Cambrian Explosion

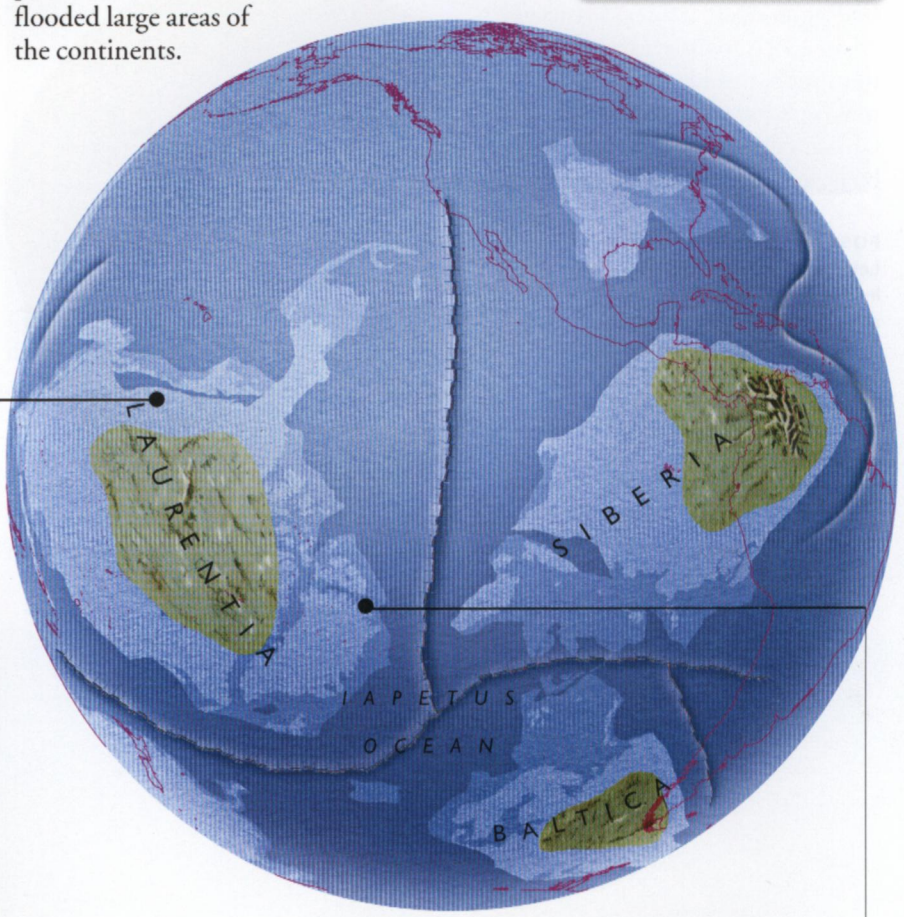
EARLY CAMBRIAN TIMES BROUGHT A DEFINING MOMENT IN THE HISTORY OF LIFE ON EARTH – A BURST IN THE EVOLUTION OF MARINE LIFE, WHICH WE KNOW FROM A WEALTH OF FOSSIL SHELLS.

The Cambrian period, beginning 545 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"). The start of the Cambrian age witnessed the rapid growth of an amazing diversity of life forms.

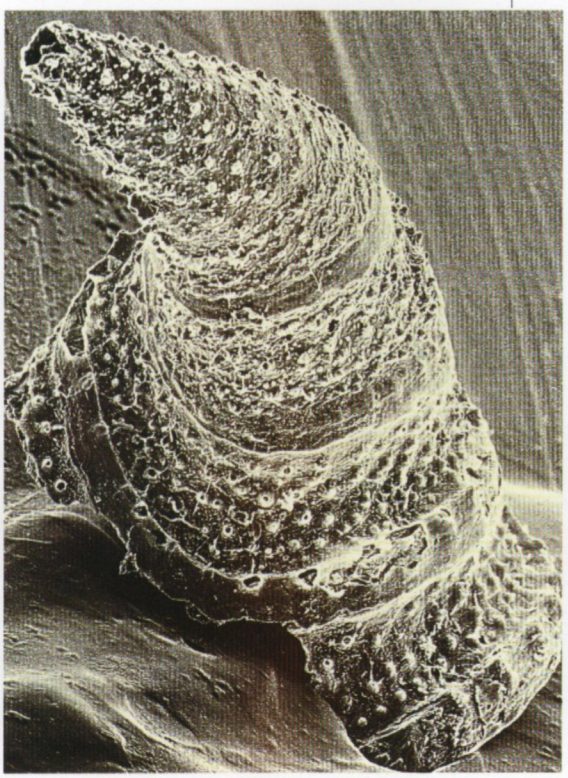
After an incredibly long Precambrian phase of early development – lasting over 3 billion years – a range of fossil forms, unknown in earlier rocks, suddenly appeared in sedimentary rocks in the sea. This important evolutionary event coincided with major environmental changes. There was global warming and sea levels steadily rose following the end of the Vendian glaciation. Seas began to flood the old continents, and in shallow equatorial waters, such as those covering much of the Siberian plate, small fossils composed of calcium carbonate were deposited as limestone. The Sauk Transgression, in the late Cambrian period, was such a time when seas flooded large areas of the continents.

NAMING TIME

The Cambrian period was first defined in 1835 by an English professor of geology, Adam Sedgwick. He mapped a series of marine strata in North Wales and showed that they lay above older rocks (called Precambrian) and below younger Silurian strata. He named them after the Latin for Wales – Cambria.



HOLLOW SHELL
The tiny, hollow cap-shaped shells of the lapworthellids have been extracted from early Cambrian strata in Canada. Lapworthellids may have been a kind of snail-like mollusc.



ODD BODY
Halkiera (right), a fossil from early Cambrian strata in Greenland, has a very strange anatomy. The flat, worm-like segmented body, with a brachiopod-like shell at either end, is covered in scales. The mixture of body structures may indicate ancestry to a number of different animal groups.

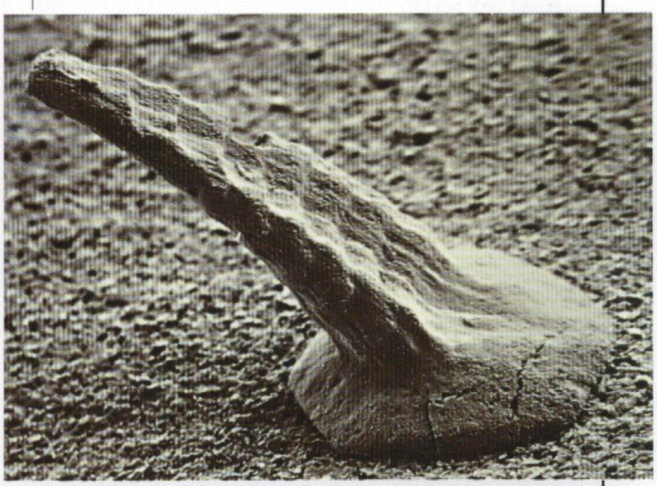
EVIDENCE OF LIFE

The fossil record shows that, time and again, groups of organisms have evolved and diversified only to become extinct and be replaced by other organisms. The start of the Cambrian period witnessed such a phase of origination and diversification. 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. Further evidence comes from the 40 different kinds of shelled creatures, no bigger than a millimetre, which have been discovered in marine limestone deposited on top of Precambrian rocks.

Many of these fossils – usually known simply as small shelly fossils – are thought to represent primitive molluscs at an early evolutionary stage. These fossils are mostly simple cones, similar in appearance to today's limpet shells, except that some of them have a curious snorkel-like tube protruding from the side of the cone. It is thought that this tube might represent an early attempt to separate inhalant currents, which bring in water needed for respiration and sometimes filter feeding, from exhalant currents, which are used for passing waste products and reproductive cells out into the sea. Along with these small shelly fossils are slightly bigger conical fossils with porous walls, known as archaeocyathans, which are probably related to the sponges.

These fossils represent the first wave of the Cambrian explosion. Although they eventually declined, to be replaced by other animals, they were widely distributed, with sequences of marine strata around the world revealing comparable remains of these early sea-dwelling creatures.

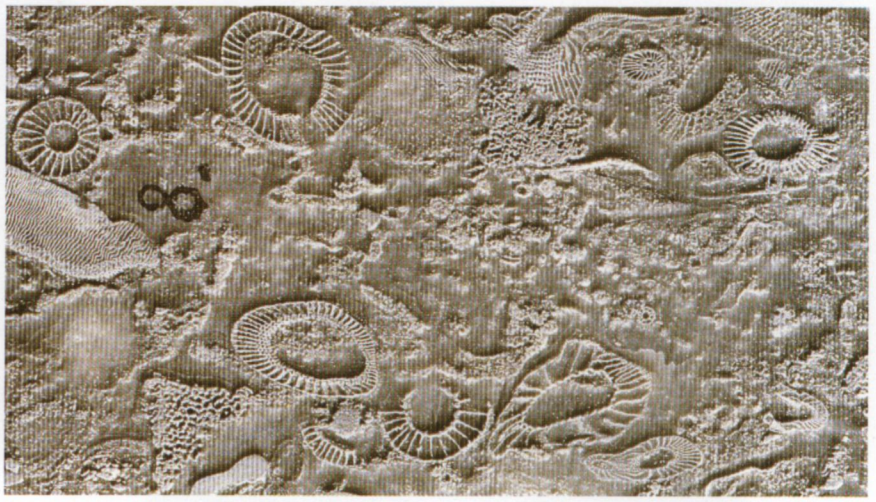
LIMPET OR BURROWER
Mobergella, a tiny cap-shaped shell from Sweden, is one of the puzzling small shelly fossils found in earliest Cambrian strata worldwide. The paired indentations are thought to be the sites of muscle attachment for a limpet-like animal.



TINY FOSSIL SPINE
This millimetre-sized fossil, *Zhijinites*, was removed chemically from the earliest Cambrian strata found in Sichuan province, China. It was probably one of a number of protective spines embedded in the skin of a larger, and as yet unknown, marine animal.

Early Cambrian Marine Life

The fossils of early Cambrian strata record a curious submarine world, inhabited by minuscule creatures. Organisms had become significantly smaller compared to the earlier Vendian fauna, which had grown up to 3 feet (1 metre) in length. By comparison, the largest organisms of early Cambrian times were small cone-shaped creatures called archaeocyathans, only a few inches high. These animals formed widespread reef-like structures in the shallow tropical waters where they lived. The surrounding seafloor sediment was ploughed by smaller snail-like animals, covered by tiny conical shells. Small worms also lived in the sediment in burrows a few inches deep. No organisms grew more than 3 inches (7.5 centimetres) above the seabed.

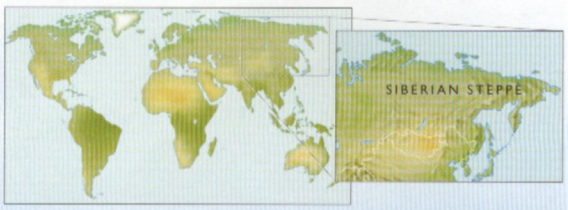


FIRST SHELLS

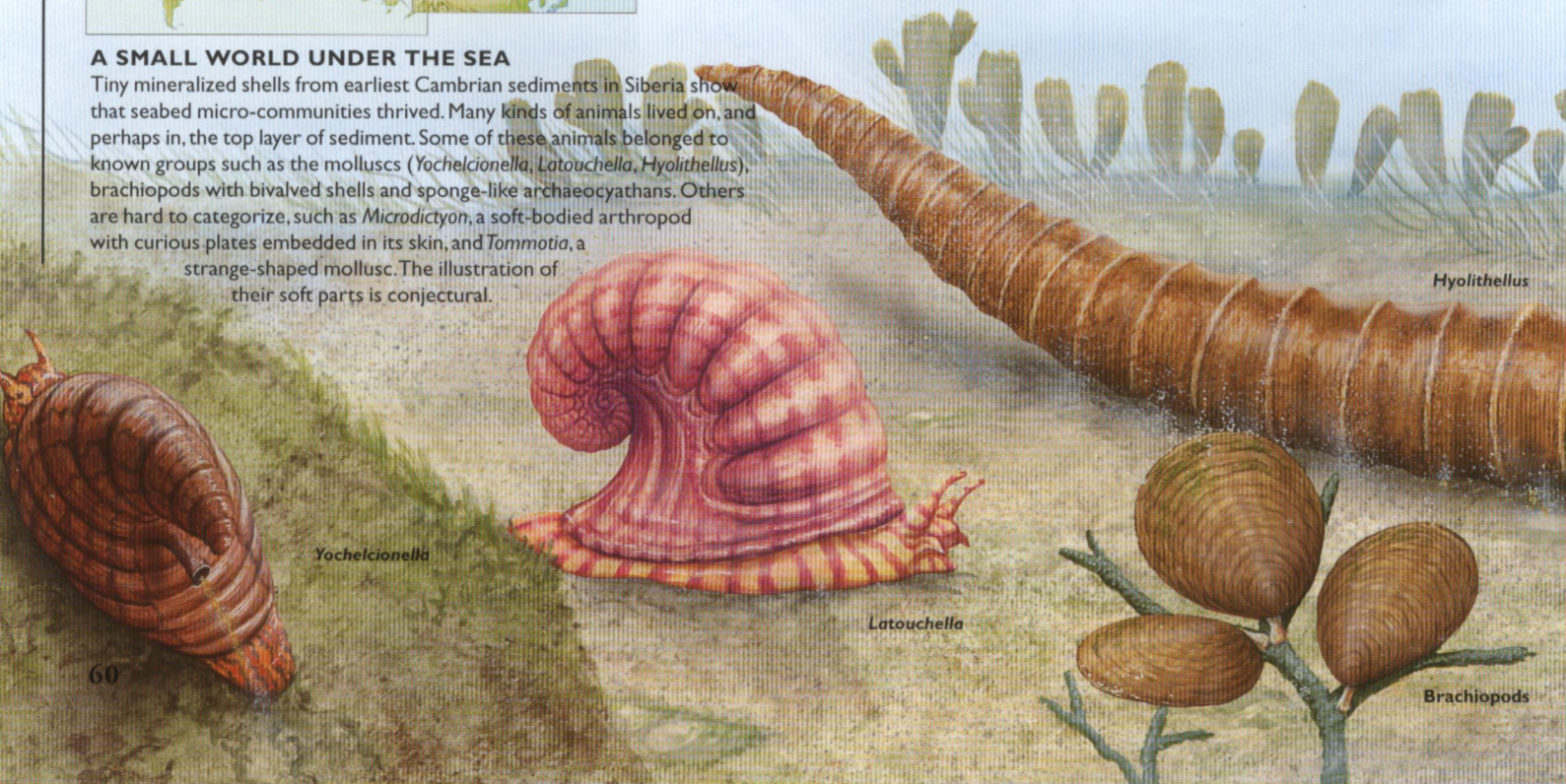
Shells were an innovation of early Cambrian times. The fossils that mark the boundary between Precambrian and Cambrian strata are trace fossils – the preserved forms of tracks, worm casts and burrows. However, in strata not far above this boundary, the first fossil shells appear. They fall into two clearly distinct groups: the shells of the archaeocyathans, which were porous cones, and the shells of the so-called "small shelly fossils", a variety of solid-walled cone shapes only 0.2 inches (5 millimetres) in size. In addition, a variety of fossilized spines, studs and scale-like plates appear, which must originally have been embedded in the skins of different small creatures.

Hard spines, scales and shells are all familiar defensive devices, suggesting a need for protection. Their appearance in the strata implies that life at this time had suddenly become much more dangerous than in previous ages. If this is true, then a revolution had taken place in the relationships between the organisms of the time. On a miniature scale, a global arms race had begun.

EARLY SHELLED CREATURES
Archaeocyathans were among the earliest fauna with hard parts, producing inner and outer calcareous walls, perforated and porous like a sponge. This double-walled structure can be clearly seen in a cross-section of the fossilized remains of a group of archaeocyathans (above).



A SMALL WORLD UNDER THE SEA
Tiny mineralized shells from earliest Cambrian sediments in Siberia show that seabed micro-communities thrived. Many kinds of animals lived on, and perhaps in, the top layer of sediment. Some of these animals belonged to known groups such as the molluscs (*Yochelcionella*, *Latouchella*, *Hyolithellus*), brachiopods with bivalved shells and sponge-like archaeocyathans. Others are hard to categorize, such as *Microdictyon*, a soft-bodied arthropod with curious plates embedded in its skin, and *Tommotia*, a strange-shaped mollusc. The illustration of their soft parts is conjectural.

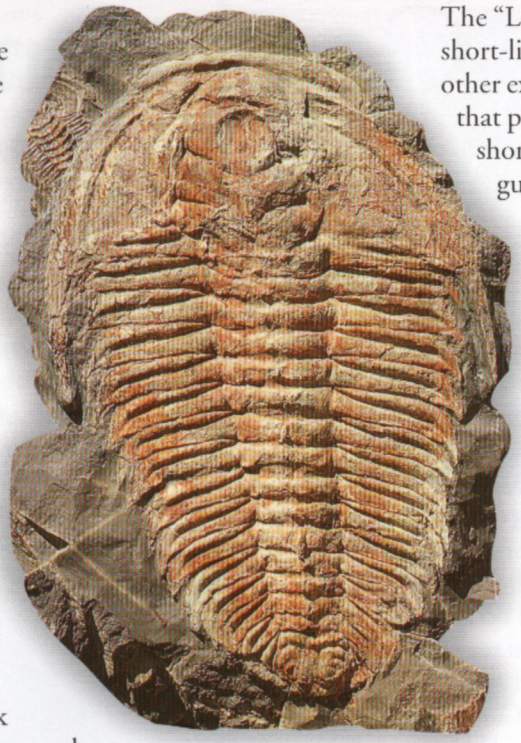


CONTRASTING FUNCTIONS

The shells of the archaeocyathans and the shells of those animals represented by the small shelly fossils had quite different functions. Archaeocyathans primarily used theirs to anchor themselves to the seabed. From here they would grow upwards, as sponges and corals do today. They almost certainly also used their shells as feeding devices. The porous walls of the shell would have filtered out microscopic food from the surrounding seawater. Providing protection against predators was probably a less important function.

By contrast, the tiny shells of the small shelly fossils were probably primarily a protective device. The inhabitants of these small shells lived on the seabed and fed by grazing on organic material from the surface of the sediment. There may have been some risk associated with feeding, however. Their exposed fleshy bodies may have made them easy targets for predators swimming in the water above.

Although the archaeocyathans quickly spread worldwide, they did not last for long by geological standards – only some 35 million years – and by late Cambrian times, they were extinct. The animals that lived in the small shells, however, are thought to be related to today's molluscs.



ARTHROPOD ARMOUR
Named for their three-lobed shell, trilobites first appeared around 545 million years ago. Trilobites are among the earliest known arthropods, and account for a third of all fossils found in Cambrian rocks. They were some of the first animals to develop an external skeleton.

The "Lilliputian" early Cambrian seaworld was short-lived. With the rapid formation of shells and other external hard structures, the organisms of that period evolved a great deal in a relatively short time. It was not, however, enough to guarantee their survival. By the end of the early Cambrian period (520 million years ago) an extinction event had wiped many of them out and another wave of diversification was underway.

SHELL THEORIES

Why did early Cambrian organisms evolve shells? The obvious answer is that they needed protection. But it has been pointed out that there were no known predators armed with teeth at this time – so what exactly were these tiny organisms protecting themselves against? One possibility is that predators used other means of attack, such as stinging cells, which left no trace in the fossil record. But it is possible that the shells were not for protection at all. They may have been energy stores, a response to chemical changes in seawater or an anchor for soft body parts.