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Children's Dinosaur and Prehistorical Animal Encyclopedia

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Douglas Palmer

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Consultant
Dr. Douglas Palmer

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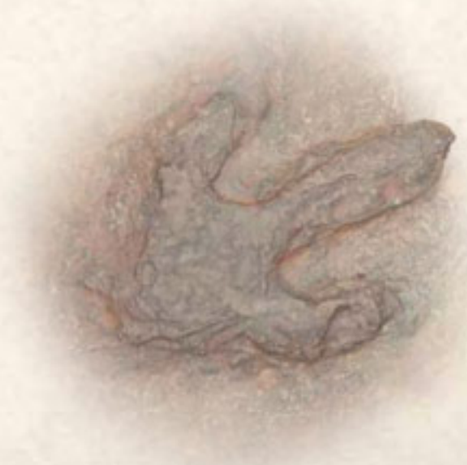


ANCIENT WORLDS

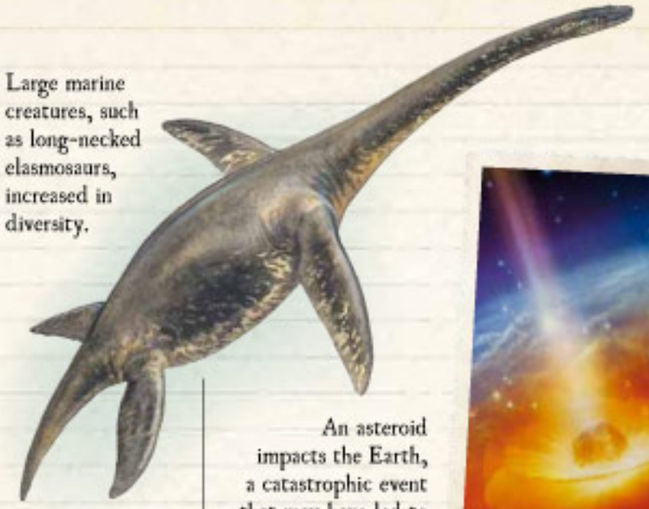
Since it was formed more than 4.5 billion years ago, the Earth has changed from an amalgamation of rock and ice space debris to the blue ocean planet we know today. These changes—the appearance of an atmosphere and water, the first stirrings of microscopic life, the evolution of complex organisms including plants and animals—have left their mark on the Earth, particularly in the rocks. Over the past 200 years, scientists have been able to reconstruct and map the ancient geological and biological history of our planet.

GEOLOGICAL TIMELINE

Throughout its long geological history, the Earth has undergone vast changes that have affected its life forms. Scientists divide the history of the Earth into different blocks of time. These include eons, whch are divided into eras, which in turn are divided into periods. The Phanerozoic Eon dates from the time when life began to thrive on the Earth and the dates below show how many millions of years ago (MA) each began.

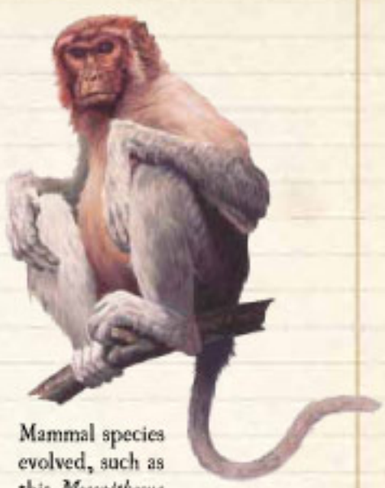
Fossilized shells of the sea creatures Brachiopods.

Early relatives of the mammals, such as this *Lystrosaurus*, dominated the Earth.



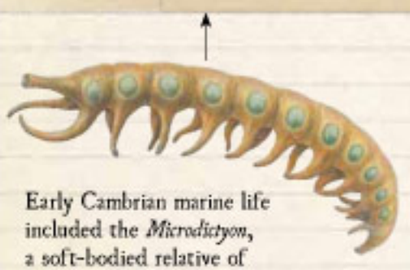
Large marine creatures, such as long-necked elasmosaurs, increased in diversity.

An asteroid impacts the Earth, a catastrophic event that may have led to the extinction of the dinosaurs.



Mammal species evolved, such as this *Mesopithecus* monkey.

PERIOD	Cambrian	Ordovician	Silurian	Devonian	Carboniferous	Permian	Triassic	Jurassic	Cretaceous	Paleogene	Neogene	Quaternary
	541 MA	485 MA	443 MA	419 MA	359 MA	299 MA	252 MA	201 MA	145 MA	66 MA	23 MA	2.5 MA
ERA	PALEOZOIC ERA						MESOZOIC ERA			CENOZOIC ERA		
EON	PHANEROZOIC											

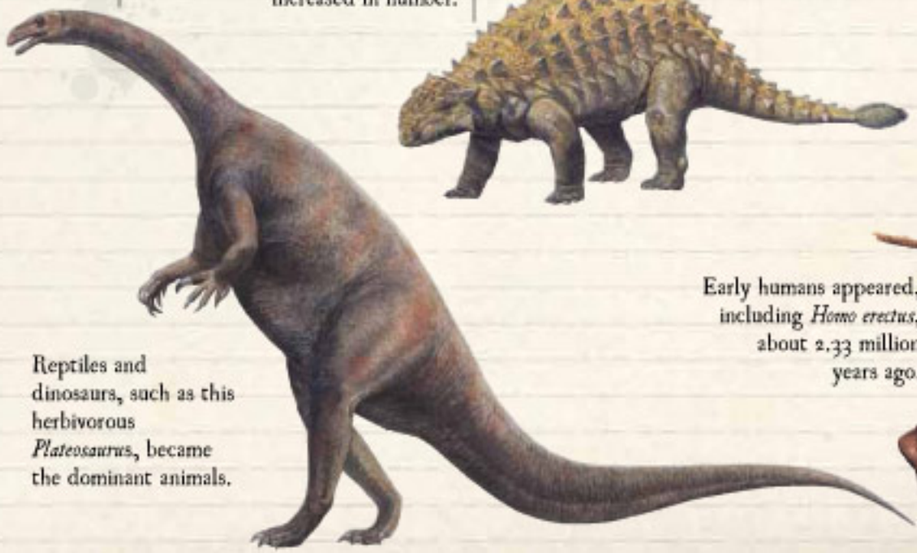


Early Cambrian marine life included the *Microdictyon*, a soft-bodied relative of the arthropods.

Trilobites, an extinct group of arthropods, were common occupants of ancient Palaeozoic seabeds.

Amphibians, similar to the modern salamander, began to appear.

A rock contains the fossilized fronds of a fern. During the Carboniferous Period, ferns were very common.



Reptiles and dinosaurs, such as this herbivorous *Plateosaurus*, became the dominant animals.

Armored dinosaurs increased in number.

Early humans appeared, including *Homo erectus*, about 2.33 million years ago.

FORMATION OF THE PLANET

The early history of the Earth is a story of slow but dramatic change, as its fiery surface cooled and produced the first signs of microscopic life. During the formation of our Solar System, the Earth was created by the coalescence of large fragments of rock and ice, along with dust and gas. As these pieces collided 4.6 billion years ago, they released enormous amounts of energy, heating the Earth to 9,000°F (5,000°C). A "meltdown" followed, lasting 100 million years, during which the Earth's interior assumed its present form.

Hydrothermal vents have been found on the seabed of the Atlantic Ocean, pumping out mineral-rich water. Early bacteria fed on these minerals.

The planets of the Solar System may have been formed by pieces of orbiting dust and rock colliding and joining together.

Scientists believe the Universe began with the "Big Bang" about 12 billion years ago, when an infinitely small volume of matter with an infinitely large density exploded.

About 4.5 billion years ago, it is thought that a planet the size of Mars may have crashed into the Earth.

LAND AND SEA

Geologists are still not sure how the land or continental crust grew. The lighter silicate rocks of the crust may have risen high enough to form land "islands" about 4 billion years ago. Collisions between these islands are believed to have formed the first large landmasses about a billion years later.

By 4 billion years ago, the crust had cooled sufficiently for microscopic life to appear.

ATMOSPHERE

Large-scale volcanic eruptions of gas and steam formed the early atmosphere and the first surface water on the Earth. About 3.9 billion years ago, the Earth had cooled sufficiently for an early oxygenless atmosphere to form.

BEGINNING OF LIFE

The oldest known fossil remains of life on Earth have been found in rocks deposited on the seabed about 3.5 billion years ago. These microscopic organisms existed in an environment devoid of oxygen and subject to extremes of temperature and acidity. Although the earliest body fossils are 3.5 billion years old, rocks dating back another 200 million years may reveal traces of even older organisms. These rocks formed when the Earth was still relatively young and so were subjected to the high temperatures and pressures that existed at the time.

STROMATOLITES

The earliest fossil remains visible to the naked eye are stromatolites, curious laminated structures that grew in shallow, lime-rich seas. The first stromatolites are more than 3 billion years old and were built by layers of bacteria and sediment forming mounds up to 3 feet (1 meter) high and 1 foot (30 centimeters) wide. Similar mounds are still being built today in warm tropical waters.

EARLY SIGNS OF LIFE

By 3.5 billion years ago, primitive algae and bacteria had extensively colonized the margins of shallow, warm seas, growing as mats over the surface of the seabed sediment. When these mats were periodically covered by sediment, the primitive organisms migrated upward toward the light, creating a new mat at a higher level. This process eventually formed distinctive "stromatolitic" mounds.

Stromatolitic mounds would have been the only visible sign of life in the bare and volcanic environment of Earth about 3.5 billion years ago.

THE EDIACARAN PERIOD

Fossil evidence shows that complex organisms came into existence in the oceans of Precambrian times. The Ediacaran Period, the last section of the Precambian age, ended 541 million years ago. It was a long period of Earth's history, a time of shifting continents and changing atmosphere and oceans. It was once regarded as a geological wasteland of complex and barren rocks, devoid of life. That complex life developed and diversified in the Ediacaran oceans is now clear both from direct fossil evidence and from the diversity of life forms found in rocks from the subsequent early Cambrian Period. This must have been the result of a long period of evolution of organisms in Ediacaran times.

DICKINSONIA

The flat disks of *Dickinsonia* grew to 2 feet (60 centimeters) long, making it one of the first "large" creatures. The body has a ribbed surface divided in two by a midline. Its body tissue may have been denser than that of jellyfish or worms.

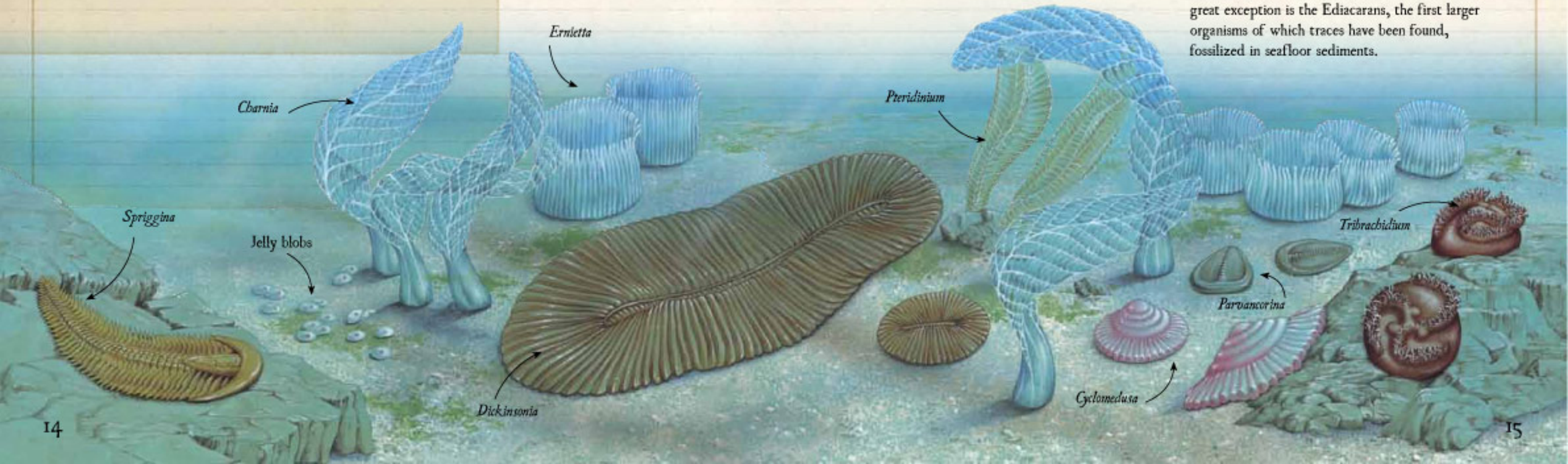
CHANGING CONTINENTS

Most of the continents were clustered in the southern hemisphere. Toward the end of the Ediacaran Period the continental plates came together to form a short-lived supercontinent, which has been called Pannotia.

The organisms that lived in the shallow-water seas of Ediacaran times were all completely soft-bodied. Once considered to be jellyfish or wormlike creatures, it is now thought they were made of tougher material.

THE FIRST LARGE LIFE

Current research suggests that most groups of complex multicelled organisms, apart from the higher plants, must have come into existence in the Ediacaran oceans. Unfortunately, however, the majority of these animals have left no trace in the fossil record. The great exception is the Ediacarans, the first larger organisms of which traces have been found, fossilized in seafloor sediments.



CAMBRIAN EXPLOSION

Early Cambrian times brought a defining moment in the history of life on Earth – a burst in the evolution of marine life. The Cambrian Period, beginning 541 million years ago and lasting for around 50 million years, marks the beginning of a major division of geological time, known as the Paleozoic (meaning "ancient life"). It witnessed the rapid growth of an amazing diversity of life forms. A range of fossil forms, unknown in earlier rocks, suddenly appeared in sedimentary rocks in the sea. The Cambrian Period saw miniscule creatures inhabiting a curious submarine world and organisms became significantly smaller. The first fossil shells also appeared as well as a variety of fossilized spines, studs, and scalelike plates, all defensive devices that imply that life at this time became much more dangerous than in previous ages.

SEA LEVELS

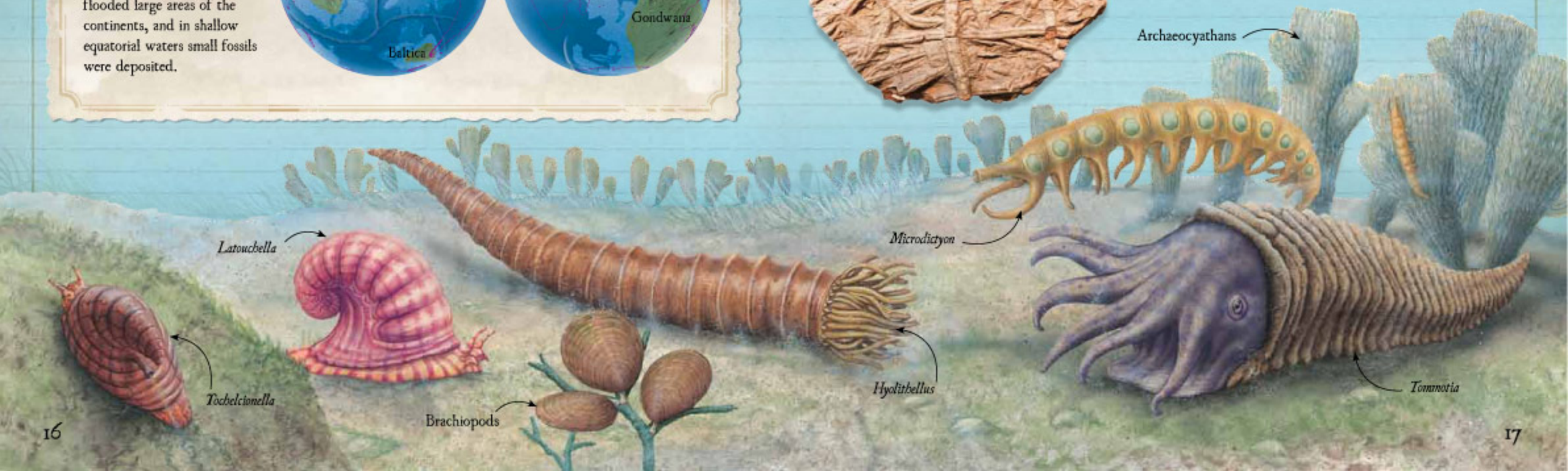
The remarkable evolutionary events also coincided with major environmental changes. There was global warming and sea levels steadily rose. Seas flooded large areas of the continents, and in shallow equatorial waters small fossils were deposited.

EVIDENCE OF LIFE

The fossil record shows that organisms evolved and diversified, only to become extinct and be replaced by other organisms. Evidence of animal activity found in seabed sediment (called trace fossils) show that increasingly complex animals were evolving. Traces include scratch marks of animals with hardened skins (exoskeletons), which were probably the first arthropods—invertebrates with jointed limbs and segmented bodies.

A SMALL WORLD UNDER THE SEA

Tiny, mineralized fossil shells and plates from earliest Cambrian sediments show that seabed microcommunities thrived. They included many different kinds of animals that lived on, and perhaps in, the top layer of sediment.



LATE CAMBRIAN PERIOD

This period was marked by the continuing success of arthropods and the emergence of a possible ancestor of the vertebrates (animals with a spinal column). The warm, light-filled waters of the Cambrian Period were an ideal environment for life to expand and diversify, but progress was not smooth. This included a large-scale extinction event at the beginning of mid-Cambrian times, which contributed to 70 percent of species disappearing.

TRILOBITE FOSSIL

Trilobites, such as *Olenoides*, were among the most successful arthropods of the time. Many had armored bodies and continued to develop and thrive. This Burgess Shale fossil shows *Olenoides*' spines in fine detail, projecting from underneath its hard, crablike covering.

CHANGING CONTINENTS

As the world emerged from the "icehouse" state of the late glaciated Precambrian Era, the supercontinent of Pannotia continued to break up, creating the Iapetus Ocean, the forerunner of today's Atlantic Ocean.

MASS EXTINCTION

The mass extinction event that occurred halfway through the Cambrian Period seems to have been caused by fluctuating sea levels. As sea levels rose from the low levels of the late Precambrian Age, marine animals colonized the expanding shelf seas. Mid-Cambrian sea levels fell again, destroying the shallow-water environments and wiping out large numbers of marine species.

Fossils found in the 505-million-year-old mudstone of the Burgess Shale in British Columbia, Canada, has provided a vivid insight into life in the Cambrian seas. They show there were a wide variety of creatures in the sea at this time.

Laggania
Marrella
Ottoia
Hallucigenia
Pirania
Pikaia
Thaumaptilon
Dinomischus
Olenoides
Canadia
Wiwaxia

THE ORDOVICIAN PERIOD

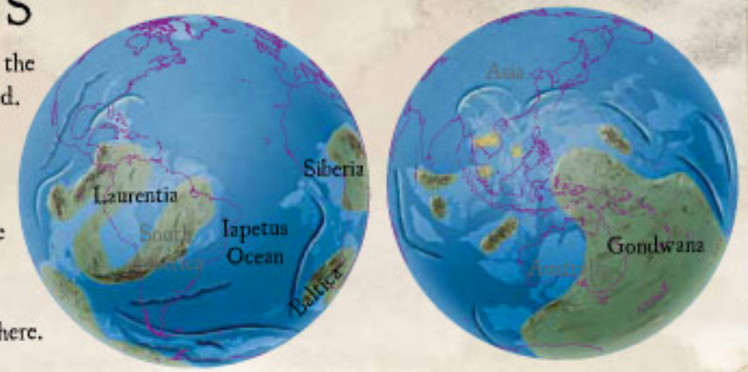
Ordovician times saw the expansion of marine life, until climatic changes destroyed the environment on which so many species depended. The Ordovician Period marked a turning point in the evolution of marine life. Many organisms were increasing in size, strength, and speed. Jawless organisms called conodonts were closely related to the first vertebrates. Fishlike jawless vertebrates were followed by the evolution of the first sharklike vertebrates, which had jaws and teeth. This diverse marine life was not to last, because an ice age drove many organisms into extinction.

BRACHIOPODS

The most common and successful Ordovician shellfish were the brachiopods. Most brachiopods, like these orthids, were permanently anchored to the seabed or to other shells by a short fleshy stalk called a pedicle, though some lay freely on the seafloor sediment. They lived by drawing seawater through their open shells and filtering out microscopic particles of food. Although they resemble clams, they are not related to them.

CONTINENTS

Throughout Ordovician times, the pace of global change quickened. Siberia and Baltica moved north, the Iapetus Ocean began to close, and the Rheic Ocean gradually opened to the south. The supercontinent of Gondwana continued to dominate the southern hemisphere.



SETTING FOOT ON LAND

During this period, animals also began to move onto land, not directly from the sea, but through the "back-door" medium of freshwater. Arthropods were ideally suited to make the transition from the supportive environment of water to dry land, with its desiccating air and primitive vegetation.

The waters of the oceans teemed with planktonic life. On the seabed, there were shellfish, corals, and moss animals. Trilobites and snails searched around the seabed for food. Swimming filter feeders were the first jawless, fishlike vertebrates.