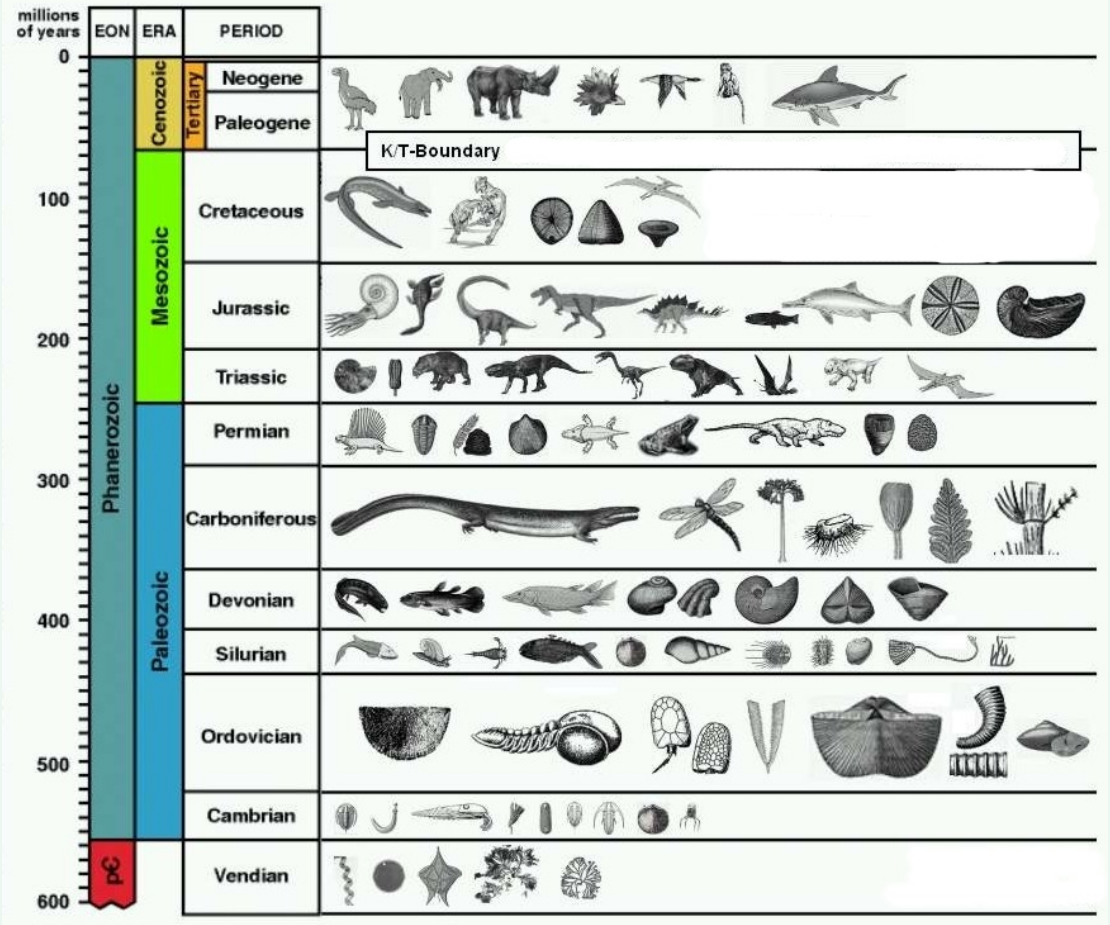
Hands On Learning
with Reading Museum Service

FOSSILS X1/A

The word fossil is derived from the Latin *fossilis*, which means 'dug up'. Fossils are the remains of creatures which existed long ago. Fossils range from thousands of years to many millions of years in age. The earliest fossils date from around 600 million years ago. However recent reports suggest bacteria may have existed up to 3,000 million years earlier. To put this in context, the dinosaurs became extinct just 65 million years ago. The earth itself is about 4,570 million years old. Geologists divide this vast time into various units according to events which took place in each period. The chart below gives the names of these periods, from the time of the first complex fossils through to the present. It also shows some of the living things (mainly animals) that lived in each period.



Not all former life was preserved as fossils. The vast majority of living things simply vanished without trace. Fossils come in a variety of sizes, from the microscopic through to large dinosaur skeletons and are formed in a variety of ways.

Permineralised fossils are organisms which became covered by sediment soon after death. As the organism slowly decayed, water infused with minerals passed through it, replacing the chemicals in it with rock-like minerals. Over millions of years the original organism was completely replaced by these minerals and what remains is a rock-like copy of the original. The fossil has the same shape as the original object, but is actually rock. This process results in loss of original colour. The photograph on the right shows the fossil of a huge tree that was formed by the permineralisation process.



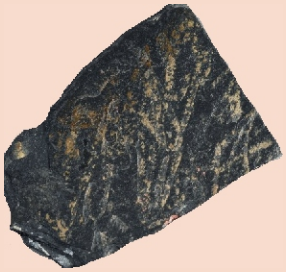


In other cases the original remains of the organism completely dissolve and all that is left is an organism-shaped hole in the rock. This kind of fossil is called a mould fossil or typolite. If this hole is later replaced by new, unrelated minerals, it is called a cast fossil. In some cases replacement occurs so gradually that tiny features are preserved despite the total loss of original material. The photograph on the left shows a mould fossil of a shell.



Finally, there are trace fossils: marks in the rock which result from the activities or presence of animals and plants. Examples of these traces include footprints, burrows, root tunnels and even animal droppings (which are called coprolites) and vomit (regurgitaliths). The photograph on the right shows a fossilised dinosaur footprint.

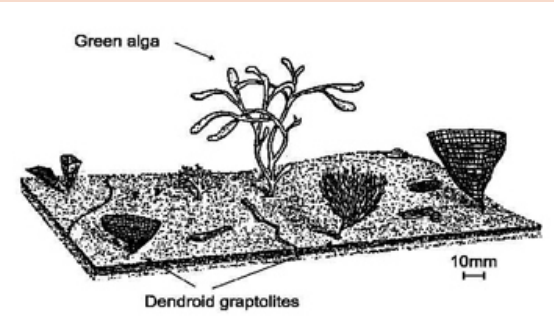
Graptolites



Graptolites are the fossil remains of small colonial animals that lived from 520 to 320 million years ago. Their skeleton is made of collagen, a complex protein similar to the material that forms finger nails. The tiny individual animals lived in a series of tiny, cup-like structures organised along the length of the graptolite skeleton. Individuals formed colonies, a bit like individual coral polyps live together and create larger organisms. After death the colonies disintegrated and only the resistant collagen skeleton material is preserved as fossils. The name graptolite comes from the Greek *graptos*, meaning written, and *lithos*, meaning rock, as many graptolite fossils resemble hieroglyphs written on the rock.

There were many different species of graptolite and it is not certain what colonies of these creatures would have looked like. Some were attached to the sea-floor by a root-like base, others drifted on the surface of ancient seas, others were attached to floating seaweed by means of a slender thread. The drawing below suggests something of how some of them may have appeared.

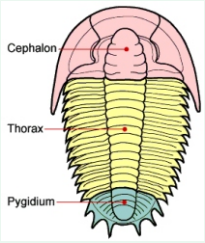
For much of that time that they lived graptolites dominated the upper layers of the ocean. They lived by the countless billion and their skeletons are preserved today in vast numbers in varied strata in every continent. Because of their diversity they are very useful to geologists when they are trying to date rocks.



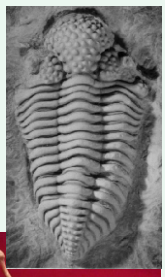
Trilobite



Trilobites first appear in the Cambrian Period and they became extinct in the Permian Period - the group lasted about 300 million years. Altogether about 17,000 species of trilobite have been recorded. Photographs of three of these species, illustrating something of their diversity, can seen below right. It is not known what species the trilobite in this box belongs to.



The bodies of trilobites are divided into three parts (left) - a cephalon (head); a thorax composed of freely articulating segments; and a pygidium (tail) composed of the last segments fused together. The thorax seems to have been fairly flexible as fossilised trilobites are often found curled up like modern woodlice for protection.







Trilobites range in length from one millimetre to 72cm (1/25inch to 28 inches), with a typical size range of two to seven centimetres (1 to 3½ inches). The world's largest trilobite, *Isotelus rex*, was found in 1998 on the shores of Hudson Bay. One specimen measured 72cm in length (over two feet four inches), 400mm in maximum width (across the cephalon) and 7cm in maximum height.

Many trilobites had eyes. They also had antennae that were probably used for taste and smell. All trilobites lived in the sea, but they found food in a variety of ways and places. Some were blind, probably living too deep in the sea for light to reach them. Some lived on the sea bed, others could swim. Some seem to have been predators, others scavengers.

Trilobites were most diverse during the late Cambrian Period. The last of the trilobites disappeared in a mass extinction at the end of the Permian, about 250 million years ago. This mysterious event - sometimes called the 'Great Dying' - saw the extinction of 96% of all species living in the sea at that time. However, even before this finished them off, it is thought that their numbers began to decrease with the arrival of the first sharks and other early fish in the Silurian and Devonian Periods. These new species had strong, hinged jaws and trilobites may have provided a rich source of food for them.

Carboniferous Limestone Fossils



The geological period between about 360 and 300 million years ago is called the Carboniferous Period. The Carboniferous Period is in turn divided into two parts called the Lower (earliest) and Upper (later) Carboniferous. In Britain the rocks of the Lower Carboniferous period were laid down under the sea, while those of the Upper Carboniferous period were made on dry land.

Much of the coal that is found beneath the landscape of Britain was created in the Upper Carboniferous period. At this time Britain and much of northern Europe was hot and was covered by a rainforest which looked superficially similar to that found in Brazil today. When trees die in a stagnant peat swamp environment low oxygen levels prevent their complete decay by bacteria. If these masses of undecayed plant remains are later buried under sediments (mud and sand swept over them by a river or the sea) then coal will form.

This piece of limestone, however, was probably formed under the sea. Limestones can form in many places, including river floodplains and lakes, but they are usually formed in clear tropical waters. Limestones are being made today in such places as the waters of the Bahamas and the Great Barrier Reef off Australia. In such locations the remains of countless sea creatures pile up on the sea bed over millions of years, then slowly change into rock as their chemistry alters. In some places beds of limestone are thousands of metres thick. Huge beds of limestone can be found in the Pennines in northern England, witnesses to the warm tropical waters that once covered the area. These two examples are from the Peninnes. One has fossil shells embedded in it while the other contains prominent crinoid stems.



Despite their plant-like appearance, crinoids are animals that live in the sea. They are often referred to as *sea lilies* (for crinoids that are attached to the floor) and *feather stars* (for free-swimming crinoids). Organisms that have been identified as crinoids first appear in the Ordovician Period (488 to 444 million years ago) and there are several hundred species of stalked and unstalked crinoids in the modern world's oceans, although this is just a tiny fraction compared to their abundance in past ages. The photograph to the right shows the passion flower feather star (*Ptilometra australis*), which lives off the coast of Australia. The fossil crinoids in this box were probably once equally brightly coloured.

Continued on next page.

Generally the stalked forms inhabit the deeper oceans, while stalkless forms are commonly found in shallower depths (including the shallows of coral reefs). Crinoids are characterised by a mouth on the top surface that is surrounded by feeding arms. There are usually five or a multiple of five arms, which may be repeatedly branched. Grooves in the arms channel food particles floating in the water to the mouth. They have a U-shaped gut, and their anus is located next to the mouth. Some ancient sea snails developed a symbiotic relationship with crinoids they would sit on the crinoid anus and feed on the excrement as it was ejected (which was obviously rich in nutrients).

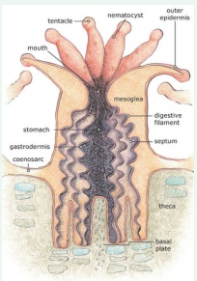


The drawing on the right shows a crinoid species. Often the disc-shaped sections of the stalk would break apart after death. These fragments are often found off the coast of north-east England, where they are known as St Cuthbert's beads.

Coral



Coral is the common name for a number of tiny marine animals closely related to sea anemones and jellyfish. What appears at first sight to be a single piece of coral is, in fact, a colony formed of thousands of individuals, each of which is only a few millimeters in diameter. A diagram of a typical, but much magnified, individual can be seen on the left. The individuals which make up the colony are usually referred to as a polyps. The colony functions as a single organism, gradually getting bigger as each generation grows on the skeletal remains of previous generations, forming a structure that has a shape characteristic of the species.



Although corals first appeared in the Cambrian Period, 542 million years ago, fossils are extremely rare until the Ordovician Period, 100 million years later. In life corals can be extremely colourful (right). When they die the polyps decay, leaving their hard core an example is included in the box. The fossil coral has been polished to reveal some of the structural details. A piece of unfossilised coral (left) has be included to show something of the typical three-dimensional structure.





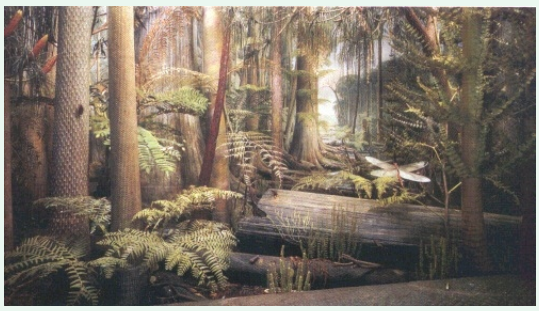
Two Coal Measure Fossils





Although the environment that produced coal looked similar to that of Brazil today, the kind of plants that flourished in the Upper Carboniferous Period were, in fact, very different from those found in a modern rainforest.

Tree-sized plants dominated, but these were largely club-mosses - extremely fast-growing plants adapted to nutrient-poor, waterlogged soils. It has been estimated that their 1-2 metre wide stems could grow upwards at several metres per year, up to a height of 40 metres. They were not seed plants as are most large plants growing today; they reproduced by means of spores. Unlike true trees their trunk contained relatively small amounts of wood. Instead, much of the trunk consisted of soft tissue called periderm, which enabled the plants to grow much more quickly than woody trees. They grew into mature plants, reproduced, and then died. Most modern-day trees, in contrast, reproduce for many years after reaching maturity. For this reason, many palaeontologists call these extinct plants giant herbs rather than trees.



Other plants also grew in the forests, but mainly in the less waterlogged areas, such as on the raised banks of rivers that threaded their way through the swamps. There were tree ferns, looking very similar to those growing today in places like New Zealand. There were also some seed plants belonging to a number of now extinct groups such as the cordaites (distant relatives of today's conifers) and the seed-ferns (distant relatives of the modern cycads).



These two fossils are witness to this lush, long-since-vanished landscape. One of them has an impression of fern-like leaves. The other is a fossilised calamites stem. Calamites were a group of extinct tree-like horsetails to which the modern horsetails (right) are closely related. Unlike their modern cousins, calamites were medium-sized trees, growing to a height of 10 meters (31 feet).

Ammonite



Ammonites were marine animals that ranged in size from under an inch (2cm) to about 9 feet (3m) in diameter. They were protected by a shell (usually spiral-coiled) that contained many air filled chambers. As the animal grew, new chambers were added behind the outer chamber. The animal lived only in the outermost chamber.

Despite the fact that they look like snails, ammonites did not move by crawling across the ocean floor. Air in the unused shell chambers allowed the animal to float and they moved by jet propulsion - expelling water through a funnel-like opening to propel themselves in the opposite direction. The modern nautilus (right) gives us some idea of what a living ammonite would have looked like.



Ammonites probably lived for about two years. A nautilus creates a new chamber in its shell at a rate of one every four weeks, equal to 13 each year. Using this as a guide an ammonite shell containing 26 chambers could be assumed to have housed the creature for two years. Evidence suggests that some female ammonites grew up to 400% larger than the males.

Ammonites began life as tiny planktonic creatures less than 1mm in diameter. In their infancy they would have been vulnerable to attack from other predators including fish. They quickly assumed a strong protective outer shell that would shield their soft interior from damage. However, fossilised adult ammonites have been found showing teeth marks from ichthyosaur attacks.

On the other hand, ammonites were themselves predators, feeding on most living marine creatures including molluscs, fish and even other cephalopods (octopuses, squids etc.). By analogy to modern cephalopods, their method of attack probably consisted of silently stalking their prey, then rapidly extending their tentacles to grasp the target. The photograph on the right shows a nautilus capturing a crab. Once caught the prey would be devoured by the ammonite's powerful jaws located at the base of the tentacles, between the eyes.



Continued on next page.

Much of an ammonite's life was spent in shallow waters. The evidence to support this includes their diet, which could be found in the greatest volumes in the warm shallows. It is also unlikely that their shells could withstand the high pressures present in deep water (over 100 meters). Another theory based around their assumed social behaviour suggests that their shells were decorated by an array of patterns, indicating that colour/good light played a large part in their lives.

Ammonites first appeared in the late Silurian to early Devonian Periods (about 400 million years ago) and were abundant in the seas for 300 million years. At several points in this long history they faced major extinction events, with often only a few species surviving. Each time, however, this handful would diversify into a multitude of forms. Ammonite fossils became less abundant during the latter part of the Mesozoic Era (from 251 to 65 million years ago),

Two Sponges



Sponges are one of the most primitive multicellular animals, lacking internal organs, nervous tissue, a circulatory system, or a gut for digesting food. To obtain food, the sponges filter the water around them as it passes through tiny pores located on their outer walls. To support and protect their soft bodies, sponges produce skeletons of calcium carbonate, silica, or a soft organic material called spongin.

Sponges date back to a period known as the Neoproterozoic Era, which began 1,000 million years ago, well before the explosion of life forms in the Cambrian Period. It is not known how old this example is or where it originates from. The fossil record of sponges is not abundant, although a famous locality for them is the Cretaceous Faringdon Sponge Gravels in Faringdon, Berkshire (now Oxfordshire). A photograph of a fossil sponge (*Raphidonema farringdonense*) from this locality can be seen on the left.



These two fossil sponges are very different. One looks very like the fossil sponge from the Faringdon Sponge Gravels illustrated above. The other, at first sight, looks like nothing more than a fragment of a flint nodule. Such flints are common in the chalk-rich soils around Reading. However, when these nodules are split open, they are sometimes found to have a cavity in the centre in which there are fossil remains. This is the case here. A few fossil fragments can be seen and the pock-marked inner surface of the nodule indicates that it once held more extensive sponge remains.

Belemnite

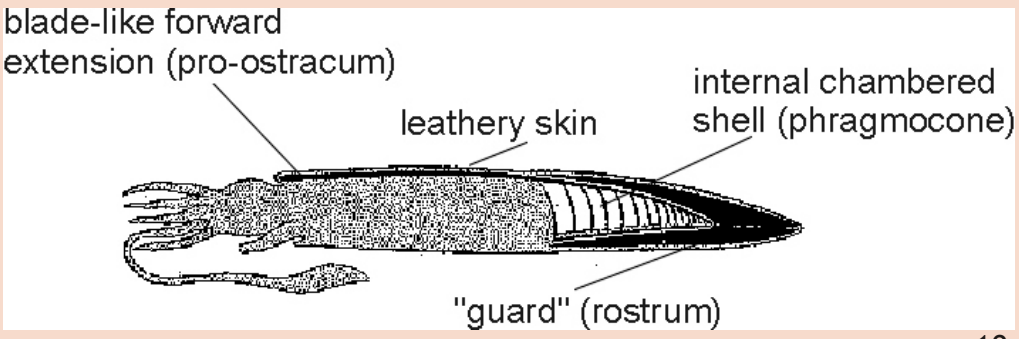


Belemnites are an extinct group of marine animals, similar in many ways to the modern squid and cuttlefish. Like them, the belemnites possessed an ink sac, but, unlike the squid, which has eight arms and two tentacles, they possessed ten arms and no tentacles. Also, unlike the modern squid, whose arms have suckers, belemnite arms carried a series of small hooks for grabbing prey. Belemnites were carnivores that caught small fish and other marine animals with their arms and ate them with their beak-like jaws. Belemnites themselves appear to have formed part of the diet of marine reptiles such as ichthyosaurs, whose fossilised stomachs frequently contain many belemnite hooks.



Normally only the back part of the belemnite shell (called the guard or rostrum) is found. The guard is elongated and bullet-shaped, being cylindrical and either pointed or rounded at the rear end. The front of the guard would have been hollow and would have enclosed a chambered section of shell. This section, which seldom survives, was divided into chambers that were gas-filled and which caused the animal to remain buoyant. The diagram below shows the structure of a typical belemnite. The picture on the right shows what a belemnite may have looked like in life. Like ammonites, belemnites moved by squirting out a jet of water which propelled them forwards.

Belemnites reached their greatest abundance and diversity during the Jurassic and early Cretaceous periods, but, like the ammonites, disappeared at the end of the Cretaceous Period.



Sea Urchin



Living sea urchins (below left) are covered with spines, but these usually decay quickly after death leaving a shell, which is also called the test. Fossilised sea urchin tests are relatively common. The earliest sea urchins are found in the Ordovician Period.



This fossilised sea urchin test appears to be made of chalk and is probably from the Cretaceous Period. During this time thick chalk beds were created all over what is now southern England. These beds are made up from tiny particles of fossil debris from microscopic green algae known as coccolithophores. Coccolithophores lived in the upper part of the water column. When they died, the microscopic calcium carbonate plates, which formed their shells settled downward through the ocean water and accumulated on the ocean bottom to form a thick layer of calcareous ooze, which eventually became the chalk bed.

Fossilised Wood from the Reading Beds



The Reading Beds are layers of clay and sands, mixed with pebbly beds and masses of fine sand converted into quartzite, that were deposited between 56 and 55 million years ago, during the Paleogene Period. These beds were created when the area was a river estuary receiving river sediment from land lying to the west. They are named after the town of Reading, Berkshire, although they (and other related formations) are found throughout the London Basin.

Wood Fragment

This is a good example of fossil wood formed by permineralisation. It was found in a chalk bed.



Fossil Shells from the London Clay



The London Clay consists of a stiff, bluish coloured clay which becomes brown when weathered. The bed was laid down between 54 and 48 million years ago on the shallow shelf of a semitropical sea near the estuary of a major river system. Fossil evidence suggests that the nearest land mass lay approximately 100 kilometres to the north and east, and was probably fringed by mangrove swamps and palms. Behind, a tropical rain forest was teeming with a diversity of plants and animals. Offshore, islands and mud banks clad with palm trees harboured birds, turtles and crocodiles. The seas would have supported large populations of sharks, rays and fish including swordfish and sturgeon. The many logs that floated out to sea formed rafts which slowly became waterlogged and sank to the bottom. Crabs, lobsters, gastropods and bivalve molluscs all thrived in this environment. This example shows a scattering of bivalve shells and shell-fragments.

Brachiopod



Brachiopods are animals that have two shells that fit together to protect the creature's soft fleshy bits. Both shells are symmetrical as individual shells, but they differ in shape from each other. Most brachiopods are attached to the ground by means of a fleshy stalk called a pedicle. The diagram to the right shows the basic brachiopod structure.

Like crinoids, brachiopods are suspension feeders they suck in particles of food that are floating in the water.
Brachiopods are extremely common fossils up to the so-called Permian extinction event, in which about 96 percent of all marine species became extinct, of about approximately 250 million years ago. Afterwards their diversity and numbers were drastically reduced, and they were largely replaced by bivalve molluscs. Molluscs continue to dominate today, and the remaining brachiopods survive largely in fringe environments of more extreme cold and depth.

IchthyosaurJaw, Vertebrae & Bone



Ichthyosaurs were giant marine reptiles resembling fish and dolphins that appeared about 250 million years ago (earlier than the dinosaurs, who put in an appearance about 230 million years ago) and which became extinct about 90 million years ago (about 25 million years before the same thing happened to the dinosaurs). Ichthyosaurs evolved from as-yet unidentified land reptiles that moved back into the water in a development parallel to that of dolphins and whales. The late Triassic and early Jurassic Periods were the heyday of the ichthyosaurs, which are represented by four families and a variety of species, ranging from one to ten meters in length.



Ichthyosaurs are important in the history of palæontology (the study of prehistoric life forms), as their fossil remains are relatively common in southern Britain and they were one of the first groups of extinct species to be studied. They were first described in 1699 from fossil fragments discovered in Wales. The first complete ichthyosaur fossil was found in 1811 by Mary Anning in Lyme Regis, along what is now called the Jurassic Coast. She subsequently discovered three separate species. The ichthyosaur skeleton on the right was found in Dorset.

The jaw and tooth specimens in this box indicate the carnivorous feeding habits of ichthyosaur species. Ichthyosaur jaws were typically studded with even rows of pointed conical teeth. Ichthyosaur teeth are often striated (grooved), like these examples. In most species the teeth were so closely spaced that when the jaws closed they meshed together, leaving no gaps - perfect for catching fish. Modern porpoises and dolphins have teeth and jaws similar to those of ichthyosaurs. We also know about the diets of some ichthyosaurs from the stomach contents preserved in fossils, which indicate that many of the fish-shaped ichthyosaurs relied heavily on belemnites. Some late ichthyosaur stomachs have been found to contain bony fish and hatchling-sized baby turtles.

When ichthyosaurs first appeared they probably swam like eels, by undulating the entire body, and had flat-ended vertebrae. The vertebrae in this box are indented at their ends, which suggests they belonged to a more fish-shaped ichthyosaur from later in their history.