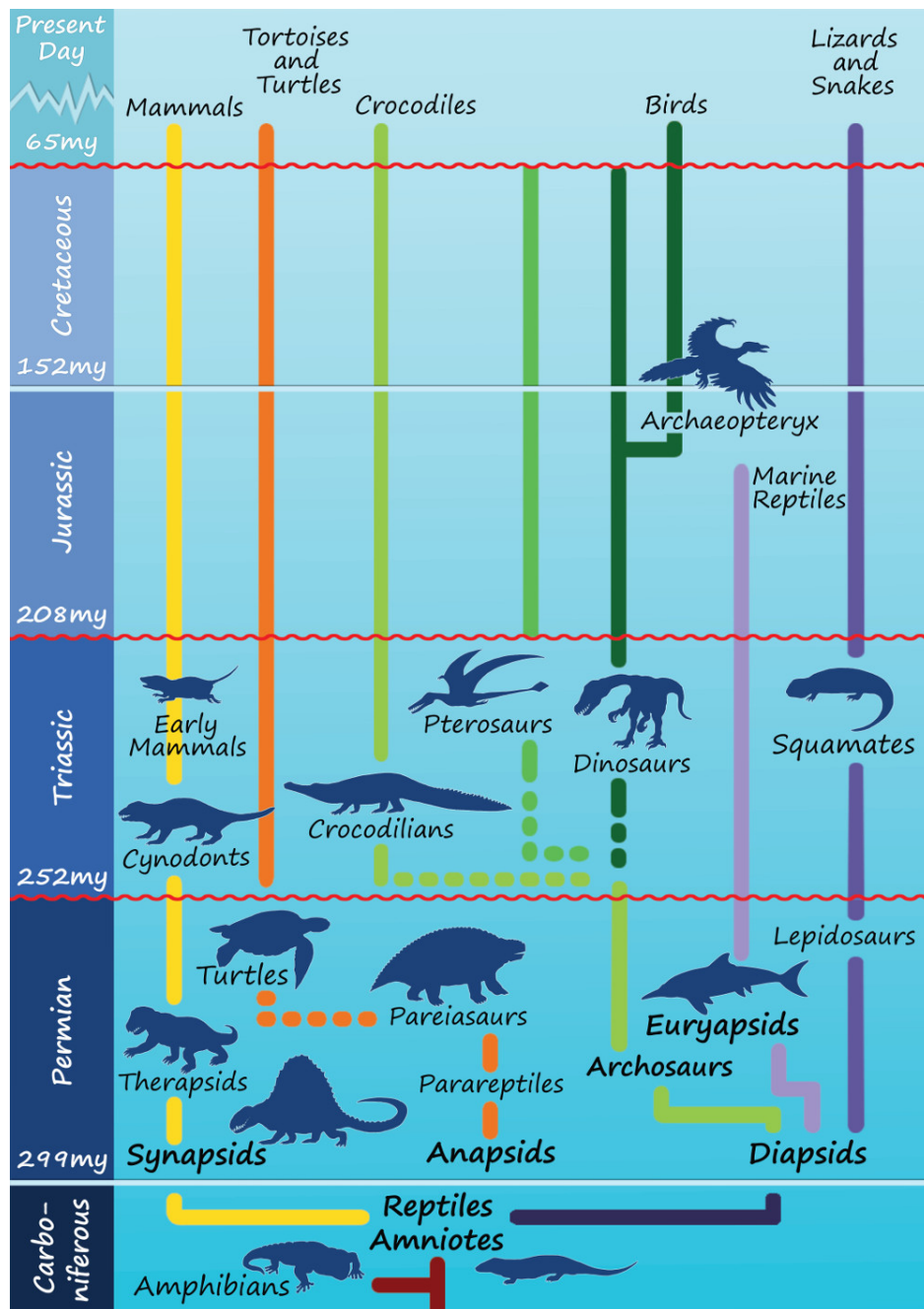
Life in the sea took about 8 million years to recover after the end of the Permian extinction event. On land, the environment changed from a world with abundant vegetation and large meandering rivers. We see that we now have a highly seasonal, drought-stricken, unpredictable environment. We know that, before the end of the Permian, there were more than 41 genera of mammal-like reptiles. But afterwards, only three genera survive. These survivors, the most important one and the one that most of you probably have heard of is *Lystrosaurus curvatus*. *Lystrosaurus* is one of those iconic mammal-like reptiles that not only survived, but it survived and spread globally to all other parts of the world. We also see the cynodonts' ancestor, *Progalesaurus*, and the small therocephalian, *Promoschorhynchus* that also survives.

The big enigma is how did these animals survive the post-extinction, drought-stricken environment? Not only did they survive, but how did they diversify thereafter?

Research suggests that these animals had special rapid rates of growth that allowed them to reach adult sizes very quickly, and they were able to reproduce faster, which allowed them to persist and survive in those unstable times. After the end of the Permian extinction event, in the Triassic, we see that mammal-like reptiles attempted to diversify further, but they never really attained the dominance they had before the end of the Permian. We see that the dominance is now taken over by the diapsid reptiles. Although the cynodonts were sparse before the end of the Permian, after the end of the Permian, they experience a significant rise in their number and their diversity, and we see, very soon thereafter, they give rise to the mammals. Even the diapsid reptiles, we know that they were present before the end of the Permian extinction event, but they only became the dominant reptiles afterwards. And amongst these reptiles we see the archosaurs, and this group of reptiles are very significant, because they give rise to dinosaurs, pterosaurs, and also to the crocodilians that we see today and ones that were around in the past.

Later this week, we will talk to Roger Smith about his research into paleoenvironments across the Permian-Triassic boundary in South Africa. So he's a geologist who looks at the sediments and is able to make deductions about the paleoenvironments. In terms of plants, we see a dramatic change in the flora, from *Glossopteris* in the Permian to *dicroidium* in the Triassic.

We will later talk to John Anderson about this change in the flora and the diversification of plants in the Triassic. All in all, it is estimated that it took about 10 to 20 million years for ecosystems on land to recover from the end of the Permian mass extinction event. And then, just when things were beginning to look brighter, when life was beginning to diversify again, the end of the Triassic extinction event struck. This will be the focus of the next lecture.



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