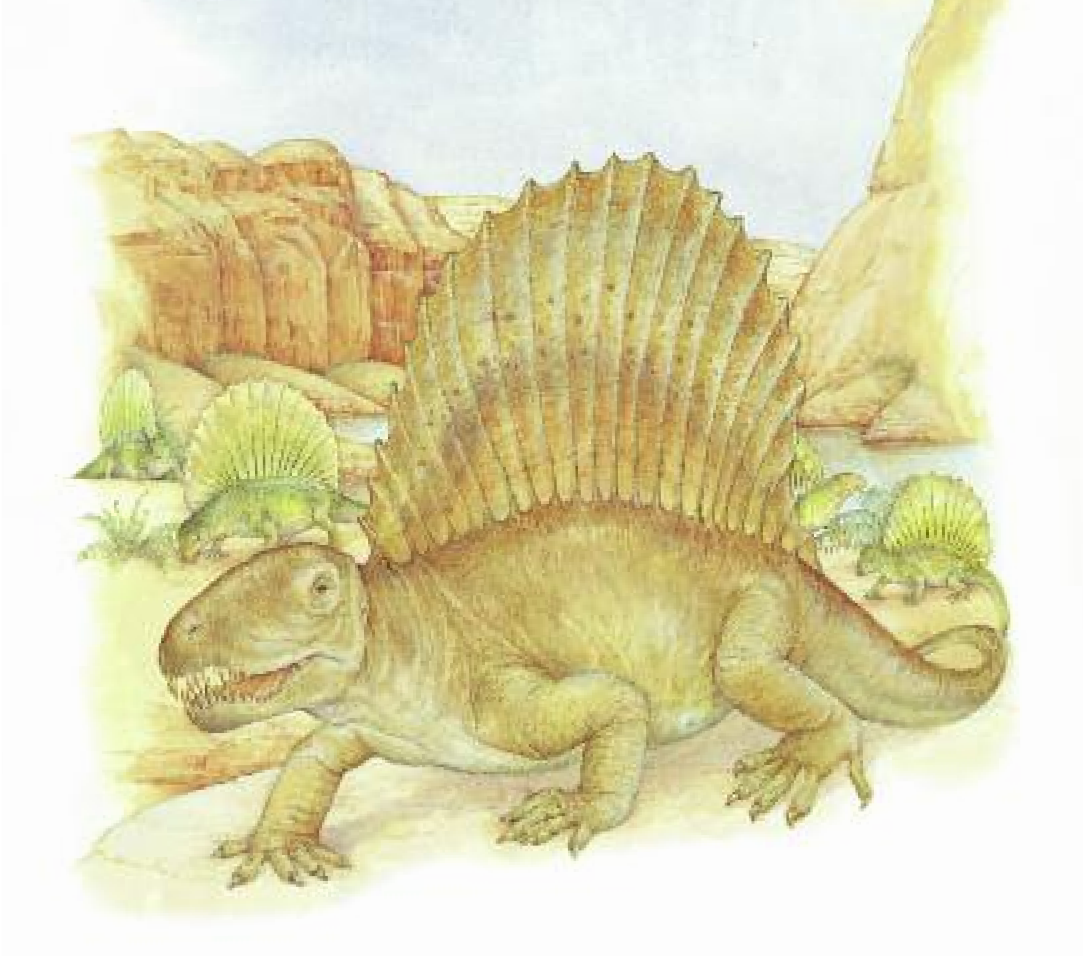
children's illustrated encyclopedia

Prehistoric Life



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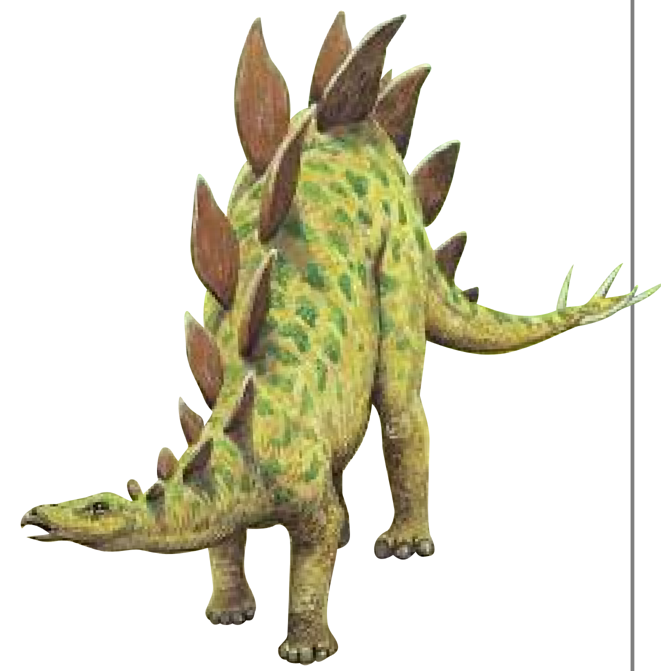
CONTENTS

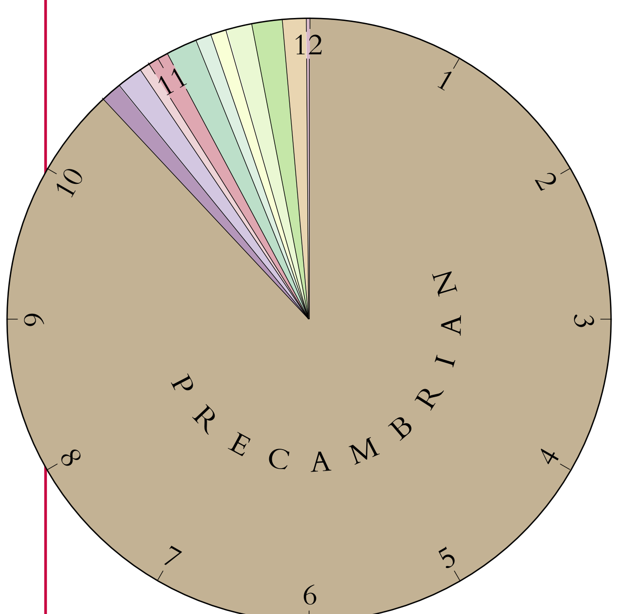
Contents



The Story of the Earth

THE EARTH is 4600 million years old. This huge span of time is difficult to imagine, so events in the Earth's history are therefore measured in geological time, spans of millions of years. A "recent" event in geological time, for example, may have happened in the last million years.

Geologists divide time into three Eons: the Archaean ("ancient"), from the origin of the Earth to about 2500 million years ago (Ma), the Proterozoic ("first life") to 530 Ma, and the Phanerozoic ("visible life") to the present. The Archaean and Proterozoic are often referred to together as the Precambrian. The Phanerozoic is subdivided into Eras: the Palaeozoic (530-250 Ma), the Mesozoic (250-65 Ma) and the Cenozoic (65 Ma-present). The Eras are split into Periods, which are shown here *(right)*. The Tertiary and Quaternary Periods are themselves divided into Epochs.



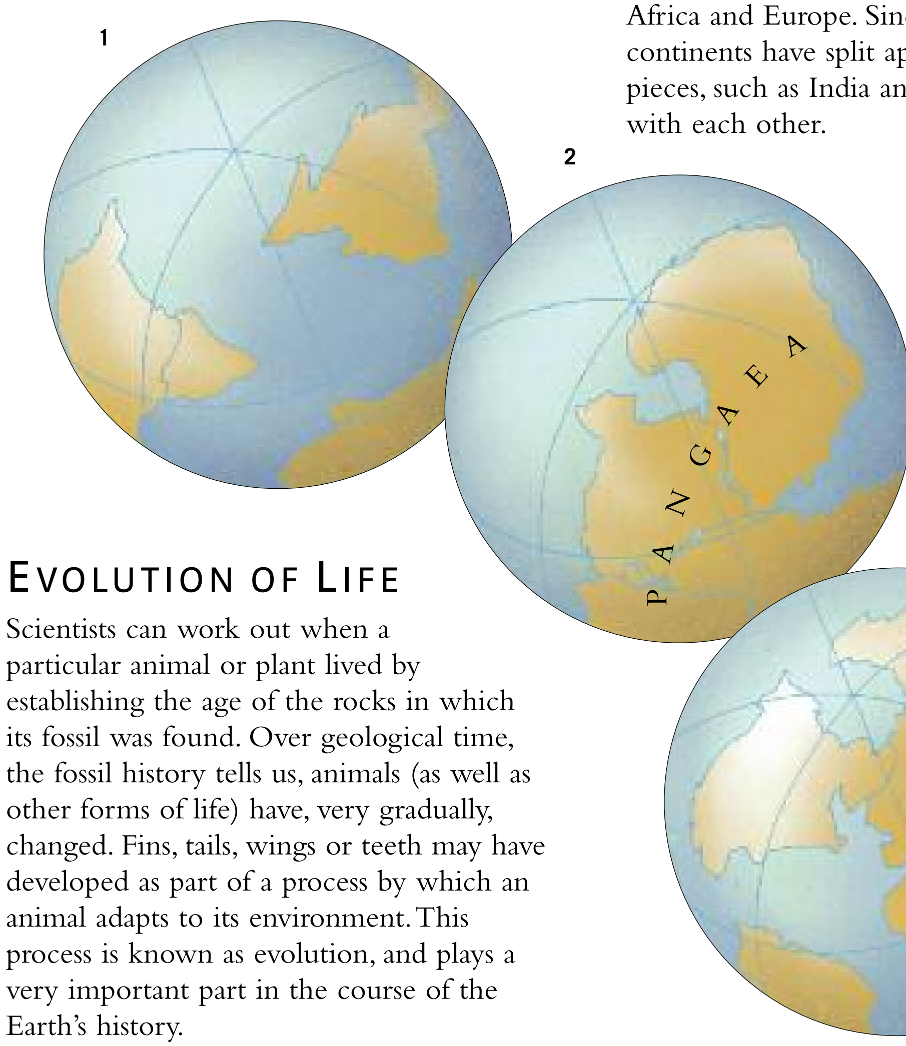
A way to understand geological time is to imagine 4600 million years of Earth's history taking place in just 12 hours! The Precambrian would take up the first 10 ½ hours. From the Cambrian "explosion" of life ***(see page 8)*** **to the present day would take up 90 minutes. The dinosaurs became extinct only 9 minutes ago. The entire history of humankind would make up the very last second.**

million years ago	Period	Events
	QUATERNARY	First modern humans
1.8	TERTIARY	
65	CRETACEOUS	Dinosaurs extinct First flowering plants
144	JURASSIC	First birds
208	TRIASSIC	First mammals First dinosaurs
250	PERMIAN	First archosaurs
286	CARBONIFEROUS	First mammal-like reptiles First reptiles
360	DEVONIAN	First amphibians First lobefin fish First insects
408	SILURIAN	First fishes with jaws
438	ORDOVICIAN	First land plants First jawless fishes
505	CAMBRIAN	First shellfish
530	PRECAMBRIAN	
3500		Oldest fossils
4600		Formation of Earth

The events of the Earth's history are recorded in the rocks that formed at a certain time. When sediments such as sand, silt or mud turned to rock, the remains of life-forms that lived at the same time became fossilized in the same rocks. Thus scientists can piece together evidence of what the world was like in the various geological periods. Layers of sedimentary rock represent every geological epoch, although there is no place on Earth where rocks from every period in geological history are found.

Drifting Continents

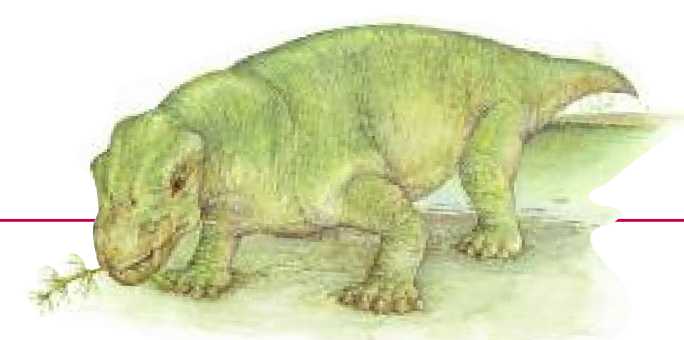
The outer shell of the Earth is divided up into large slabs, called tectonic plates. These plates, which include both the continents and the floors of the oceans, move slowly at a rate of about one centimetre a year. Over geological time, entire continents have wandered around the globe, colliding into one another or drifting apart. About 200 million years ago, they came together to form a single "super-continent" called Pangaea. There was no Atlantic Ocean, and the Americas were jammed up against Africa and Europe. Since then, the continents have split apart, although some pieces, such as India and Asia, have collided with each other.



These three globes show the movement of the continents over geological time. Still widely separated 400 Ma (1), they had collided to form Pangaea by 320 Ma (2). They split apart during the Age of Dinosaurs, after 180 Ma (3).

Evolution of Life

Scientists can work out when a particular animal or plant lived by establishing the age of the rocks in which its fossil was found. Over geological time, the fossil history tells us, animals (as well as other forms of life) have, very gradually, changed. Fins, tails, wings or teeth may have developed as part of a process by which an animal adapts to its environment. This process is known as evolution, and plays a very important part in the course of the Earth's history.



How do we know that continental drift has taken place? Fossils, once again, provide the evidence. The discovery of fossils of ***Lystrosaurus (left),*** **a Triassic reptile, in South Africa, India and Antarctica proves that these lands were once joined together (in Gondwanaland—*see page 14*). How else would this land animal have come to live in all three places?**

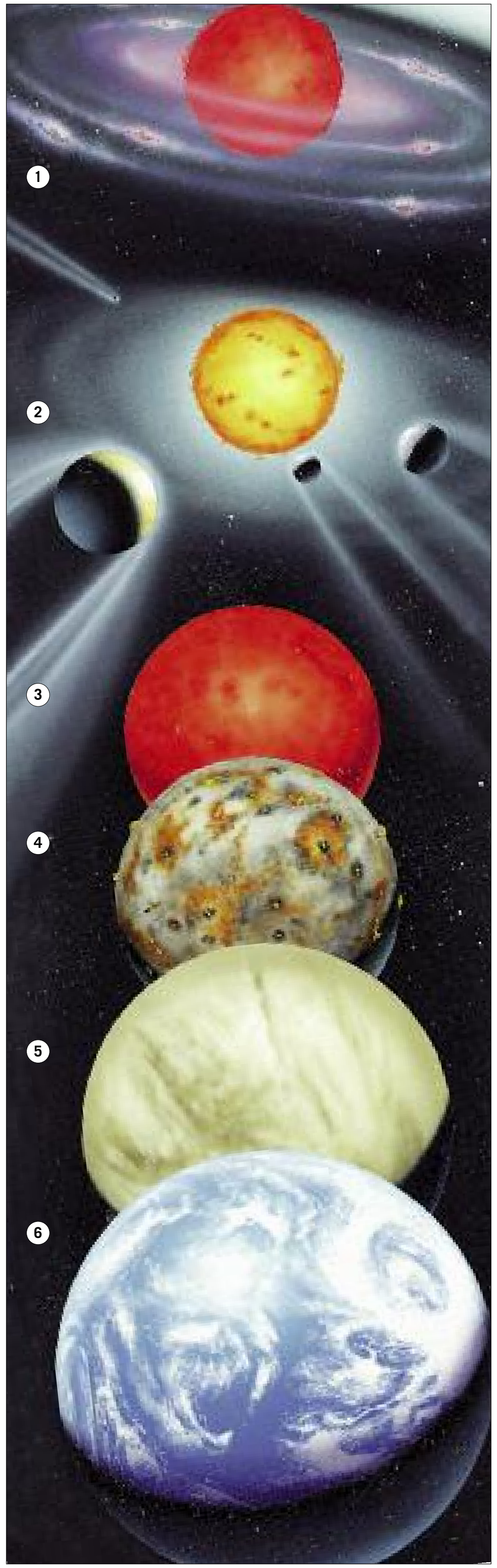
The Origin of the Earth

PLANET EARTH is one of eight planets orbiting the Sun, one of billions of stars in the Milky Way Galaxy, itself one of billions of galaxies in the Universe. The Universe came into existence 12-15 billion years ago. A few billion years later our Galaxy was formed, but it was not until about 4600 million years ago that the Sun and its family of planets, including Earth, made their appearance.

The Solar System Forms

No-one can say for sure how the Earth was formed, but many scientists agree on a likely sequence of events. The Solar System started out as a cloud of gas and dust drifting in space (many other such clouds in the Galaxy are known to astronomers). Something—perhaps a series of shock waves emitted from a star exploding close by—caused the cloud to clump together under its own gravity. A huge, whirling disc of gas and dust was set in motion (1). Matter fell towards the centre and became hotter and denser than at the edge of the disc. This core of intense energy was the beginnings of our Sun.

Meanwhile, the fragments of dust spinning around the core started to clump together, becoming at first small rocks, then "snowballing" into larger boulders, before growing into chunks several kilometres across, known as planetesimals. The planetesimals started to collide with one another, eventually building up to become the four rocky inner planets, Mercury, Venus, Earth and Mars, and the rocky cores of the "gas giants", Jupiter, Saturn, Uranus and Neptune. Energy from the Sun (the "solar wind") stripped away the gas that surrounded the inner planets (2). But the giant planets lay beyond the solar wind's fiercest blast and so held on to their thick atmospheres, which remain to this day.

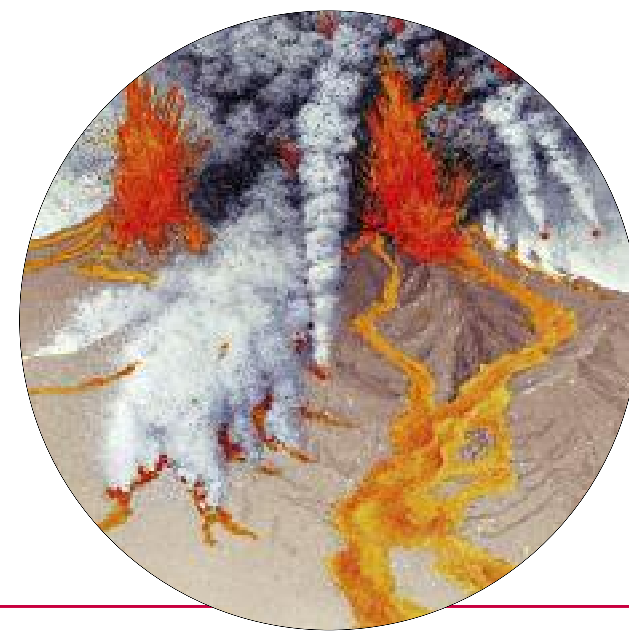


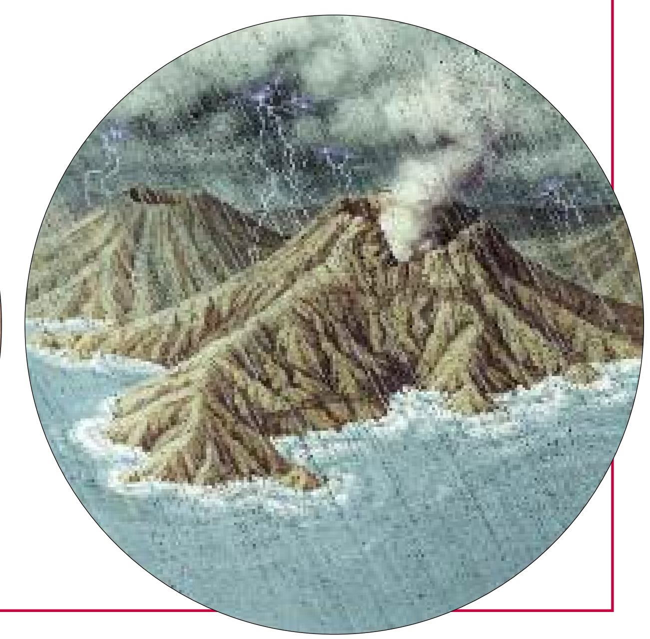
Young Earth

In its early days, Earth was a barren planet, rather like the Moon is today. Unprotected by an atmosphere, it was continually bombarded by meteorites, millions of rocky fragments that careered around the youthful Solar System. These crashed to the ground, some gouging out massive craters *(above left)*. The persistent bombardment may have caused the Earth's rocky surface to melt: the planet became a global sea of extremely hot, molten rock *(above right and 3 opposite)*. Eventually the bombardment eased and the surface cooled. But the newly solidifed surface trapped gases beneath it.

The pressure built up and hydrogen, carbon dioxide, water vapour and nitrogen burst through the crust in volcanoes. Thousands of eruptions raged all over the globe *(below left and 4)*. The gases collected to form a new atmosphere around the Earth. Water vapour rose to form the clouds that enveloped the planet (5).

Soon, as the Sun's intense heat began to cool, rain started to fall. It must have been the longest storm the Earth has ever known. Water poured from the sky for many thousands of years until the basins in the land filled up, becoming the great oceans *(below right and 6)*.





FIRST LIFE

THE FIRST LIFE on Earth appeared not on land but in the oceans. The atmosphere was still thin, so there was not enough oxygen in the air to sustain life. Ultraviolet radiation, lethal to life-forms, was also still at dangerous levels. Neither problem affected life underwater.

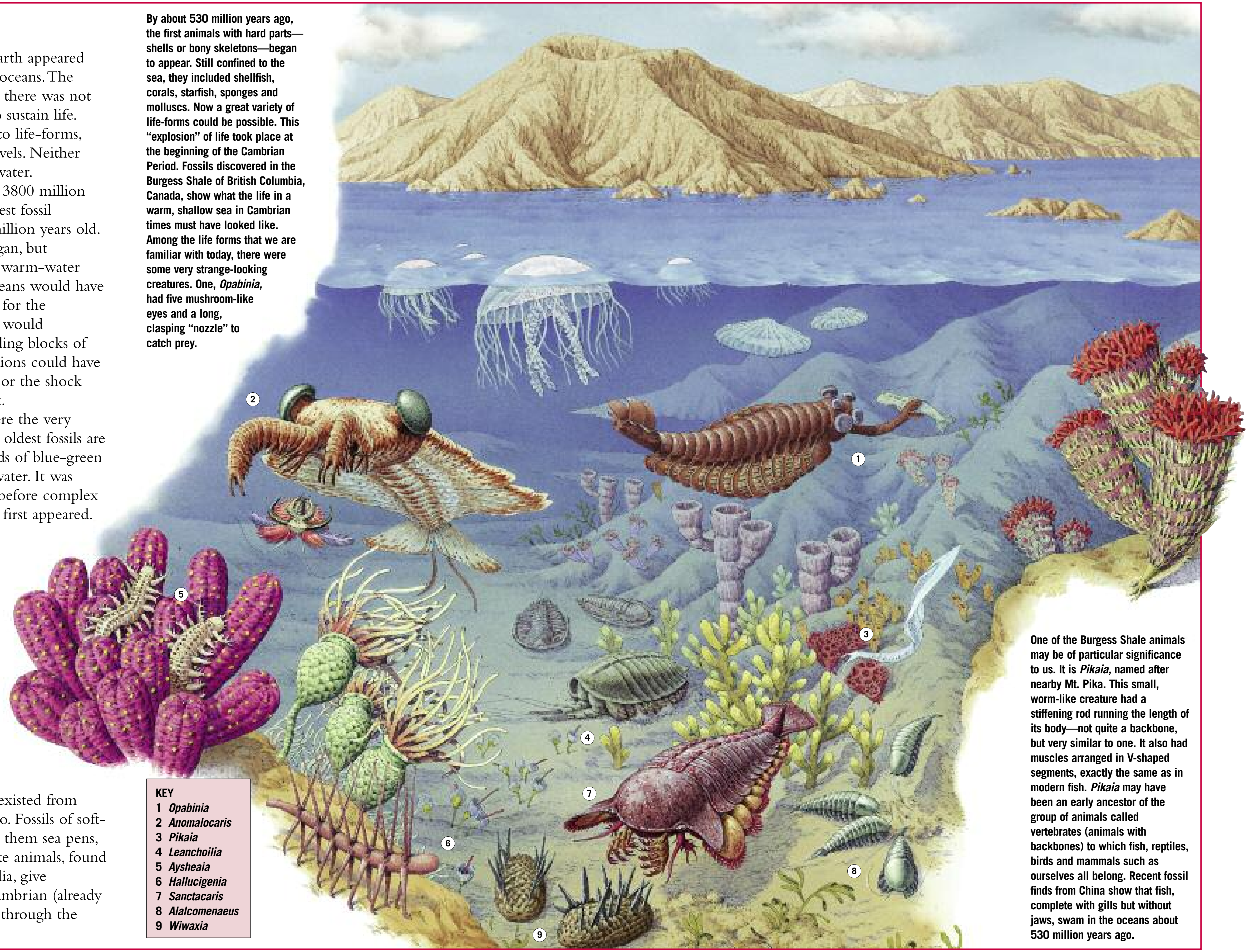
Life probably arose about 3800 million years ago, although the earliest fossil evidence we have is 3500 million years old. No-one knows how life began, but scientists think that shallow, warm-water pools at the edges of the oceans would have been the ideal environment for the formation of chemicals that would eventually become the building blocks of life. The vital chemical reactions could have been triggered by lightning or the shock waves of a meteorite impact.

The earliest life-forms were the very simplest kinds: bacteria. The oldest fossils are known as stromatolites, bands of blue-green algae that grew in shallow water. It was another 2500 million years before complex life forms, types of seaweed, first appeared.

The largest and fiercest of all Cambrian creatures was the 60-centimetre-long *Anomalocaris,* a name meaning "odd shrimp". It had a cloak-like body, two large eyes set on stalks and a pair of pincer-like arms. Other smaller marine life-forms had defences to repel such giant marine predators. *Hallucigenia,* which moved about the sea bed on seven pairs of stilts, had a row of defensive spines on its back. *Wiwaxia* was hat-shaped, complete with two rows of dagger-like blades.

The first known animals existed from around 580 million years ago. Fossils of soft-bodied sea creatures, among them sea pens, jellyfish, worms and crab-like animals, found in the Ediacara Hills, Australia, give evidence of life in the Precambrian (already some five-sixths of the way through the story of the Earth).

By about 530 million years ago, the first animals with hard parts—shells or bony skeletons—began to appear. Still confined to the sea, they included shellfish, corals, starfish, sponges and molluscs. Now a great variety of life-forms could be possible. This "explosion" of life took place at the beginning of the Cambrian Period. Fossils discovered in the Burgess Shale of British Columbia, Canada, show what the life in a warm, shallow sea in Cambrian times must have looked like. Among the life forms that we are familiar with today, there were some very strange-looking creatures. One, *Opabinia,* had five mushroom-like eyes and a long, clasping "nozzle" to catch prey.

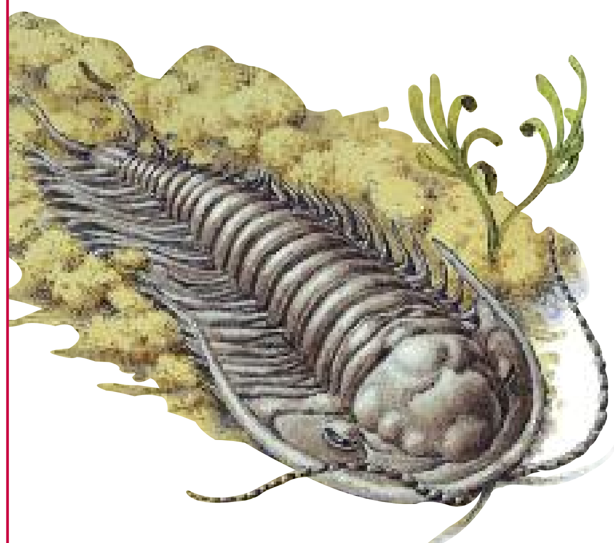


KEY
1 *Opabinia*
2 *Anomalocaris*
3 *Pikaia*
4 *Leanchoilia*
5 *Aysheaia*
6 *Hallucigenia*
7 *Sanctacaris*
8 *Alalcomenaeus*
9 *Wiwaxia*

One of the Burgess Shale animals may be of particular significance to us. It is *Pikaia,* named after nearby Mt. Pika. This small, worm-like creature had a stiffening rod running the length of its body—not quite a backbone, but very similar to one. It also had muscles arranged in V-shaped segments, exactly the same as in modern fish. *Pikaia* may have been an early ancestor of the group of animals called vertebrates (animals with backbones) to which fish, reptiles, birds and mammals such as ourselves all belong. Recent fossil finds from China show that fish, complete with gills but without jaws, swam in the oceans about 530 million years ago.

Early Marine Life

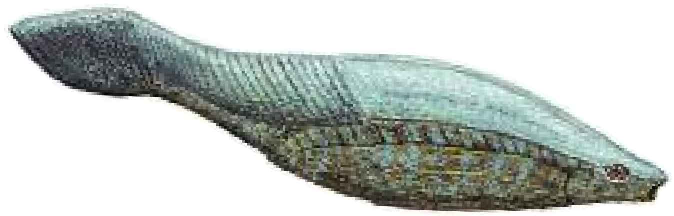
THE CAMBRIAN Period was followed, 505 million years ago, by the Ordovician Period. Many species died out, to be replaced by new ones in another evolutionary "explosion". Trilobites first appeared in the Cambrian and rapidly became, for the next 250 million years, some of the most numerous of all kinds. Trilobites were members of the arthropod group, (creatures with a hard external skeleton and jointed limbs).



A trilobite's body was covered by a hard, jointed carapace (shield) divided into three lengthwise strips (its name means "three lobes"). Its legs allowed it to scuttle along the sea bed, or to paddle it through the water as it swam. Having no jaws, it used its legs to carry food to its mouth.

The First Fish

The first fish, perhaps descendants of *Pikaia* *(see page 9),* had "armour" plating to protect them from predators like the eurypterids. These were arthropods with large claws, some of which reached lengths of two metres. *Arandapsis,* known from fossils found in Australia, was one of the earliest. It fed by sucking in scraps of other dead animals floating in the water. Such fish dominated the seas for 130 million years.

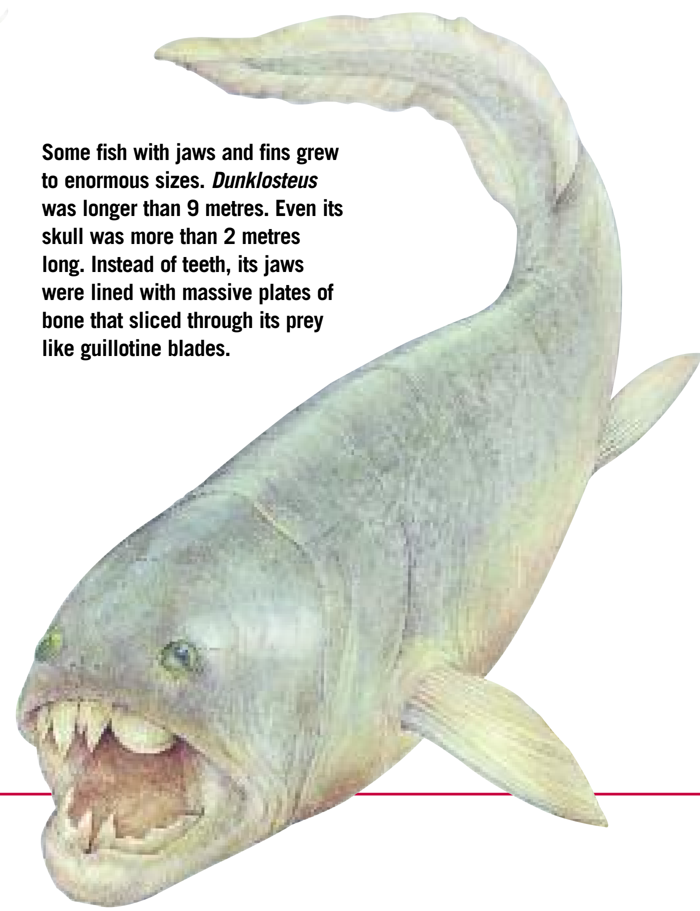


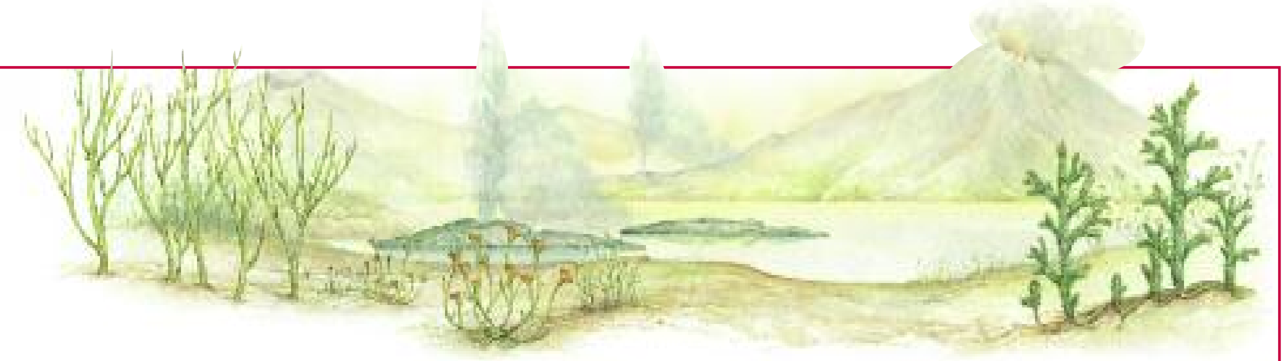
***Arandapsis,* an armoured, jawless fish from the Ordovician Period.**

Fish developed rapidly during the Silurian and Devonian Periods, evolving jaws, teeth and fins. The evolution of jaws and teeth allowed fish to become active predators. Fins gave them greater speed and manoeuvrability in the water. Two distinct types of fish emerged: those with skeletons made of soft cartilage (like the sharks and rays of today), and those that had hard, bony skeletons. This second group became dominant in late Devonian seas and rivers.

Some species with fleshy fins, called the lobefins, lived in warm waters in Devonian times, feeding on lakeside plants. One, a long, slender fish known as *Eusthenopteron,* developed lungs and could spend some time heaving itself around out of the water.

Some fish with jaws and fins grew to enormous sizes. *Dunklosteus* was longer than 9 metres. Even its skull was more than 2 metres long. Instead of teeth, its jaws were lined with massive plates of bone that sliced through its prey like guillotine blades.

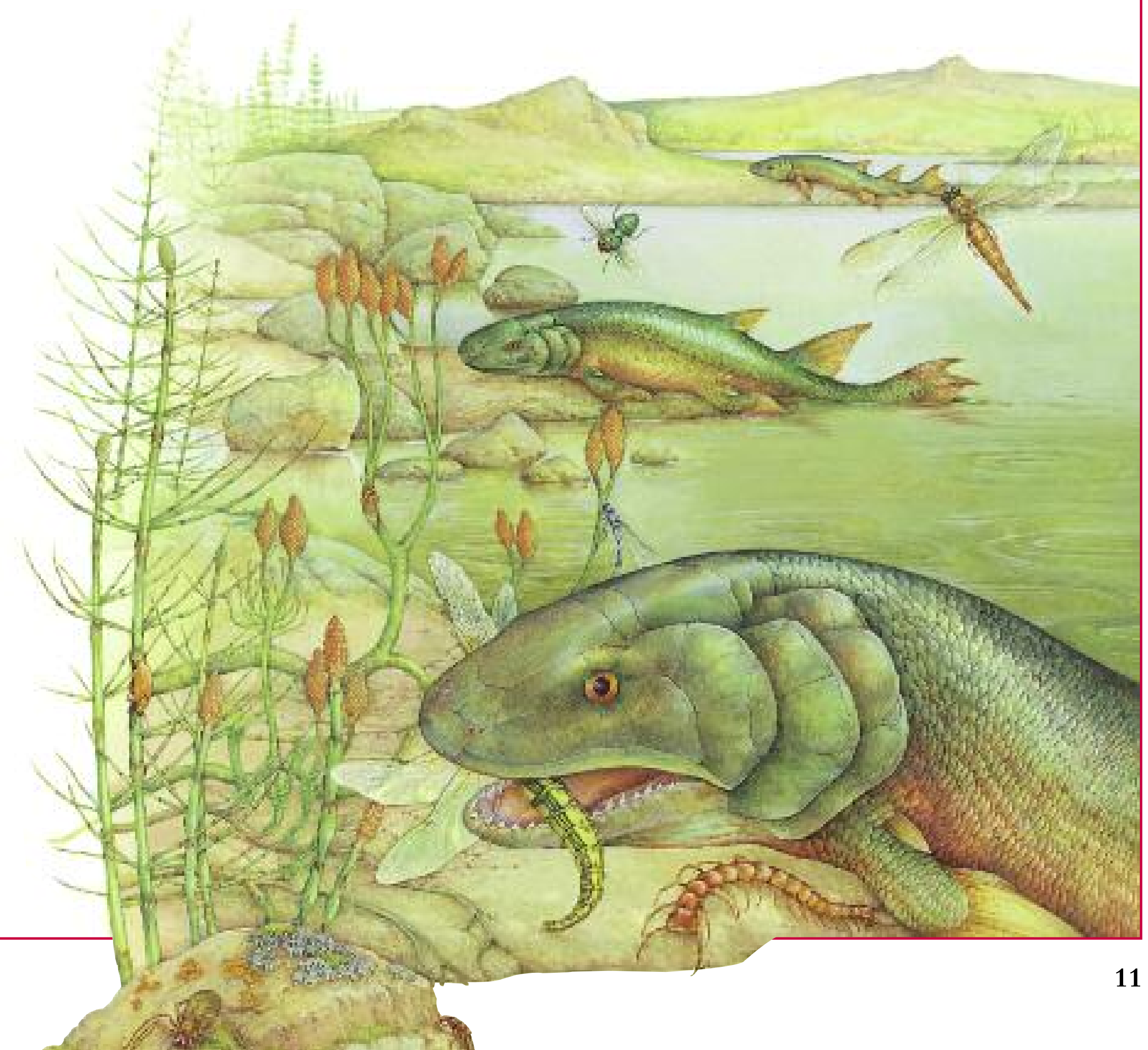




Life on Land

Until about 450 million years ago, there was no life on land. Blue-green algae may have been exposed to the air, or even washed ashore, at low tide. Very gradually, these minute plants may have acquired the means to stay alive longer on land. A waxy skin evolved to prevent them from drying out, followed by simple roots to anchor them in place. By the late Ordovician, plants had gained a foothold on land. By the end of the Silurian Period, plants had branching stems and water-conducting tubes *(above).*

Land plants were a plentiful food source and certain marine animals evolved to take advantage of it. The arthropods' external skeletons were ideal protection against dehydration while out of the water. Their jointed legs allowed them to scuttle over uneven ground. Insects and spiders became the first land animals. They, in turn, were food for fish that lived near the water's edge. Gradually, lobefins like *Eusthenopteron* evolved the ability to "crawl" on their fins in pursuit of prey *(below).* These fish may have been ancestors of the amphibians.

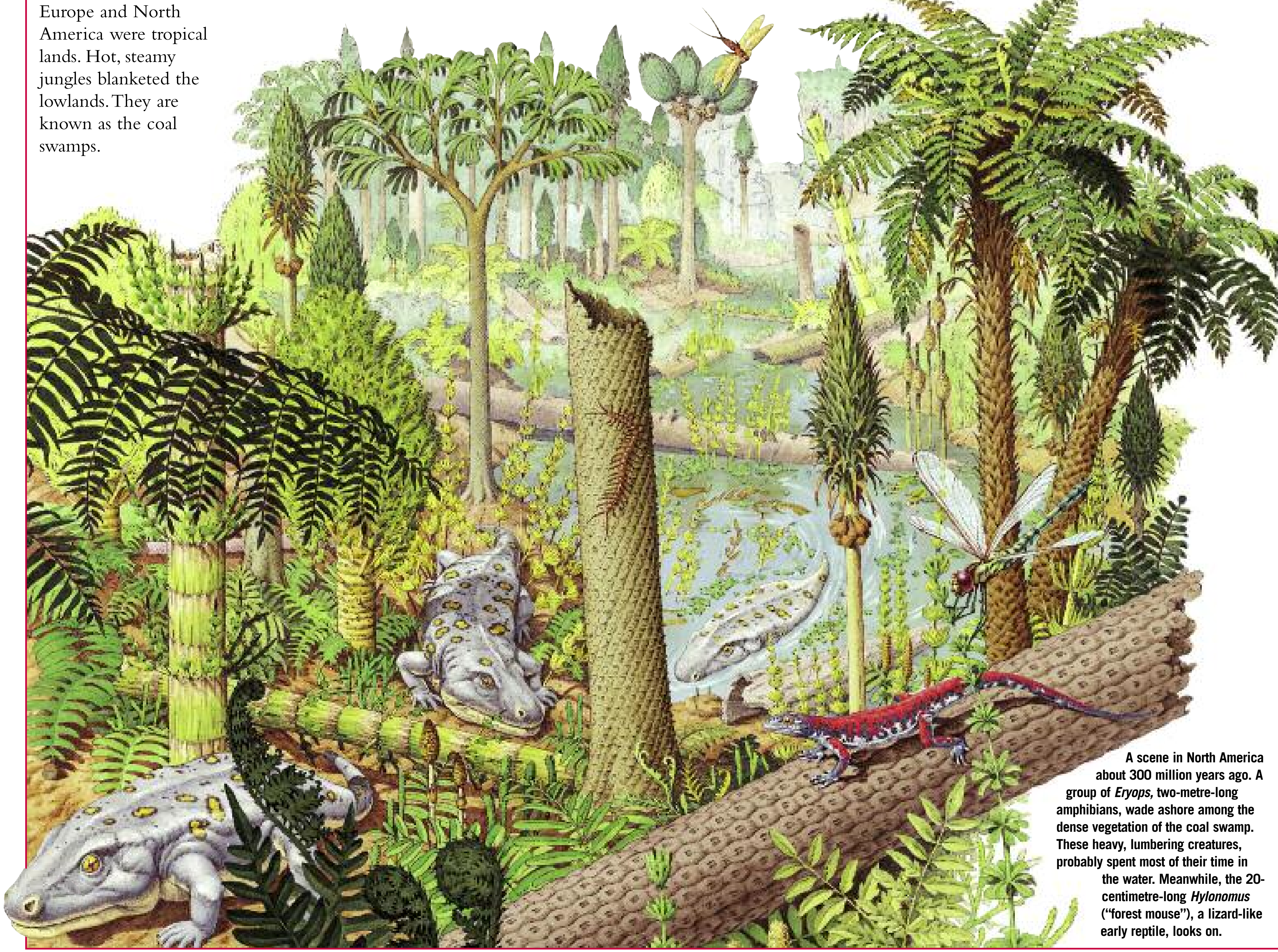


Coal Swamps

By the beginning of the Carboniferous Period, plants had spread across the world's continents and had evolved into many different kinds, including massive trees. About 350 million years ago, Europe and North America were tropical lands. Hot, steamy jungles blanketed the lowlands. They are known as the coal swamps.

The continual cycle of growth and death of swampy vegetation produced thick layers of rotting matter that turned to peat, a dense, dark soil. Over millions of years, the thick beds of peat, overlain by sediments, were compressed, eventually becoming rock. This we know today as coal.

Massive trees, including *Lepidendron,* a kind of lycopod or club moss, and *Calamites,* a large horsetail, dominated the coal swamps. Dragonflies the size of pigeons, giant cockroaches and two-metre-long millipedes lived among the branches.



A scene in North America about 300 million years ago. A group of *Eryops,* two-metre-long amphibians, wade ashore among the dense vegetation of the coal swamp. These heavy, lumbering creatures, probably spent most of their time in the water. Meanwhile, the 20-centimetre-long *Hylonomus* ("forest mouse"), a lizard-like early reptile, looks on.

Giant insects, like this dragonfly, flourished in the hot, damp forests, but were prey for the swamp-dwelling amphibians and reptiles.

Amphibian to Reptile

Lurking in the waters of the Carboniferous coal swamps were the first amphibians. These animals had evolved from fish, their fins having become limbs with fingers and toes. *Ichthyostega,* an amphibian that lived in the tropics of Greenland (now a polar island), had a fish-like head and tail as it still spent time in the water, especially for the purpose of laying its jelly-covered eggs.

Eventually, some kinds of amphibian evolved a way of reproducing on land, thus avoiding the need to return to the water. Animals like tiny *Hylonomus* laid hard-shelled eggs. They were the first reptiles.

The Carboniferous seas also teemed with life. Sharks were the dominant predators. *Stethacanthus* had a strange, tooth-covered projection above its head.

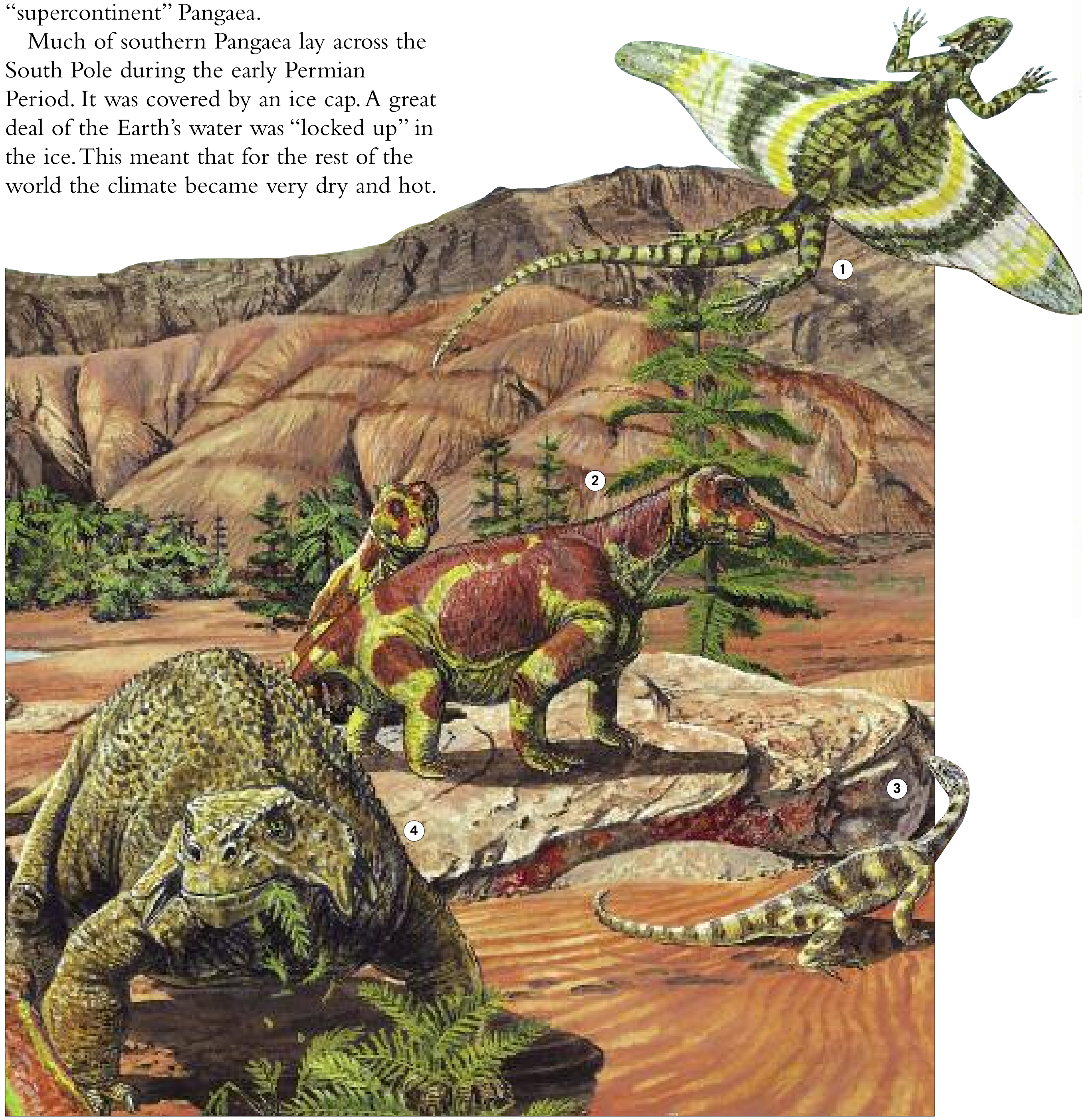
PREHISTORIC LIFE

PERMIAN WORLD

DURING the Carboniferous Period, the Earth's two great continents, Laurasia (made up of parts of present-day Asia, North America and Europe) and Gondwanaland (a combination of South America, Africa, Antarctica and Australia) collided with one another, forming a single huge land-mass. Geologists call this "supercontinent" Pangaea.

Much of southern Pangaea lay across the South Pole during the early Permian Period. It was covered by an ice cap. A great deal of the Earth's water was "locked up" in the ice. This meant that for the rest of the world the climate became very dry and hot.

The humid, tropical forests of the Carboniferous gave way to vast, dry scrub-lands and deserts. Large amphibians dependent on water for breeding started to die out, while reptiles multiplied. Their ability to lay eggs on land allowed them to live in dry environments. Besides strong legs and tough skin, they also developed powerful jaw muscles, which enabled them to eat tough desert plants.



AGE OF REPTILES

Reptiles of all kinds dominated the parched Permian world. (Some species, like *Mesosaurus,* adapted to life, once again, in the water. In future years, the strength and size of marine reptiles would make them fearsome predators.) Land reptiles could be classified into three groups, distinguished by openings in their skulls. The anapsids, fore-runners of turtles and tortoises, had none. The synapsids, which dominated the Permian landscape, had one opening on each side. Members of the third group, the diapsids, had two skull openings on each side. This group gave rise not only to modern lizards, snakes and crocodiles, but also, in the Triassic Period, to the dinosaurs.

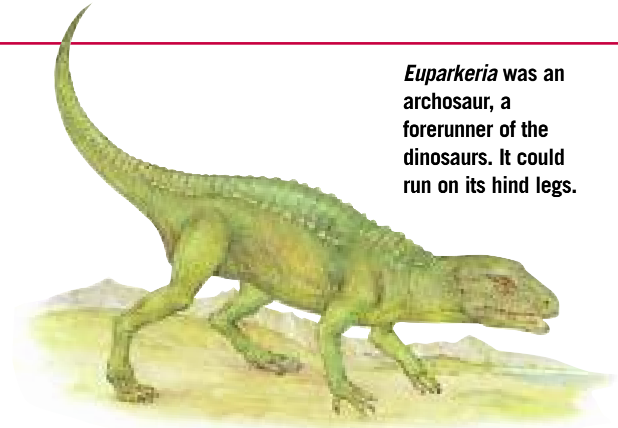
Synapsid reptiles were also known as mammal-like reptiles because they were the ancestors of the mammals. The earliest kinds to evolve were the pelycosaurs. Some, like *Dimetrodon* and *Edaphosaurus (above),* were three-metre-long giants that had great sails on their backs. These were made of skin, supported by long thin spines sticking up from the backbone. It is thought that they may have acted as temperature regulators, the blood vessels in the skin quickly taking up, or giving off, the sun's heat.

The pelycosaurs were succeeded by the therapsids, a group that included the five-metre-long, lumbering herbivore, *Moschops.* Equally slow-moving was the anapsid *Scutosaurus.* Diapsids were still quite scarce. They included *Coelurosauravus,* a tiny glider, and fast-moving *Protorosaurus.*

TRIASSIC WORLD

THE TRIASSIC PERIOD began at a time, 250 million years ago, when a vast number of animals, both on land and in the sea, became extinct. Scientists are unsure why, although the extreme hot and dry climatic conditions across the continent of Pangaea may have been responsible.

A number of reptiles survived the extinctions, however, including the mammal-like reptiles. *Lystrosaurus,* a tusked, pig-like reptile, spread rapidly *(see page 5).* Another group of reptiles began to achieve dominance at this time. With their powerful jaws and bony armour, the archosaurs, from the diapsid group, quickly multiplied. Early archosaurs had a low, sprawling gait (like modern lizards), but, as the Triassic went on, some kinds began to stand more upright. The powerful runner *Ornithosuchus,* for example, had a short body with a long, counter-balancing tail and strong hind legs. By the late Triassic, some archosaur species moved around on two legs all the time. They were the first dinosaurs.

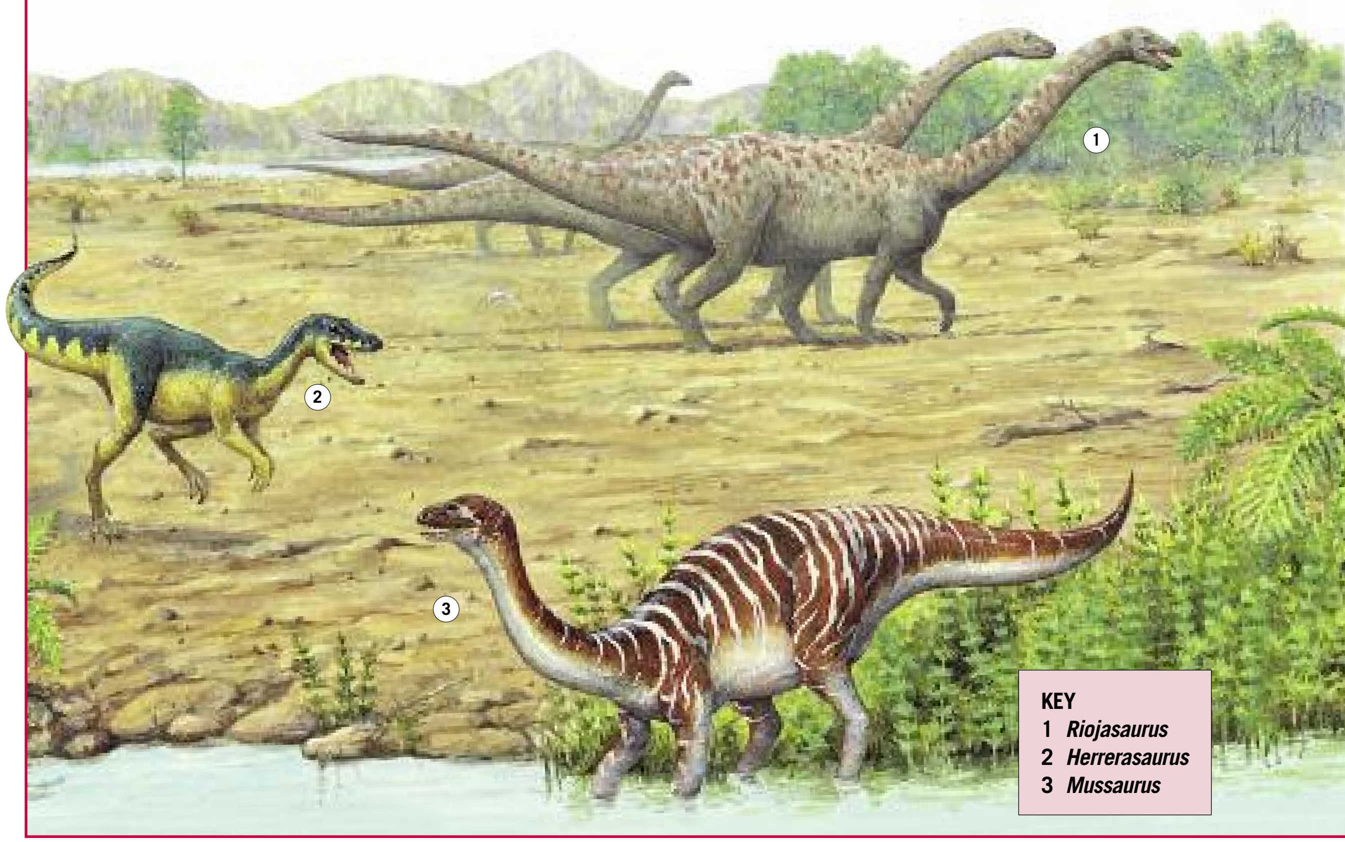


Euparkeria **was an archosaur, a forerunner of the dinosaurs. It could run on its hind legs.**

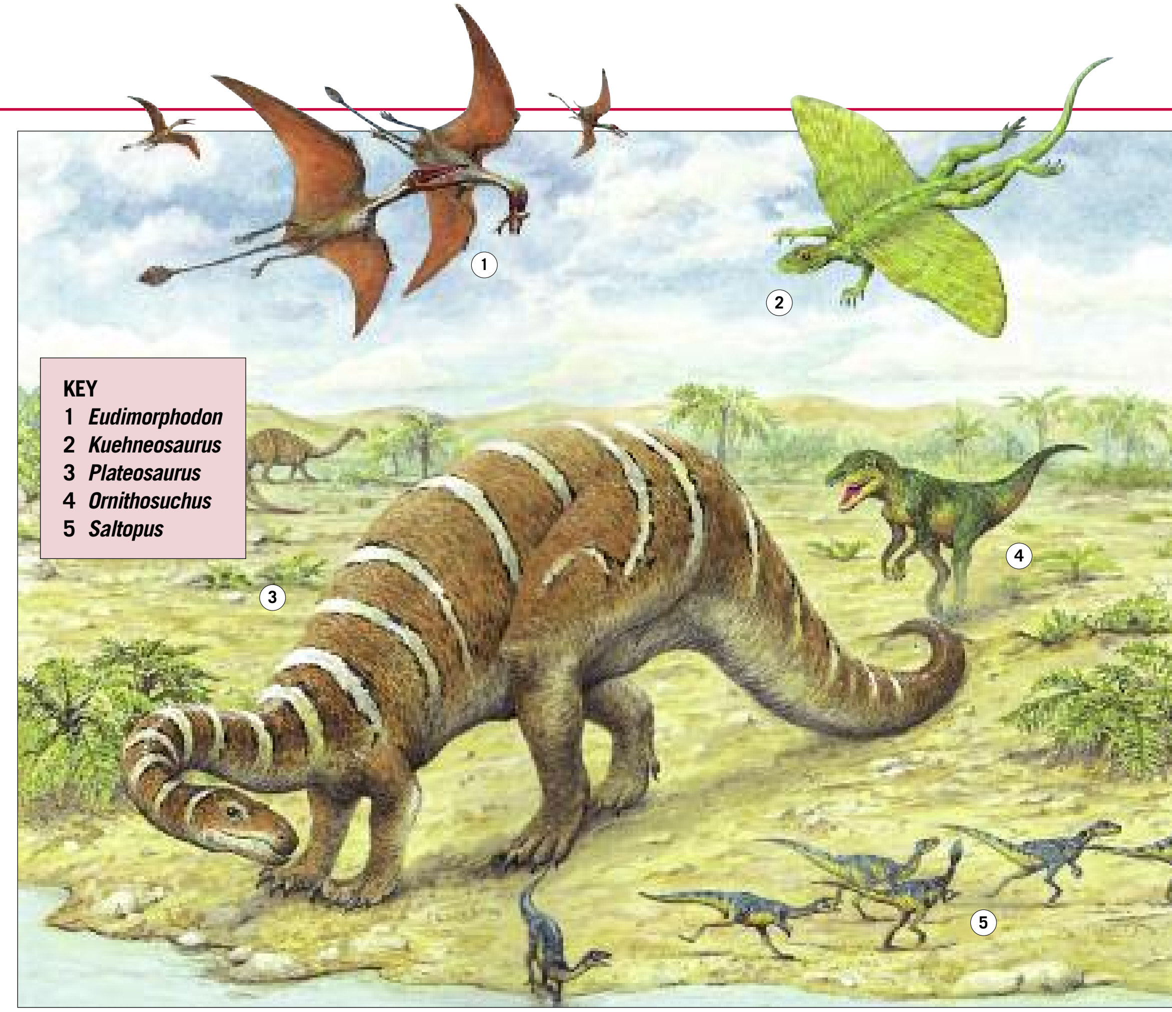
THE FIRST DINOSAURS

The first known dinosaurs appeared about 230 million years ago in the southern part of South America and in southern Europe. In Triassic times, both these regions lay on the fringes of Pangaea, a lush landscape—in contrast to the supercontinent's arid interior. These early dinosaurs were small theropods (meat-eaters) which ran on two legs. *Herrerasaurus,* from South America, had a flexible neck, large, eyes, sharp teeth and a long tail, which acted as a balance. Its strong back legs left its arms free to grasp its prey.

South America in the Triassic Period.



KEY
1 ***Riojasaurus***
2 ***Herrerasaurus***
3 ***Mussaurus***

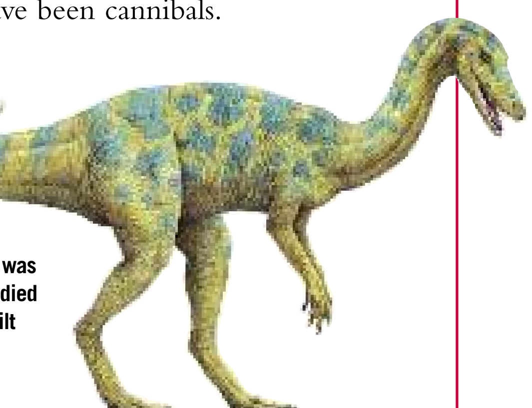


KEY
1 ***Eudimorphodon***
2 ***Kuehneosaurus***
3 ***Plateosaurus***
4 ***Ornithosuchus***
5 ***Saltopus***

The plant-eaters, or sauropodomorphs, emerged later, towards the end of the Triassic. One of the largest of these types of dinosaur, the prosauropods, was the 10-metre-long *Riojasaurus,* also from south America. Another was *Plateosaurus,* from Europe *(above).* Eight metres long, it probably spent some of its time on all fours, but most of the time walked and ran on its two long, powerful back legs. *Plateosaurus* may have used its large, curved thumb-claw to pull down branches. Unable, like many dinosaurs, to chew its food, it swallowed stones which ground up tough plants inside its stomach, making them easier to digest.

Not all plant-eaters were so enormous. *Mussaurus* was from South America. Its name, meaning "mouse lizard", was given to it because the first skeleton to be discovered was tiny. Scientists later realised that this skeleton was actually that of a baby. Adults grew to be three metres long.

One of the best-known of all Triassic dinosaurs was *Coelophysis.* A three-metre-long theropod, it lived in what is now the southern United States. *Coelophysis* had a long, narrow head and sharp, saw-edged teeth, which it used to devour lizards and other small prey. Large numbers of fossils have been found together, suggesting that *Coelophysis* lived in packs like wolves. Some skeletons contained the bones of their young, suggesting that these dinosaurs might have been cannibals.



Coelophysis **was a slender-bodied dinosaur, built for speed.**

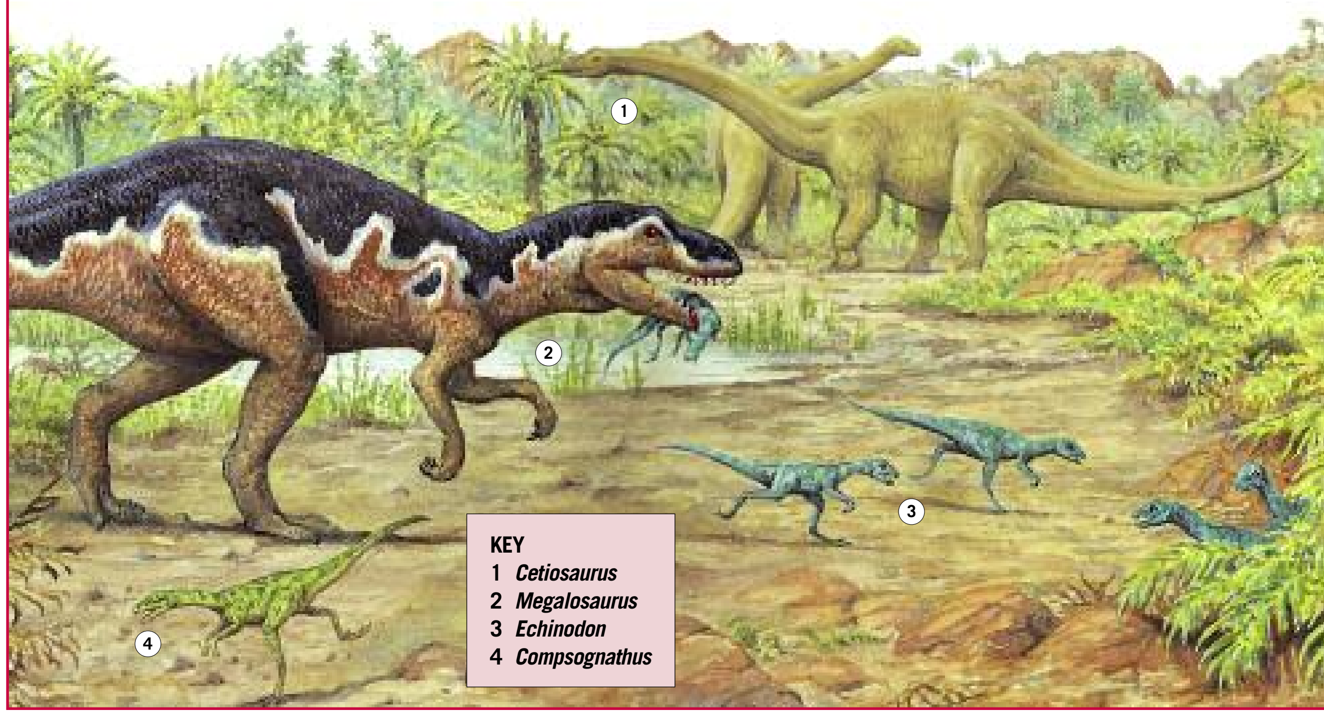
JURASSIC WORLD

DURING JURASSIC times, from 208 to 144 million years ago, the supercontinent of Pangaea began to split in two: Laurasia and Gondwanaland started to drift apart again. The climate, while still warm, became much wetter. Sea levels rose, causing widespread flooding of low-lying lands. Plants, especially coniferous trees, became abundant, providing a rich food source for the dinosaurs, now the only large land-living animals.

Sauropods took over from prosauropods as the dominant plant-eaters, culminating in such giants as *Diplodocus* and *Brachiosaurus,* among the longest and largest land animals that have ever lived. These enormous creatures, measuring more than 20 metres long, had very long necks and equally long, whip-like tails to balance them. Their teeth, shaped like pegs (in *Diplodocus* and *Brachiosaurus*) or spoons (in *Cetiosaurus* and *Camarasaurus*), were perfectly designed for tearing off leaves from trees.

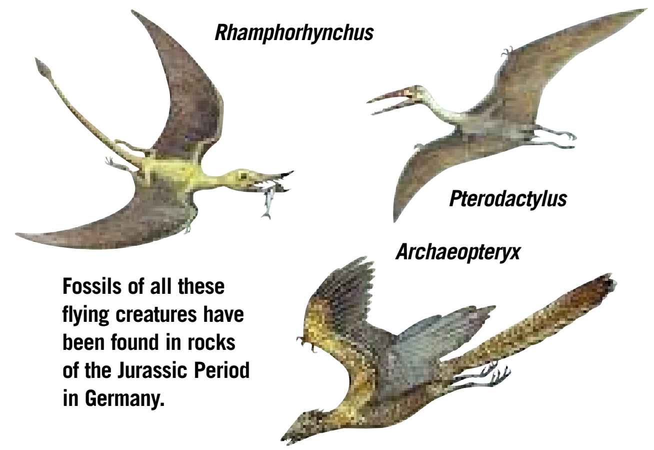
As the sauropods became larger and more numerous, so the meat-eating theropods became more powerful hunters, capable of bringing down a 20-metre sauropod, either individually or hunting in packs. *Megalosaurus,* from Jurassic Europe, was about nine metres long. Equipped with powerful jaws, it was able to attack even quite large sauropods. (*Megalosaurus* was the first dinosaur to be discovered and, in 1824, to be given a name.) Top predator in North America at the same time was 12-metre-long *Allosaurus.* It may have hunted in packs to attack *Diplodocus.* Any prey trapped in its backwards-curving teeth would have found it hard to escape.

Stegosaurus **was a plant-eating dinosaur. It may have been able to rear up on its back legs to feed from trees.**



KEY
1 *Cetiosaurus*
2 *Megalosaurus*
3 *Echinodon*
4 *Compsognathus*

To defend themselves against these fearsome predators, some plant-eaters developed armour. *Stegosaurus,* a 10-metre-long, slow-moving dinosaur from North America, had a double row of diamond-shaped bony plates running the length of its back. It also possessed several long spines at the end of its tail, with which it could lash out at its attacker.



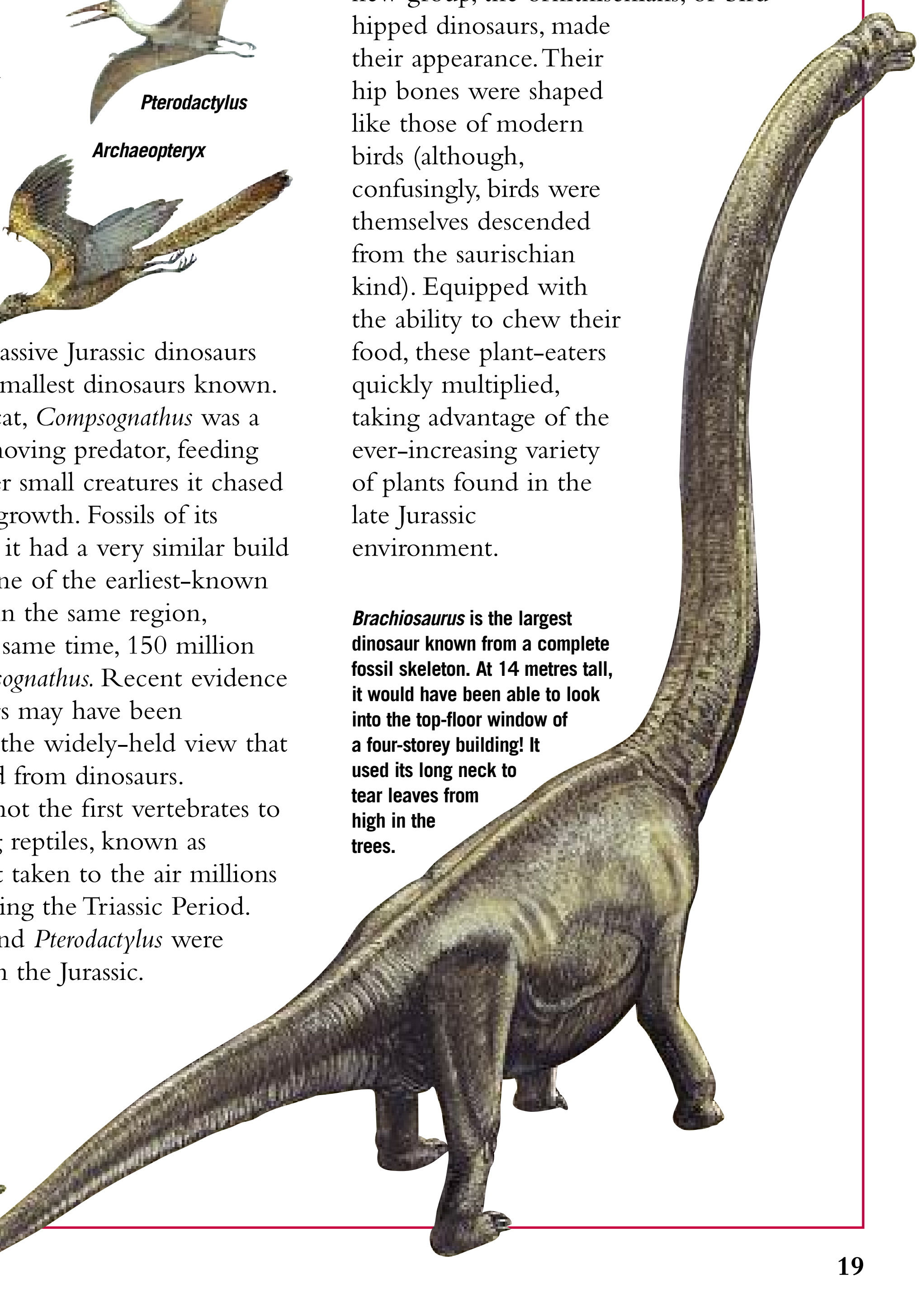
Fossils of all these flying creatures have been found in rocks of the Jurassic Period in Germany.

Alongside the massive Jurassic dinosaurs lived some of the smallest dinosaurs known. No bigger than a cat, *Compsognathus* was a long-legged, fast-moving predator, feeding on lizards and other small creatures it chased through the undergrowth. Fossils of its skeleton show that it had a very similar build to *Archaeopteryx,* one of the earliest-known birds, which lived in the same region, Europe, and at the same time, 150 million years ago, as *Compsognathus.* Recent evidence that some dinosaurs may have been feathered supports the widely-held view that birds are descended from dinosaurs.

The birds were not the first vertebrates to fly, however. Flying reptiles, known as pterosaurs, had first taken to the air millions of years earlier during the Triassic Period. *Rhamphorhynchus* and *Pterodactylus* were marine predators in the Jurassic.

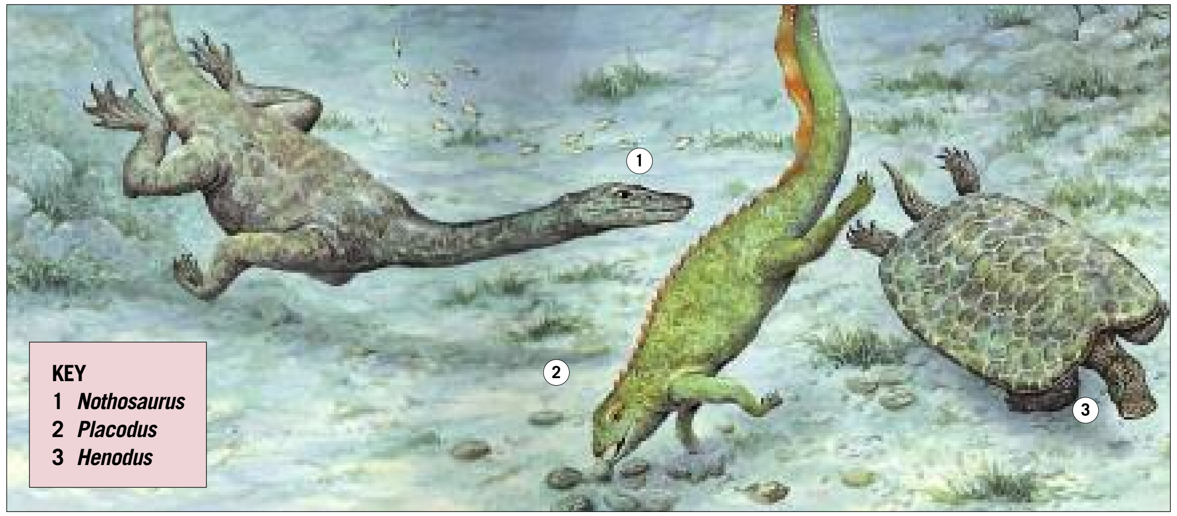
Sheets of skin between the fourth finger and the body made up a pterosaur's wings, Many had powerful, toothed beaks that were perfect for seizing, and holding on to, fish they caught while skimming the surface of the sea.

The Jurassic saw the emergence of a new kind of dinosaur. The sauropods and theropods were saurischian, or lizard-hipped, dinosaurs: their hip bones were shaped like those of other reptiles. Now a new group, the ornithischians, or bird-hipped dinosaurs, made their appearance. Their hip bones were shaped like those of modern birds (although, confusingly, birds were themselves descended from the saurischian kind). Equipped with the ability to chew their food, these plant-eaters quickly multiplied, taking advantage of the ever-increasing variety of plants found in the late Jurassic environment.



Brachiosaurus **is the largest dinosaur known from a complete fossil skeleton. At 14 metres tall, it would have been able to look into the top-floor window of a four-storey building! It used its long neck to tear leaves from high in the trees.**

Human being (at same scale)

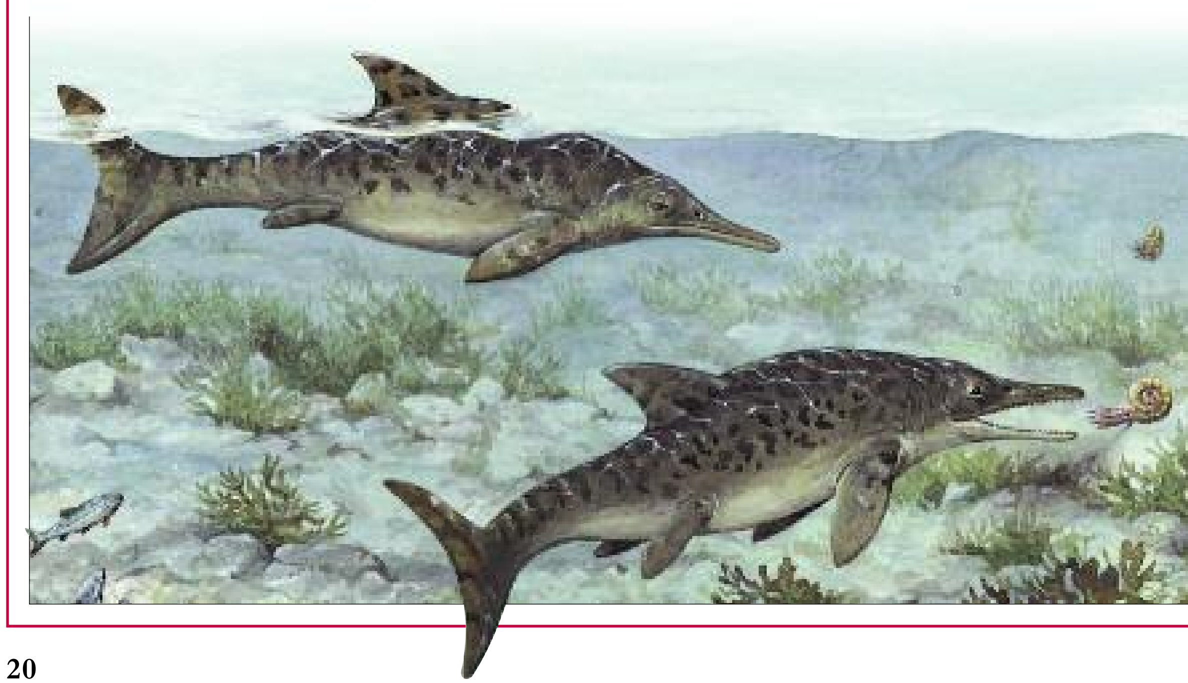


Marine Reptiles

WHILE the dinosaurs ruled the land and the pterosaurs circled in the skies, reptiles also dominated the seas. Some kinds of reptile began to feed on marine life during the Triassic Period, and gradually the body design of marine reptiles adapted to an underwater lifestyle.

One of the earliest marine reptiles, *Placodus,* lived in shallow coastal waters. Apart from its long, fishy tail, it looked very much like a land reptile, with its short neck, heavy body and sprawling legs. It used its powerful jaws to crush shellfish. Long-necked *Nothosaurus* was a more streamlined swimmer, spending its time resting on land and feeding in the water in the same way that seals do today. *Henodus* was quite similar to a modern turtle. Its bony-plated shell protected it from attack by predators. A toothless beak was designed for breaking open shellfish.

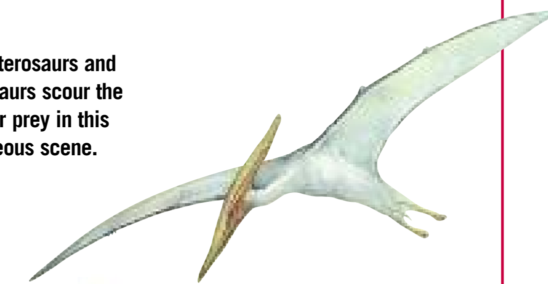
The best-adapted ocean reptiles were the **ichthyosaurs,** such as *Ichthyosaurus (below).* They were at their most abundant during the Jurassic Period, a time when shallow, warm seas covered much of the Earth. Like modern dolphins, ichthyosaurs were perfectly streamlined, with long flippers for steering and strong tails to propel them through the water. They were the first marine reptiles to spend all of their time in the water. They gave birth to live young.

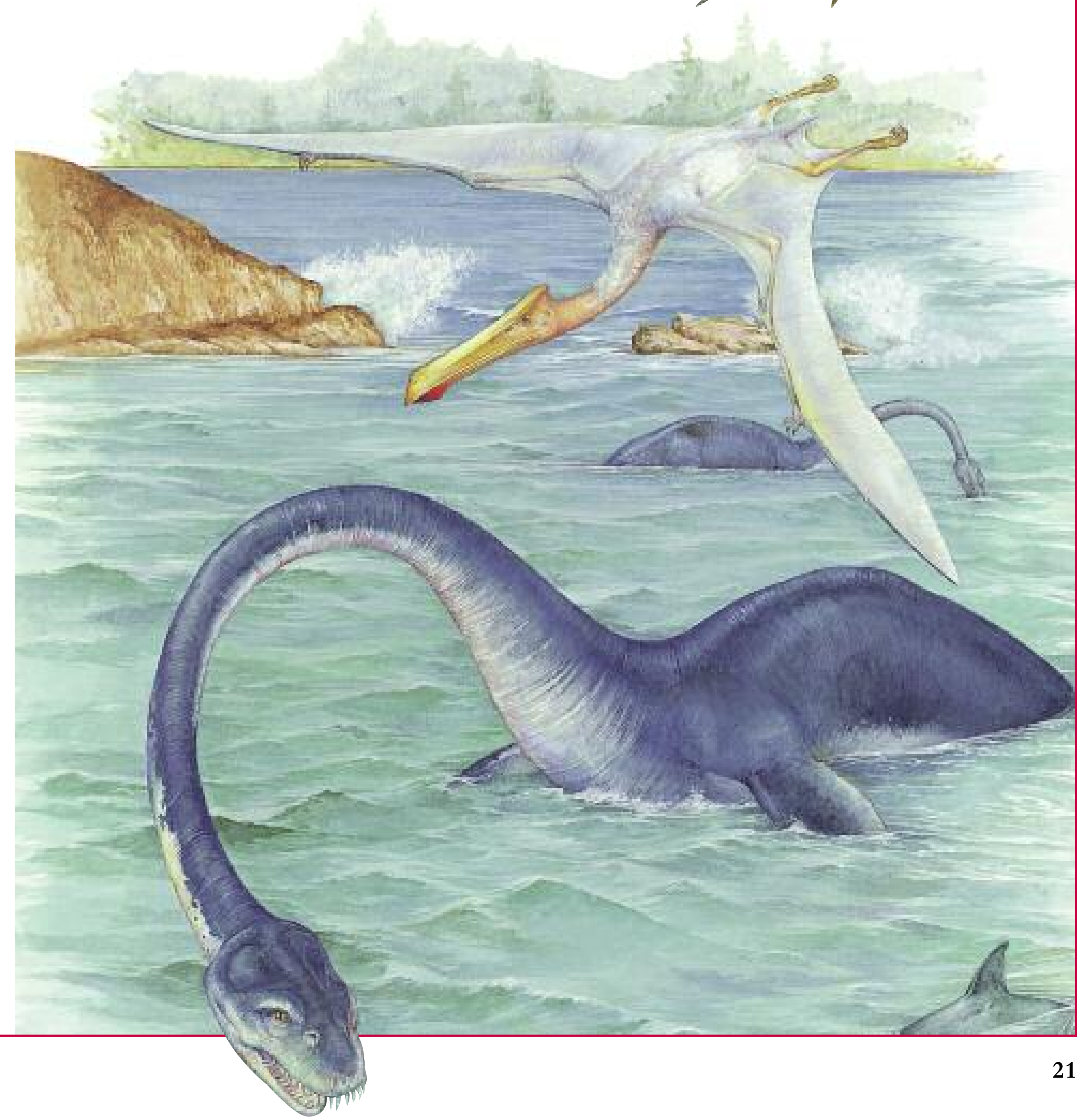


The Jurassic Period saw the emergence of another important group of marine reptiles: the **plesiosaurs.** Like dinosaurs, they had long necks and small heads. Instead of legs, their limbs had become large, paddle-like flippers which they used like underwater "wings" to pull themselves through the water, beating in a slow, steady rhythm. Plesiosaurs fed on fish and squid, darting their long, flexible necks backwards and forwards to pick off their prey. They spent most of their time in the water, coming ashore only to lay their eggs.

By the late Cretaceous, some plesiosaurs had become giants. *Elasmosaurus* was 14 metres long—with a neck more than half its body length. It could have held its head clear of the water, hunting for prey from a high vantage point *(below).*

Giant pterosaurs and plesiosaurs scour the seas for prey in this Cretaceous scene.



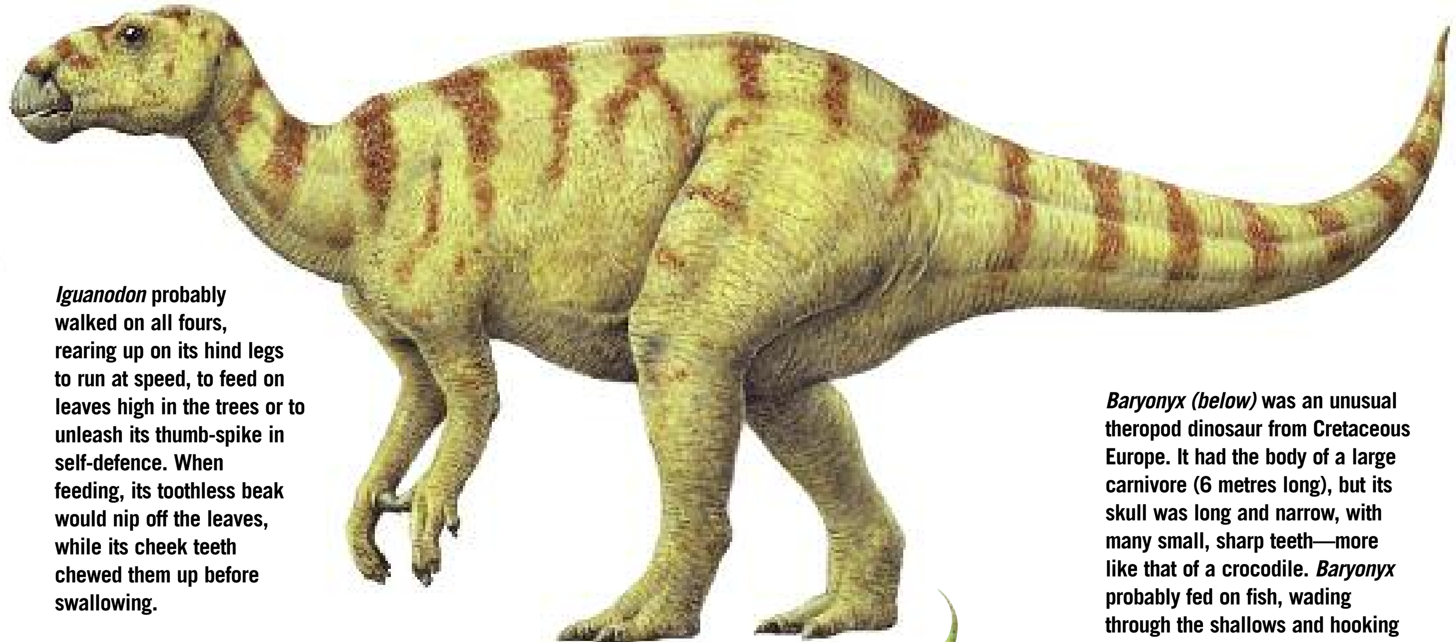


PREHISTORIC LIFE

CRETACEOUS WORLD

THE CRETACEOUS PERIOD was the heyday for the dinosaurs. Laurasia and Gondwanaland, the northern and southern halves of Pangaea, themselves started to break up into smaller land-masses. These would later become the continents we know today. The climate remained as warm and humid as in Jurassic times, and a wide variety of plant life grew in all parts of the world—including Antarctica, today a frozen wasteland. Flowering plants, including deciduous trees, which had evolved during the Jurassic, replaced some more ancient plant species.

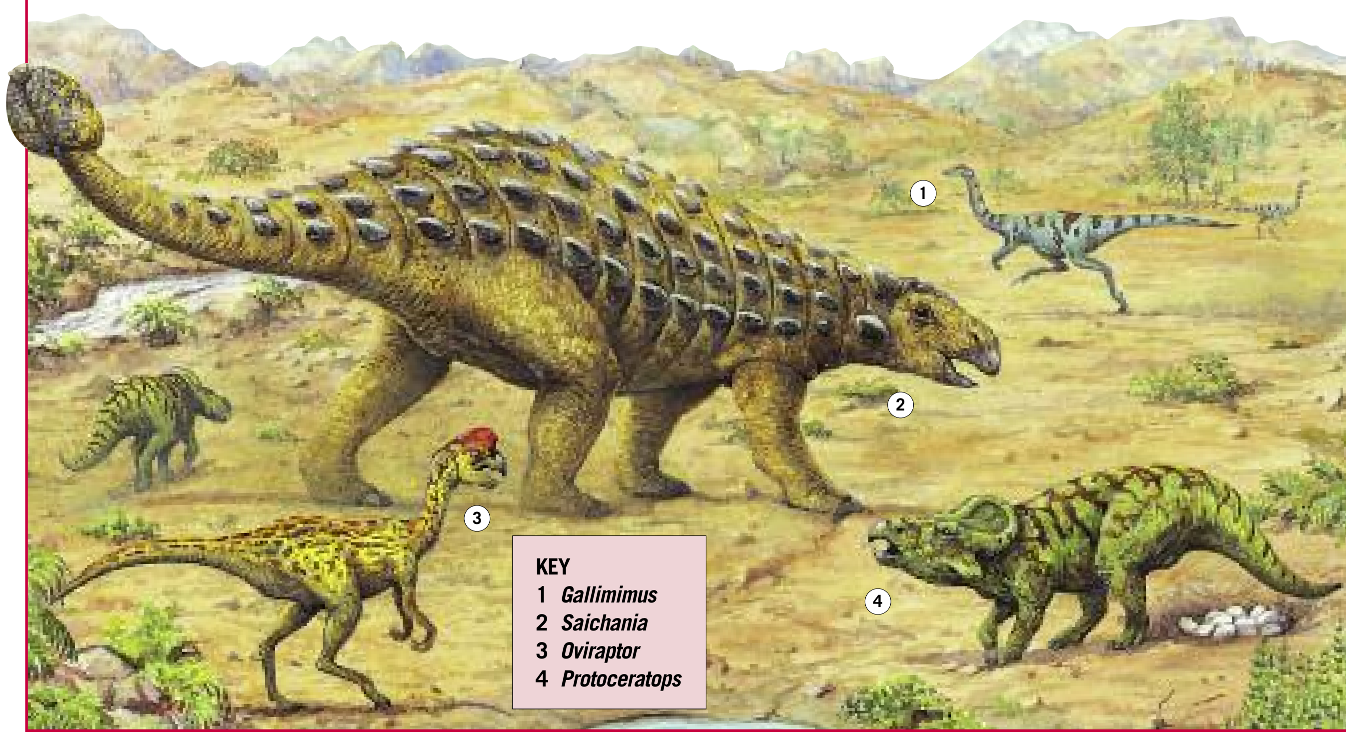
The abundance of plant food favoured new kinds of ornithischians. They became more abundant during the early Cretaceous, while many of the massive, long-necked sauropods, such as *Brachiosaurus* and *Apatosaurus,* died out. Unlike the slow, lumbering sauropods, many of these new kinds were small, fast-moving dinosaurs. Like gazelles, when danger threatened, a herd of *Hypsilophodon,* from Cretaceous Europe, would sprint for safety.



Iguanodon probably walked on all fours, rearing up on its hind legs to run at speed, to feed on leaves high in the trees or to unleash its thumb-spike in self-defence. When feeding, its toothless beak would nip off the leaves, while its cheek teeth chewed them up before swallowing.

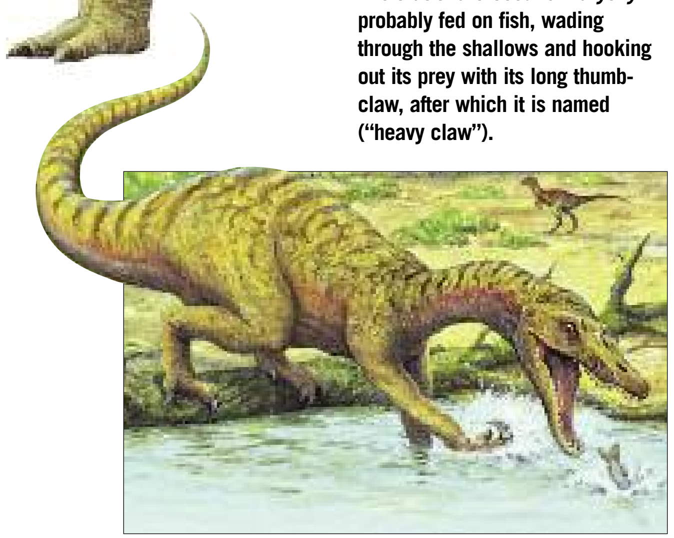
IGUANODON

Iguanodon, a considerably larger animal (nine metres long), was much less nimble than *Hypsilophodon,* relying instead on another means of defence. As well as its clawed fingers, *Iguanodon* had a large, viciously sharp thumb-spike, which it could have jabbed into the neck of any predatory dinosaur. Herds of *Iguanodon* roamed tropical forests the world over.



KEY
1 _Gallimimus_
2 _Saichania_
3 _Oviraptor_
4 _Protoceratops_

Baryonyx (below) was an unusual theropod dinosaur from Cretaceous Europe. It had the body of a large carnivore (6 metres long), but its skull was long and narrow, with many small, sharp teeth—more like that of a crocodile. _Baryonyx_ probably fed on fish, wading through the shallows and hooking out its prey with its long thumb-claw, after which it is named ("heavy claw").



OTHER HERBIVORES

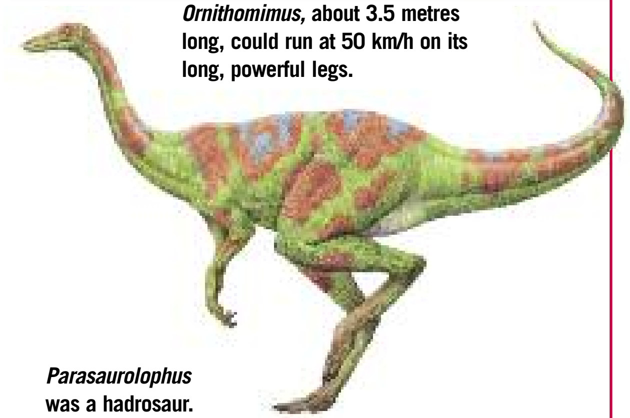
The Cretaceous Period also saw the emergence of the hadrosaurs, ornithischian dinosaurs that had cheek teeth which continually replaced old, worn ones. It enabled them to take full advantage of the plentiful vegetation that grew in late Cretaceous times.

Armoured dinosaurs also evolved many different forms. The ankylosaurs were formidable, tank-like dinosaurs, covered with rows of hard, bony plates and spikes. If this were not enough to deter an attacker, ankylosaurs like *Saichania,* from Mongolia, had a large ball of bone at the end of their tails which they could swing like clubs.

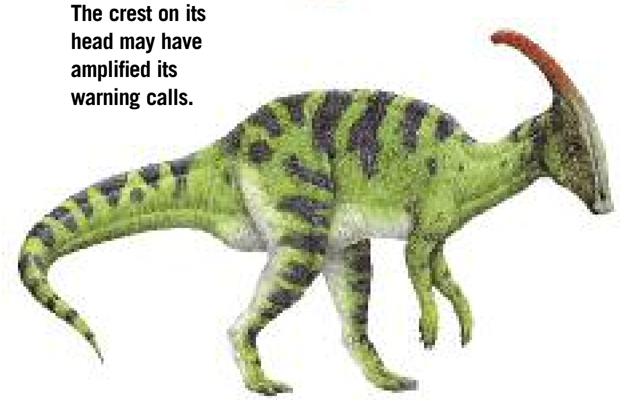
CRETACEOUS CARNIVORES

During Cretaceous times, a variety of new predatory dinosaurs appeared, some very large, like *Carnotaurus,* and some relatively small, like the dromaeosaurs. Hunting in packs, *Deinonychus,* a three-metre-long dromaeosaur from North America could bring down larger prey using its hooked, slashing foot-claws. Other predators included the ornithomimids, intelligent, fast-running hunters of small prey, and the giant tyrannosaurs *(see page 24)*.

Deinonychus, whose name means "terrible claw" had grasping claws as well as deadly foot-claws.



Ornithomimus, about 3.5 metres long, could run at 50 km/h on its long, powerful legs.



Parasaurolophus was a hadrosaur. The crest on its head may have amplified its warning calls.

PREHISTORIC LIFE

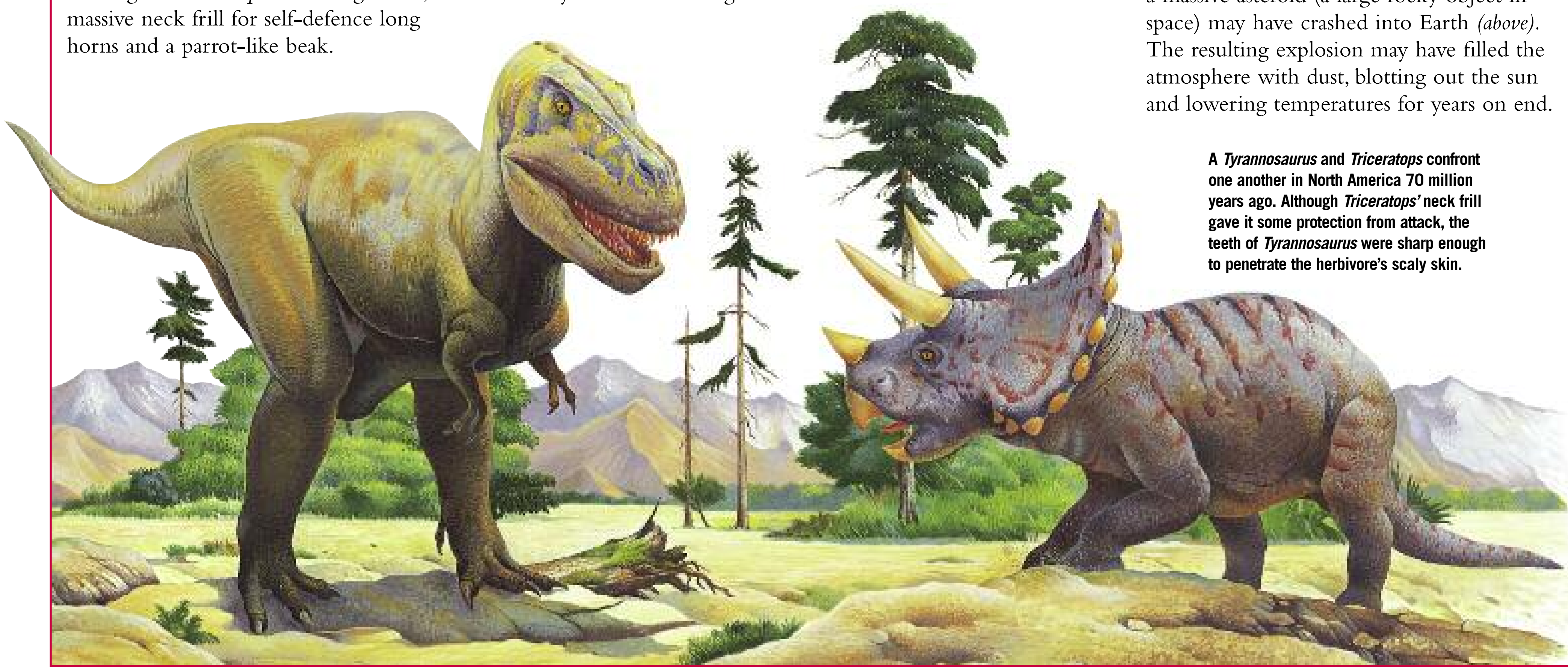
The End of the Dinosaurs

BY THE END of the Cretaceous Period, about 65 million years ago, all the dinosaurs were extinct. They had ruled the land for more than 160 million years (by comparison, anatomically modern humans have existed for just 125,000 years). Although birds and mammals had evolved during the Age of Dinosaurs, no other large land creatures, save crocodiles, which spent most of their time in rivers, existed.

The last years of the dinosaurs produced some of the most spectacular kinds. Of the plant-eaters, the hadrosaurs, such as *Lambeosaurus* and *Pachycephalosaurus,* were very numerous, but they were joined by a new group, the ceratopians, the horned dinosaurs. In North America, for the last 20 million years or so of the dinosaurs' reign, they were the most abundant large herbivores on Earth. Animals like the nine-metre giant *Triceratops* had a huge skull, a massive neck frill for self-defence long horns and a parrot-like beak.

Megazostrodon **was one of the first mammals. It was an insect-eater, just 5 cm long.**

Only the largest, most powerful predator would have been a match for *Triceratops.* Unfortunately for *Triceratops,* just such a monster existed: *Tyrannosaurus rex*. This awesome, 12-metre-long killing machine had massive powerful back legs which gave it great speed over short distances. It had an enormous head, with jaws surrounded by rows of saw-edged teeth, some up to 18 centimetres long. Only its arms were puny, but had they been longer, the dinosaur would have over-balanced. *Tyrannosaurus* probably made its kill by charging its prey, bringing it down with devastating bites. It may also have scavenged the kills of others.



A *Tyrannosaurus* and *Triceratops* confront one another in North America 70 million years ago. Although *Triceratops'* neck frill gave it some protection from attack, the teeth of *Tyrannosaurus* were sharp enough to penetrate the herbivore's scaly skin.

Mass Extinction

The dinosaurs, the pterosaurs, all marine reptiles and a large number of other species all died out at the end of the Cretaceous. No-one yet knows why this was so, but the evidence shows that the event was quite abrupt. It is thought by some scientists that a massive asteroid (a large rocky object in space) may have crashed into Earth *(above).* The resulting explosion may have filled the atmosphere with dust, blotting out the sun and lowering temperatures for years on end.

By another theory, a massive volcanic eruption could have taken place on Earth, blasting millions of cubic kilometres of lava into the atmosphere, producing the same effect on the climate as an asteroid collision.

Evidence for both theories comes from the discovery by geologists of a layer of metal, called iridium, in late Cretaceous rocks. This metal is believed to be present in the core of the Earth and in asteroids, but nowhere else. Iridium dust thrown up by an exploding asteroid or lava from inside the Earth may have settled on the surface, then later compacted in the rocks of the time.

Small mammals explore the skeleton of a *Triceratops.* The Age of Dinosaurs is over.

Survivors

While the dinosaurs and others perished, a number of reptile species survived the extinction, including lizards, snakes, crocodiles and turtles. But the disappearance of the dinosaurs and pterosaurs offered an opportunity for mammals to become the dominant land animals, and for birds to rule supreme in the air.

Mammals had evolved from mammal-like reptiles back in the Triassic Period, 225 million years ago. They had fur on their skins, enabling them to become warm-blooded. But, while dangerous dinosaur predators were about, they remained tiny, shrew-like animals venturing out only at night to feed. Their time had now come.

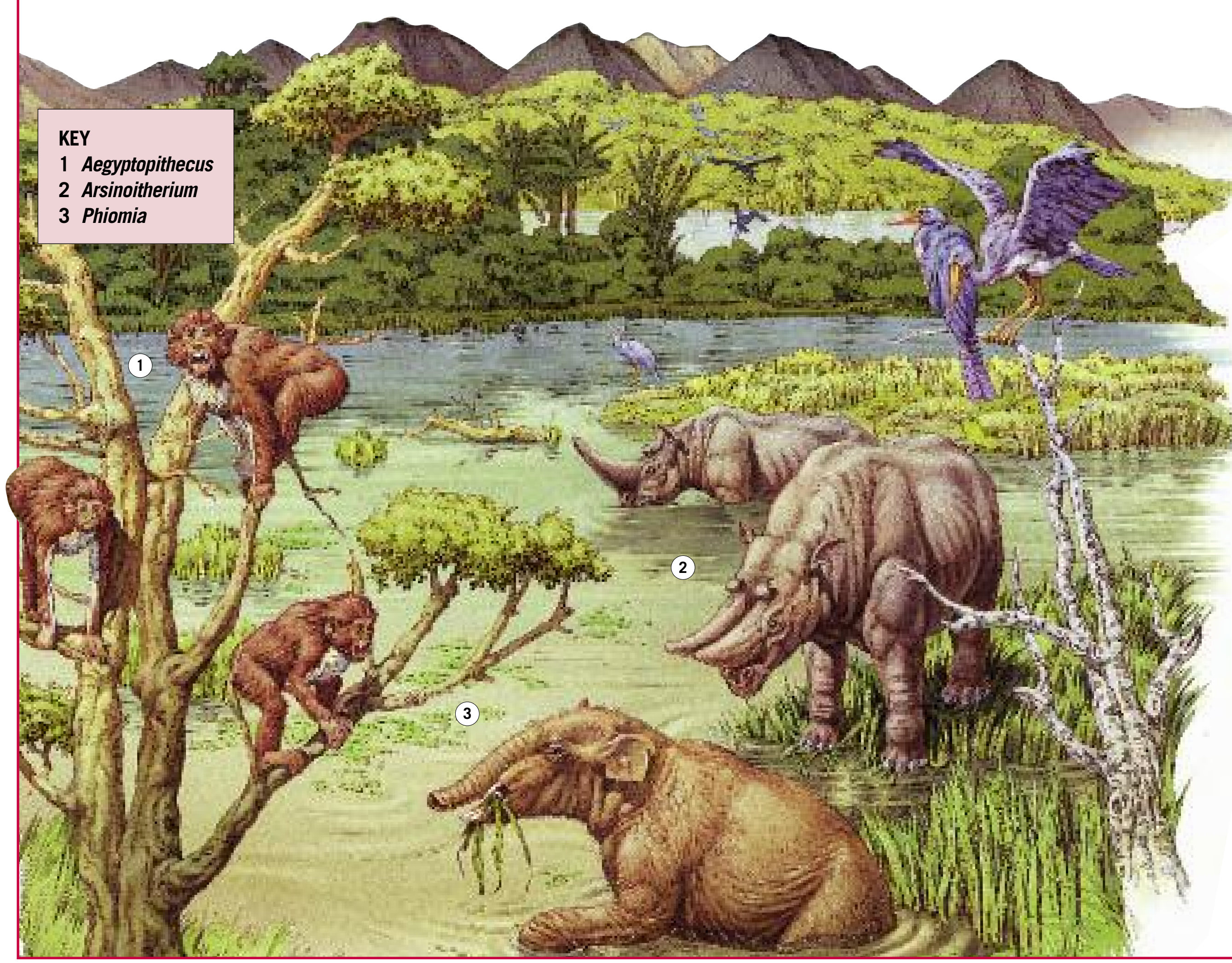
The Age of Mammals

After the dramatic extinctions at the end of the Cretaceous Period, the Earth entered what is known as the Tertiary Period. It is divided into a number of Epochs *(see page 4)* beginning with the Palaeocene and finishing 1.8 million years ago as the Ice Ages dawned.

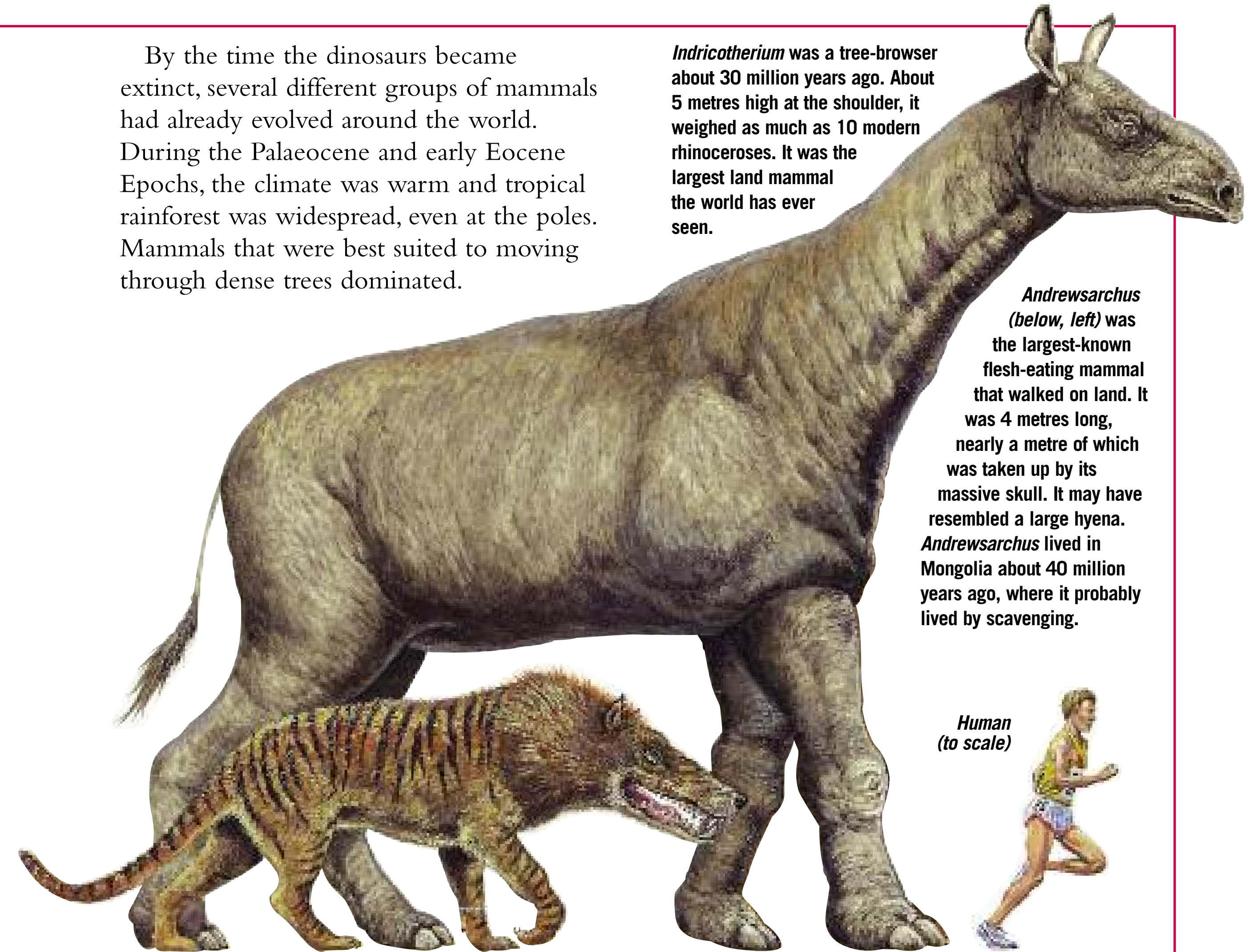
By the beginning of the Tertiary, the continents had drifted to approximately their present positions, although North and South America were still separated. Each continent, with the exception of Australia and Antarctica which were still linked together, had become an isolated land-mass. This meant that early mammals evolved separately on their own island continent.

This is a map of the world during Eocene times (part of the Tertiary Period), about 50 million years ago *(above)*. The pale blue areas are shallow seas, tracts of land that have been submerged beneath high sea levels.

This is what a region of North Africa, today barren desert, would have looked like 35 million years ago *(below)*. Living in the swamps were the early elephant *Phiomia*, the rhinoceros-like *Arsinoitherium* and a primitive ape *Aegyptopithecus*.



By the time the dinosaurs became extinct, several different groups of mammals had already evolved around the world. During the Palaeocene and early Eocene Epochs, the climate was warm and tropical rainforest was widespread, even at the poles. Mammals that were best suited to moving through dense trees dominated.



***Indricotherium* was a tree-browser about 30 million years ago. About 5 metres high at the shoulder, it weighed as much as 10 modern rhinoceroses. It was the largest land mammal the world has ever seen.**

***Andrewsarchus* *(below, left)* was the largest-known flesh-eating mammal that walked on land. It was 4 metres long, nearly a metre of which was taken up by its massive skull. It may have resembled a large hyena. *Andrewsarchus* lived in Mongolia about 40 million years ago, where it probably lived by scavenging.**

Rooters and Browsers

The mammals of the Palaeocene were forest-dwellers. They included a number of species that look unfamiliar to us today. Some roamed the forest floor seeking plant stems or roots. They included the strange, knobbly-headed *Uintatherium* or twin-horned *Arsinoitherium*. Others, such as rodents and primates, browsed for leaves and fruits in the trees themselves.

No large carnivorous mammals then existed. But among the birds, which had also developed into a wide variety of species, were some predatory giants—for example, the three-metre-high, ground-dwelling *Diatryma* from North America. With its enormous, bone-crushing beak, *Diatryma* feasted on mammals, including even small, primitive horses!

Mammal Giants

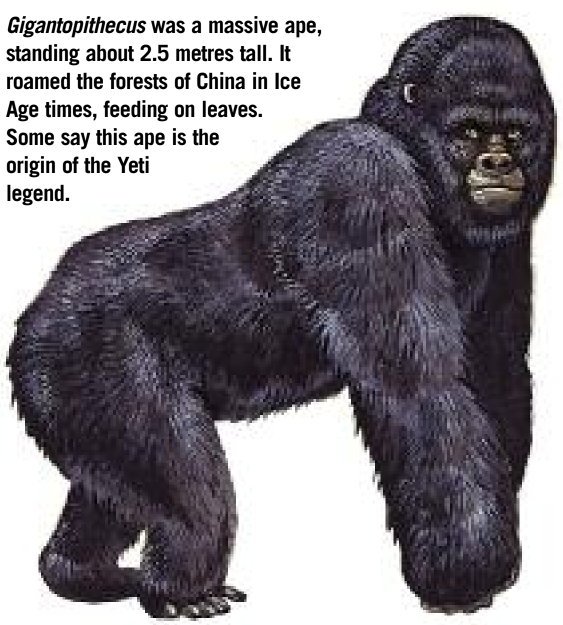
During the Oligocene Epoch, the climate began to cool. Ice caps formed at the poles and many dense forests were replaced by more open woodland. The forest-dwellers gave way to much larger mammals that thrived in these conditions. They included *Indricotherium,* a massive rhinoceros from Central Asia, and *Andrewsarchus,* an early mammalian carnivorous giant.

By the Miocene, vast areas of grassland had opened up, leading to the evolution of fast-running horses and antelopes, as well as predatory dogs, cats and hyenas. Massive elephants, adapted to feeding from trees on grasslands, evolved. Meanwhile, some fish-eating carnivores developed the ability to spend more time in the water, and evolved into the group we now call the whales.

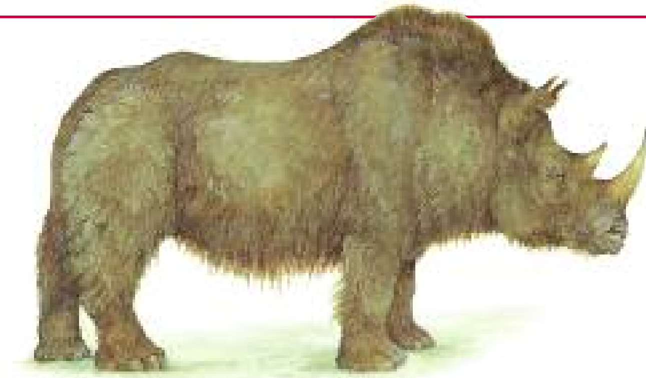
THE ICE AGES

THE QUARTERNARY Period runs from about 1.8 million years ago to the present. The Pleistocene Epoch, which occupies all but the last 10,000 years, was the time of the Ice Ages, during which, on at least four occasions, great ice sheets spread southwards and buried much of northern Europe, North America and Asia. In between, there were periods of warmer, even subtropical, climate, called interglacials.

This is a map of the world as it was 40,000 years ago, at the height of the last Ice Age during the Pleistocene Epoch. The white areas show the ice caps. Today, ice caps cover the Arctic Ocean, Greenland and some of the islands of Northern Canada. During the Ice Ages, ice caps stretched much further south. The ice "locked up" a great deal of the world's water, resulting in lower sea levels.



***Gigantopithecus* was a massive ape, standing about 2.5 metres tall. It roamed the forests of China in Ice Age times, feeding on leaves. Some say this ape is the origin of the Yeti legend.**



***Coelodonta*, the Ice Age woolly rhinoceros.**

The Pleistocene Ice Ages are not the only ones in the history of the Earth. A major Ice Age occurred in the late Carboniferous and early Permian Periods, about 290 million years ago *(see page 14)*. Today's climates are generally cooler than on many occasions in prehistory, so it is quite possible that we are living through an interglacial. A fifth Ice Age may one day grip the world.

It is not clear what causes an Ice Age. It may be that the Earth's angle of rotation changes slightly, tipping the poles further away from the sun's rays.

Most of North America and northern Europe looked like this 40,000 years ago. The ice was 3 km thick in places. The advancing ice gouged out valleys, smoothed over hills and plains and filled rock basins with water, forming lakes, when they melted.

The Ice Ages had a major effect on the world's climate, and its wildlife experienced major changes, too. During the warmer interglacials, animals like elephants, hippopotamuses and hyenas could migrate northwards. When the ice sheets spread southwards, mammoths, rhinoceroses, reindeer and bears adapted to life in the vast regions of tundra, treeless areas of low grasses and frozen soils. Some migrated south in winter, others hibernated.

Mammoths are the best-known Ice Age mammals. Woolly mammoths *(below),* with their shaggy coats and layers of body fat, were well suited to the cold, summer-less environments of the north. They roamed the northern tundra lands until about 10,000 years ago (although a small number survived on a Siberian island until just 3500 years ago). Complete carcasses, preserved in ice, are still found today. Climatic change probably finished them, but they may have been hunted to extinction by humans.

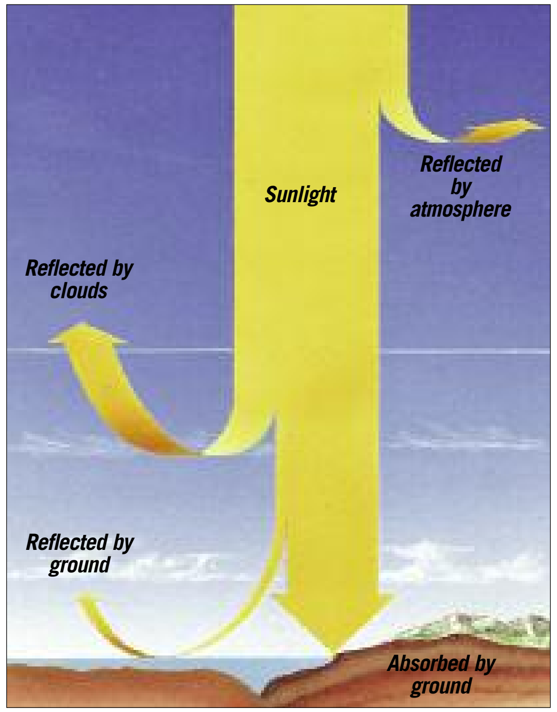
HUMAN EVOLUTION

Human-like animals, called hominids, first appeared about four million years ago, but the evolution of modern human beings took place during the Ice Ages. The fossil evidence points to the grasslands of Africa being our place of origin, from where humans spread out to all parts. One branch of the hominid group, called Neanderthals, adapted to the cold European climate, but died out 30,000 years ago.

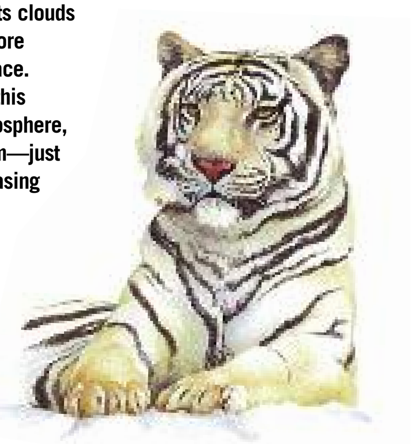
FUTURE EARTH

THE EARTH is 4600 million years old and is expected to have a natural life of another 5000 million years. What will the future hold? Living things, in one form or another, have existed for at least 3500 million years, undergoing constant change and evolution. What will future living things be like? How long will humans survive?

In the short term, the one thing scientists are agreed upon is that the Earth will become much warmer. This is known as global warming. The average temperature has risen by more than 0.5°C in the past century. This is predicted to rise to 2°C by 2050. The effects may be felt as more violent storms, shifting rainfall patterns and rising seas, which could submerge many of the world's coastal areas. Many scientists believe that the the emission of certain gases—chlorofluorocarbons (CFCs), carbon dioxide and methane—from factories, cars, and power stations may contribute to the "greenhouse effect" *(above right),* a likely reason for the rise in global temperatures.

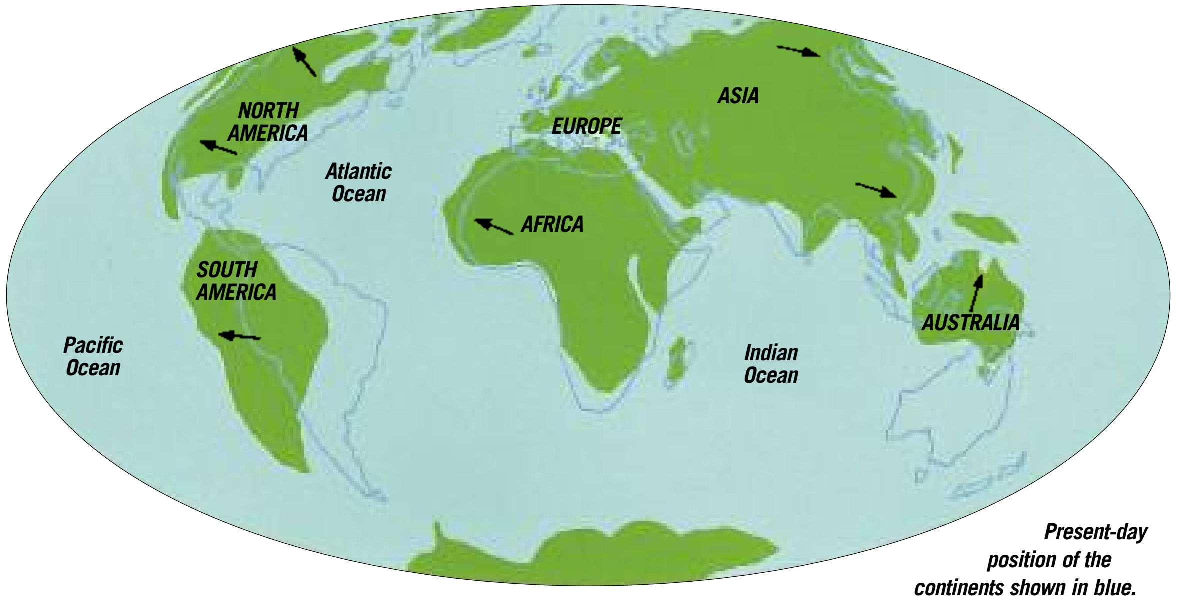


The Earth's surface and its clouds both absorb sunlight, before releasing it back into space. Some gases trap part of this outgoing heat in the atmosphere, keeping the surface warm—just like a greenhouse. Increasing levels of these so-called greenhouse gases may warm the Earth too much.



Another change we are likely to see over the next 50-100 years is the extinction of some familiar mammals. The tiger, for example, is already endangered because of severe reduction of its natural habitat in Asia.

Volcanic eruptions occur all over the Earth. Occasionally, a major eruption may throw up so much material into the atmosphere that the climate is affected. This could have led to the extinction of the dinosaurs. Could it happen to us?



Present-day position of the continents shown in blue.

This is how the world may look 50 million years from now. The Atlantic Ocean has spread apart. North and South America are no longer joined together and Africa and Asia have split at the Red Sea. Australia has collided with Indonesia.

In the longer term—millions of years into the future—the Earth itself will continue to change. Rivers and glaciers will erode upland areas, creating new lowlands. These may then be uplifted, creating, in turn, new uplands. The continents will go on drifting around the globe, creating or destroying land-masses and ocean floors. Despite the probable destruction of a number of living environments by humans, life will go on evolving.

How will humankind cope with this change? The reduction of greenhouse gases, by a switch to alternative forms of energy, could arrest global warming. A new approach to conservation may save some well-known species from immediate extinction. In the longer term, it would seem very little could save our planet from an asteroid impact or cataclysmic volcanic eruption. The search for new planets to inhabit may provide a safe haven for people to survive such a catastrophe.

The impact of a large asteroid colliding with Earth would be catastrophic. Over millions of years, it is bound to happen ...

The discovery of new planets around other stars raises the possibility that we might one day encounter life from other worlds. Will extra-terrestrial life-forms look like this, the popular idea of an alien? What will be the impact on us and our planet?

INDEX

Page numbers in **bold** refer to main entries.