



PERMIAN MONSTERS

Life Before the Dinosaurs



INTRODUCING THE PERMIAN, ITS BIZARRE CREATURES
AND THE GREATEST EXTINCTION EARTH EVER EXPERIENCED.

A Travelling Exhibition Blending Art and Science





EXHIBITION OVERVIEW

Step back in time 290 million years when bizarre-looking animals dominated life on land and sea, and find out about the greatest extinction the world has ever seen in 'Permian Monsters: Life before the Dinosaurs'. This unique exhibition brings the past back to life with fossilized skeletons and full size life models of the animals that ruled the world millions of years before the age of dinosaurs, in a time known as the Permian.

The Permian period ended with the largest extinction Earth ever experienced, which wiped out 90% of all species on the planet. The cause of the end-Permian extinction had baffled scientists for the past 20 years but a recent discovery shed new light on the cause of this catastrophe: global warming. Find out how this familiar phenomenon, started by a huge volcanic eruption, set off a chain of events that led to the greatest extinction on Earth.

The exhibition blends art and science with a collection of new artwork which offers a glimpse back in time through the eyes of award winning paleo-artist Julius Csotonyi. View fossilised skeletons and reconstructed models of these amazing but bizarre creatures that dominated land and sea; and dig and identify fossils in the interactive dig pits throughout the exhibition.

'Permian Monsters' showcases an amazing collection of fossils and models from this relatively unknown time period, from giant insects, bizarre looking sharks to strange reptiles with mammal-like characteristics. Meet the top predator of the time, the giant saber-toothed gorgonopsid 'Inostrancevia' and find out what nearly killed them all to make way for Earth's next rulers, the Dinosaurs.

INTRODUCTION

THE PERMIAN IS A GEOLOGICAL PERIOD THAT BEGAN APPROXIMATELY 290 MILLION YEARS AGO, MILLIONS OF YEARS BEFORE THE AGE OF THE DINOSAURS.

DURING THE PERMIAN, THE FIRST LARGE HERBIVORES AND CARNIVORES CONQUERED LIFE ON LAND.

THE PERMIAN ENDED WITH THE LARGEST MASS EXTINCTION IN THE HISTORY OF EARTH.

WHAT WAS THE EARTH LIKE?

During the Permian the Earth's land masses were joined in one supercontinent known as Pangea.

The Permian began at the end of an ice age, therefore the Earth was cooler than present day. As time passed, the icecaps melted and the Earth slowly warmed up, becoming a lush green planet, where both animal and plant life thrived.

WHAT LIFE FORMS EXISTED DURING THE PERMIAN?

Plant life consisted of ferns, conifers and small shrubs.

Animals included fish, arthropods, amphibians and reptiles.

During the Permian reptiles developed mammal-like characteristics, but the first true mammals would not appear until the next geological period, the Triassic.

HOW LONG DID IT LAST?

The Permian period lasted 40 million years. It ended 250 million years ago with the start of the Triassic period.

HOW DID IT END?

The Permian ended with the largest mass extinction in the history of Earth: over 90% of all plant and animal life were wiped out. By the end of the Permian the Earth had become a biological desert.

PERMIAN SEA

DURING THE PERMIAN, EARTH'S SINGLE LAND MASS PANGEA WAS SURROUNDED BY AN ENORMOUS OCEAN CALLED PANTHALASSA.

PANTHALASSA TEEMED WITH LIFE FROM TINY SINGLE-CELLED ORGANISMS TO MARINE ARTHROPODS AND LARGE FISH.

The Permian period was the end of an era called the Paleozoic, meaning "ancient life". During the Paleozoic life in the sea evolved into many strange creatures, from giant sea scorpions to bizarre looking sharks. There were also many invertebrate life forms such as sponges, ammonites, nautiloids, crinoids, gastropods, brachiopods and trilobites. Corals also formed in the Paleozoic; after their near-extinction at the end of the Devonian period, they began to regenerate during the Permian period producing huge reefs.





The end of an era

Marine life was the most affected by the Permian-Triassic Extinction, with the loss of most invertebrates. By the end of the Permian 96% of all marine life had disappeared.

Some groups that had dominated the ocean during the Permian, such as ammonites, nautiloids, brachiopods and crinoids, did survive the extinction but their species were greatly diminished in number and they never held ecological dominance again.

Sharks and bony fishes suffered a major reduction in species but did survive the extinction.

Many corals did not survive the extinction. The horn corals and tabulate corals that had built many reefs disappeared during the Permian-Triassic extinction.

Trilobites, a dominant life form in the ocean for 290 million years, became extinct by the end of the Permian.

Artwork 'Permian Sea' by Julius Csotonyi



AMPHIBIANS

AMPHIBIANS BECAME TOP PREDATORS BY THE EARLY PERMIAN, HOWEVER THEIR NUMBERS WERE REDUCED WITH THE EVOLUTION OF LARGE LAND-DWELLING CARNIVORES AND GLOBAL WARMING. MANY AMPHIBIAN LINEAGES WERE WIPED OUT DURING THE PERMIAN-TRIASSIC EXTINCTION.

Conquering the land

Unlike the small amphibians of today, such as frogs, toads and salamanders; amphibians were the dominant land animals of the early Permian. They achieved monstrous sizes, with massive, tooth-studded jaws and strong legs.

The large reptile-like **TEMNOSPONDYLI** (meaning "cut vertebra") resembled large crocodiles and flourished worldwide during the Permian. Several groups evolved strong, robust limbs and vertebrae and became adapted to life on land, while others developed into heavy-bodied semi-aquatic predators. Toward the end of the Permian they were pushed back into the swamps by the newly evolved mammal-like large reptiles.

The small weird-looking **LEPOSPONDYLI** (meaning "husk vertebra") were a small but diverse group of amphibians that lived in the early Permian. Species were aquatic, semi-aquatic, or terrestrial. They were mostly

just a few centimetres long but some species grew up to a metre in length. Lepospondyli are thought to have lived in ecological niches not taken by the larger Temnospondyl amphibians.

How did they evolve?

Amphibians originally evolved from fish in the Devonian period, millions of years before the Permian. They were forced out of the ocean onto land with the evolution of larger marine creatures: land was a safe haven from these new predators.

Like today's amphibians, Permian amphibians were cold-blooded creatures that metamorphosed (changed) from a juvenile water-breathing form to an air-breathing adult; and laid their eggs in water, as did their fish ancestors.



Diplocaulus skull



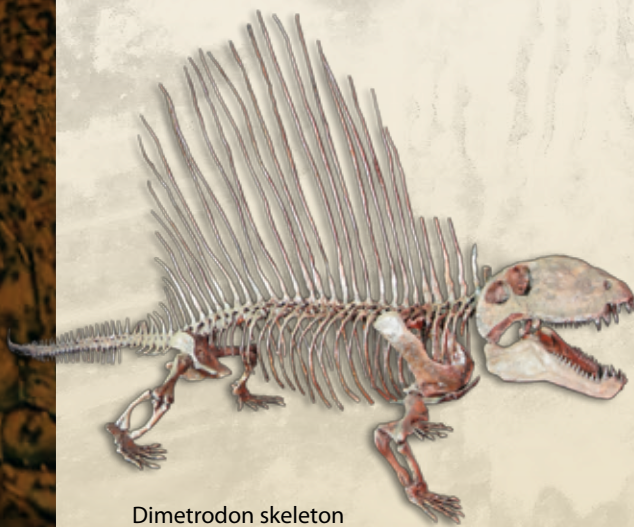
Artwork 'Permian Amphibians' by Julius Csotonyi

REPTILES

REPTILES DOMINATED LAND FOR THE FIRST TIME DURING THE PERMIAN. THEY EVOLVED INTO MANY FORMS, FROM SABER-TOOTHED FLESH-EATER TO LARGE HERBIVORES AND SMALL, LIKELY WARM-BLOODED REPTILES WHICH WOULD EVENTUALLY GIVE RISE TO MAMMALS.

Reptiles first appeared at the end of the Carboniferous, the period immediately before the Permian, evolving from amphibians. During the Permian, they evolved into large and bizarre creatures reaching up to 4.5 metres in length.

Paleontologists classify Permian reptiles into three main groups- synapsids, anapsids and diapsids- based on the number of holes in their skull.



Dimetrodon skeleton

Permian Synapsids: the Ancestors of mammals

The synapsids were the dominant group of reptiles during the Permian. They are also commonly known as 'mammal-like reptiles' because they showed characteristics of mammals, which had not yet evolved. These characteristics include a single hole in the skull behind each eye, and, in some species, the presence of hair. They also had different types of teeth: frontal incisors, big lateral canines for tearing and molars for chewing; a characteristic shared by modern mammals.

Synapsids are divided into the following two main groups:

Pelycosaurs dominated the early Permian, and they include the well-known sail-backed Dimetrodon.

Therapsids evolved into many different groups, and became the dominant terrestrial carnivores and herbivores of the late Permian. They include the gorgonopsid 'Inostrancevia' which became a top predator in the late Permian.

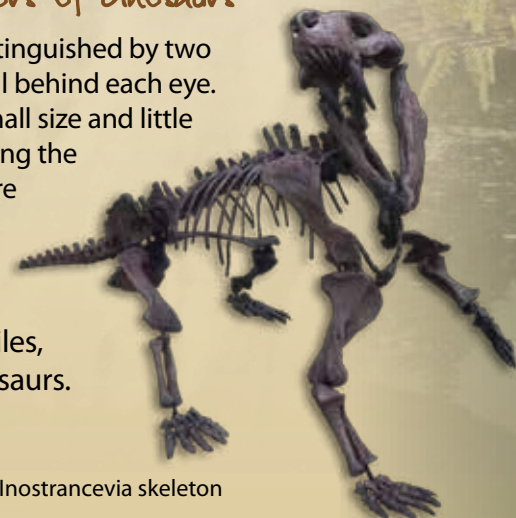
Therapsids are believed to be the ancestors of all mammals, and therefore our own ancestors.

Permian anapsids: the ancestors of turtles?

Anapsids are distinguished by the absence of a hole in the skull behind each eye. They include the pareiasaur 'Scutosaurus', one of the largest herbivores (plant-eaters) that lived during the Permian, reaching up to 3 metres in length. Turtles are also anapsids and are believed by some to be descendants of Permian anapsids.

Permian Diapsids: the ancestors of dinosaurs

Diapsids are distinguished by two holes in the skull behind each eye. Despite their small size and little dominance during the Permian, they are believed to be the ancestors of snakes, lizards, crocodiles, birds and dinosaurs.



Inostrancevia skeleton



Artwork 'Gorgonopsids' by Julius Csotonyi

DINOCEPHALIA meaning "TERRIBLE HEAD"

Dinocephalians were therapsids that appeared in the early Permian and became the largest animals of this period, some possibly weighing up to 2 tons. Some were carnivores (meat eaters), while others were herbivores (plant eaters) or omnivores (meat and plant eaters).

The dinocephalians mysteriously became extinct at the end of the middle Permian leaving no descendants.



DICYNODONT meaning "TWO DOG TEETH"

Dicynodonts are therapsids that appeared in the middle Permian. They belong to the group Anomodontia. They were toothless, except for two tusk-like canines, and herbivores (plant eaters). They ranged in sizes from small rodent-like animals to up to 4 metres in length during the Triassic. The dicynodonts survived the Permian extinction and dominated the Triassic.



PELYCOSAUR meaning "BASIN LIZARD"

Pelycosaurs are synapsids that appeared in the late Carboniferous and dominated the early Permian. Early pelycosaurs were small lizard-like animals which evolved into many different types of herbivores and carnivores, both small and large, no more than 4 metres in length.

The most well known pelycosaur is the sail-backed Dimetrodon.

Pelycosaurs lost their dominance in the middle Permian and the few groups that made it through became extinct during the Permian-Triassic extinction.



PAREIASAUR meaning "CHEEK LIZARD"

Pareiasaurs are a group of anapsids that were dominant in the late Permian. These medium to large-sized herbivores (plant-eaters) include the biggest terrestrial anapsids that ever lived, growing up to 3 metres in length. Pareiasaurs had small heads with a large round body, stocky limbs and short pointy tail. It has been suggested that they are related to modern turtles. Pareiasaurs became extinct during the Permian-Triassic extinction.

**CYNODONT** meaning "DOG TEETH"

Cynodonts are therapsids that appeared towards the end of the Permian. It is believed that they are the direct ancestors of mammals. Small holes in the snout suggest that cynodonts had whiskers and were covered with hair, indicating that they were warm-blooded. Cynodonts have characteristics of both mammals and reptile and could be the missing link between the two groups. Cynodonts were among the few groups that survived the Permian-Triassic extinction.

**GORGONOPSID** meaning "GORGON FACE"

Gorgonopsids are therapsids that appeared in the middle Permian. They were carnivores, some were dog size while others possibly grew up to 4 metres in length. Gorgonopsids had huge powerful jaws and large saber-teeth; and were the top predator of the late Permian. Gorgonopsids became extinct during the Permian-Triassic extinction.



THE GREAT DYING

The Permian - Triassic Extinction

The Permian ended with the largest extinction in Earth's history, known as the Permian-Triassic extinction or 'The Great Dying'.

Recent discoveries relate the Permian-Triassic extinction to a major event that occurred at the time: the volcanic eruption that created the Siberian Traps. Also known as a flood basalt eruption, this volcanic eruption continued for one million years, and covered 2 million square kilometres, roughly the size of Western Europe. Its effects were acid rain, blocked out sunlight and disruption of photosynthesis, causing a collapse of the food chain. Carbon dioxide emitted from the eruption would have caused global warming and raised land and sea temperatures by

approximately 5 degrees Celsius.

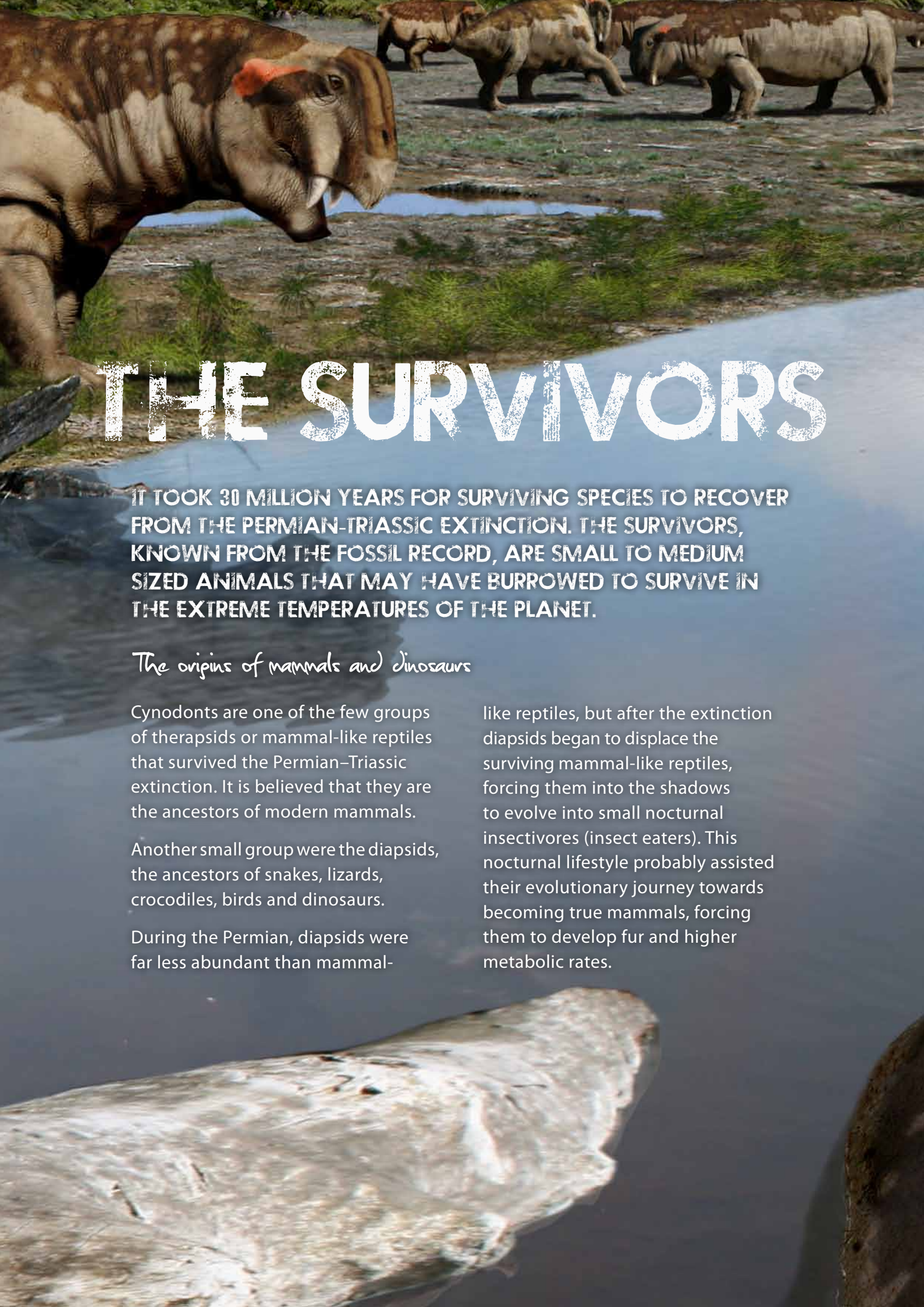
As a result of global warming from volcanic activity, frozen methane hydrate stored in large deposits beneath the ocean floor melted, releasing methane gas into the atmosphere. This caused global warming by a further 5 degrees Celsius. This 10 degree Celsius increase was enough to wipe out 90% of all species on the planet.

Up to 96% of the Earth's marine species and 70% of reptile, amphibian, insect, and plants species became extinct.





Artwork 'Permian-Triassic Extinction' by Julius Csotonyi



THE SURVIVORS

IT TOOK 30 MILLION YEARS FOR SURVIVING SPECIES TO RECOVER FROM THE PERMIAN-TRIASSIC EXTINCTION. THE SURVIVORS, KNOWN FROM THE FOSSIL RECORD, ARE SMALL TO MEDIUM SIZED ANIMALS THAT MAY HAVE BURROWED TO SURVIVE IN THE EXTREME TEMPERATURES OF THE PLANET.

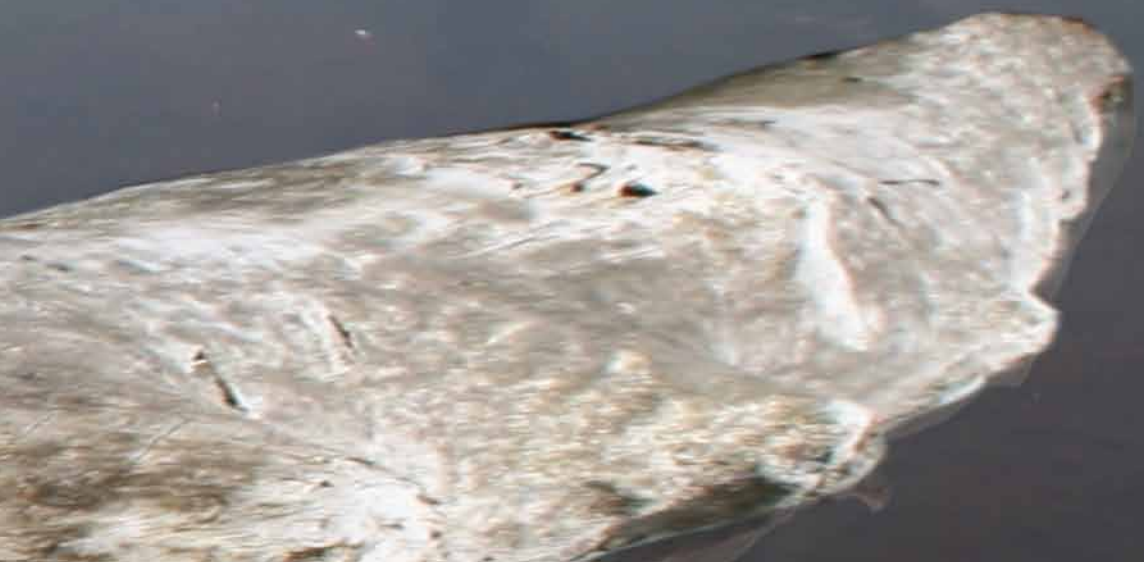
The origins of mammals and dinosaurs

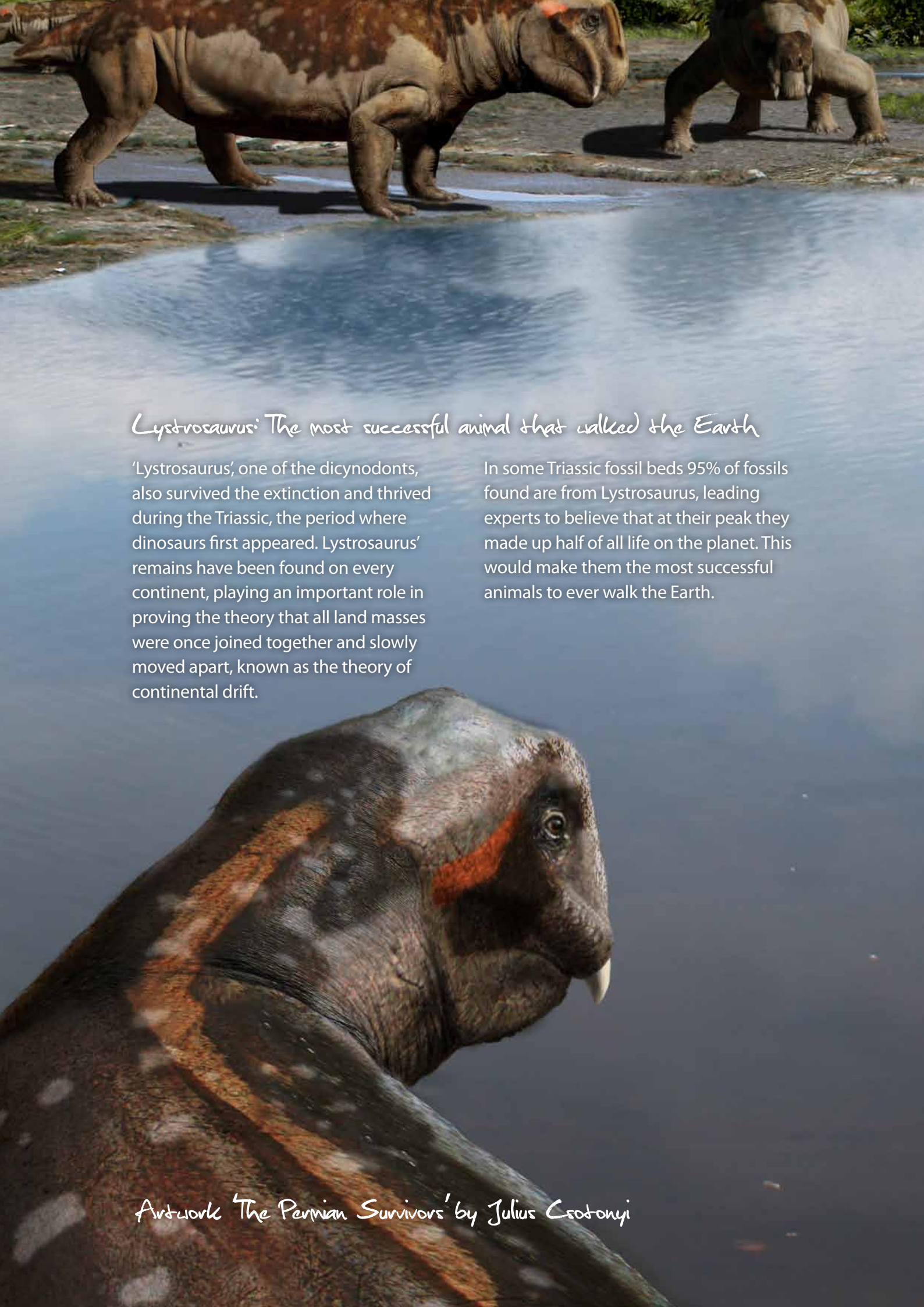
Cynodonts are one of the few groups of therapsids or mammal-like reptiles that survived the Permian-Triassic extinction. It is believed that they are the ancestors of modern mammals.

Another small group were the diapsids, the ancestors of snakes, lizards, crocodiles, birds and dinosaurs.

During the Permian, diapsids were far less abundant than mammal-

like reptiles, but after the extinction diapsids began to displace the surviving mammal-like reptiles, forcing them into the shadows to evolve into small nocturnal insectivores (insect eaters). This nocturnal lifestyle probably assisted their evolutionary journey towards becoming true mammals, forcing them to develop fur and higher metabolic rates.





Lystrosaurus: The most successful animal that walked the Earth

'Lystrosaurus', one of the dicynodonts, also survived the extinction and thrived during the Triassic, the period where dinosaurs first appeared. Lystrosaurus' remains have been found on every continent, playing an important role in proving the theory that all land masses were once joined together and slowly moved apart, known as the theory of continental drift.

In some Triassic fossil beds 95% of fossils found are from Lystrosaurus, leading experts to believe that at their peak they made up half of all life on the planet. This would make them the most successful animals to ever walk the Earth.

Artwork 'The Permian Survivors' by Julius Csotonyi

EXHIBITION AUDIENCES

'Permian Monsters' is designed to appeal directly to families, dinosaur enthusiasts and educational groups. Children's interests and school curricula have framed the exhibition approach. With these in mind, all exhibition text keeps scientific terms and jargon to a minimum.

The exhibition is rich in natural history specimens and interactives, with the majority of objects on display being casts and life models. The use of casts aids in the interactive nature of the

show and allows people to touch and get close to the specimens.

Other elements that contribute to the kid-friendly approach are a large number of colourful artworks - especially commissioned to illustrate scenes or 'windows' into Permian life; full size life models, digpits for kids to dig for fossil bones, interactive stations, touch fossils (casts), question & answer computer quizzes and a Permian soundscape with insect, reptile and amphibian sounds.

EXHIBITION PRODUCTION

'Permian Monsters' has been produced by Australian-based company Gondwana Studios, which specializes in the fabrication of scientific replicas and museum exhibitions. Holding a large collection of fossil casts from the Permian and a long-term interest in this time period, Gondwana Studios decided to produce an exhibition focusing on this fascinating and relatively unknown part of Earth's history.

The following associates have contributed to the development of the exhibition:

SCIENTIFIC

Prof Paul Wignall, University of Leeds, Leeds, UK

Ron Blakey, Colorado Plateau Geosystems, Colorado, USA

ARTISTS

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Staab Studios, Missouri, USA

GRAPHIC DESIGNER

Louise Thrush, Launceston, Australia

FOSSIL REPRODUCTIONS

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Black Hills Institute of Geological Research, South Dakota, USA
Gaston Design, Colorado, USA
Chris Moore Fossils, Dorset, UK

AUDIO ENGINEER

Nick Monson, Illinois, USA

COMPUTER INTERACTIVE

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