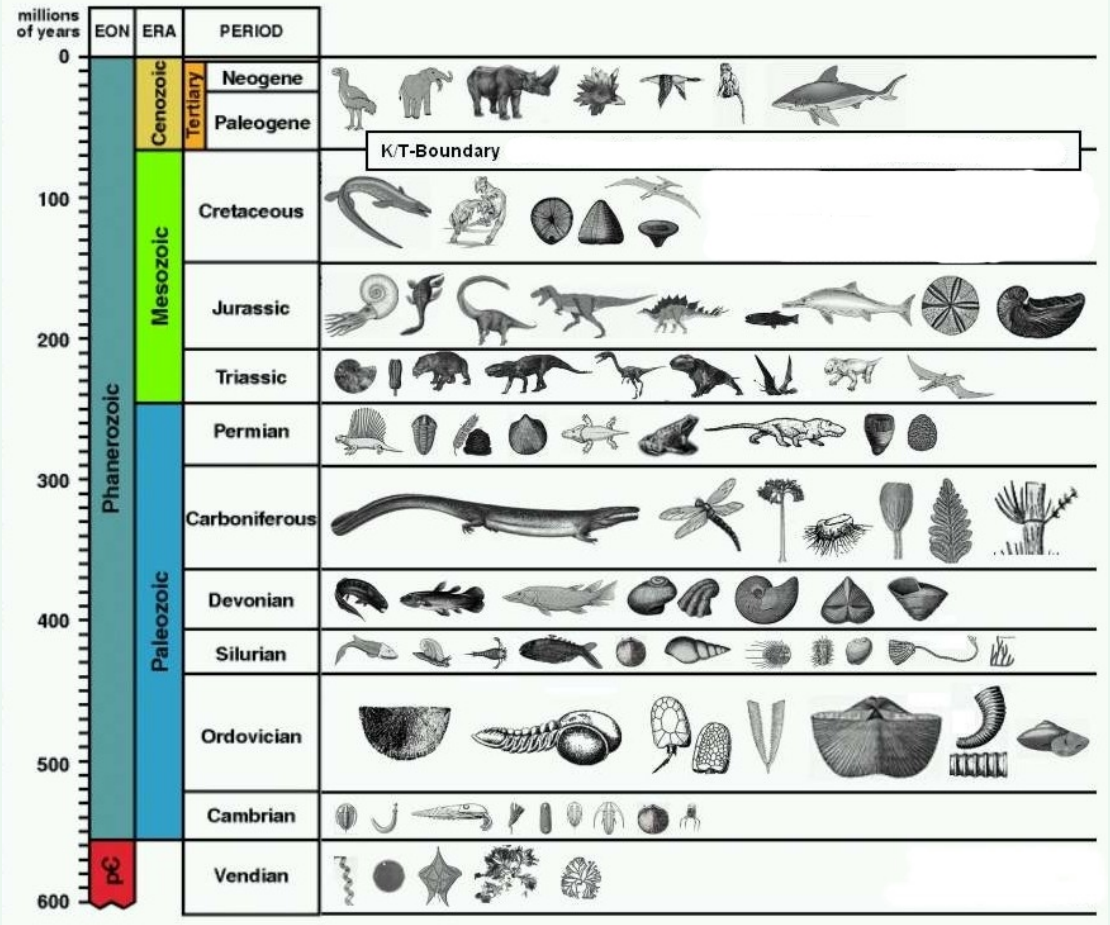
READING MUSEUM SERVICE

# Hands On Learning
## *with Reading Museum Service*

## FOSSILS X1/E

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 organisms (mainly animals) that lived in each period.




Reading Borough Council

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## FOSSILS X1/E

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.

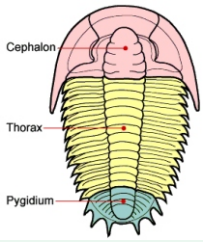
Finally, there are trace fossils: marks in the rock which result from the activities or presence of animals and plants. Examples of these traces include footprints, burrows, root tunnels and even animal droppings (which are called coprolites) and vomit (regurgitaliths). The photograph on the right shows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



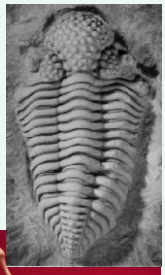
## Trilobite



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), 40cm 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.

## Coal Measure Fossil



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 plants called club-mosses - extremely fast-growing plants adapted to growing in low nutrient, waterlogged soils. It has been estimated that their 1-2 m 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 a true tree 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 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 tree ferns 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).

This fossils is a witness to this lush, long-since-vanished landscape. It shows the leaves of extinct fern-like plant .

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### Two Sea Urchins



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. These two specimens are from the Cretaceous Period.





In folklore, fossilised sea urchins were thought to be thunderstones which fell from the sky during storms.

### Natural Flint



Chert and flintstones are common in the soils around Reading. Most beds of chert are formed from the ooze that covers the deep ocean floor. The ooze is built up from the constant rain of plankton that drops to the floor when these small creatures die. Once the ooze is buried it solidifies into chert.

Not all chert is biochemical in origin. Sometimes the calcite crystals in limestone are gradually replaced by silica. Flints, the nodules of black or toffee coloured rock, are an example of this process. Sometimes, when these nodules are split open, they are found to have a cavity in the centre in which there are fossil remains, very often of a sponge.

### Oolite, with Tooth



In the Jurassic Period the waters were clear and the sediments were limy or chalky. The chalky deposits formed a series of limestones often made up of round grains. These bear a superficial resemblence to eggs in the roe of a fish and the rock was called oolite, or oolitic limestone, from the the Greek word 'oon' meaning egg. This specimen has a fish tooth embedded in it.

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FOSSILS X1/E

## Amber



Amber is the common name for fossil resin that was produced by trees between 30 and 90 million years old. Resin is a secretion of many plants, particularly coniferous trees. As resin is sticky it often traps insects, leaves and other small organisms as it oozes down the tree trunk. Some pieces of amber contain preserved insects. The photograph on the right shows an insect trapped in a piece of amber.

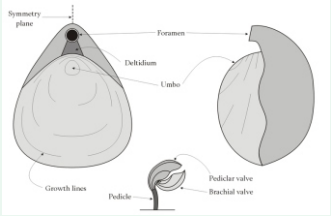


## Shells



For millions of years life was confined to the sea. Shells, which reproduce abundantly, have left a plentiful fossil record. The shells in this box represent a tiny fragment of the thousands of species that once existed.

None of these examples have been identified. One of them, though, is a species of brachiopod. Brachiopods are two-shelled animals, which look similar to the more common bivalve molluscs (such as mussels), but which are actually not closely related. After the Permian extinction event brachiopod numbers declined and bivalves began to increase. Bivalve molluscs continue to dominate today and the remaining orders of brachiopods survive largely in fringe environments of more extreme cold and depth.




The two groups of animals differ in a number of ways. For example, most brachiopods are attached to the sea bed by means of a fleshy pedicle. In contrast, although some bivalves (such as oysters) are fixed to the sea bed, most are free-moving, usually by means of a muscular foot. A diagram of a typical brachiopod can be seen on the right.



One of the shell samples in the box consists of a mass of fragments embedded in a piece of London Clay. London Clay 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 was probably fringed by mangrove swamps and palms. Offshore, islands and mud banks clad with palm trees harboured birds, turtles and crocodiles. Crabs, lobsters, gastropods and bivalve molluscs all thrived in this environment.

## Ammonites



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 animals 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 the 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 metres).

Iron pyrite (iron sulphide or, more commonly, fool's gold) can be seen on one of these fossils. Sometimes entire fossils are made up from iron pyrite. This most frequently occurs with marine fossils because of a process known as bacterial sulphate reduction, in which bacteria causes sulphur and iron minerals to form iron sulphides.

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. Ammonite fossils became less abundant during the latter part of the Mesozoic Era (from 251 to 65 million years ago), with none surviving into the Cenozoic Era.

## Gryphaea



Gryphaea is the name given to a genus (group) of extinct oysters popularly known as Devil's toenails. They are common fossils in many parts of Britain and date from the Jurassic Period.

Gryphaea lived on the sea bed in shallow waters, possibly in large colonies. Complete Gryphaea fossils consist of a larger gnarly-shaped shell (the 'toenail') and sometimes a smaller, flattened shell, forming a lid. The animal occupied the cavity between the two shells, just like modern oysters. The shells also feature prominent growth bands. The larger, curved shell sat within the mud on the sea floor.

## Bunter Pebble



Bunter pebbles are worn pieces of rock that originally formed in mountain ranges to the south of Britain, such as Brittany in northern France. They were washed northwards into the midlands by powerful streams, 220 million years ago. Then, during the last ice age, some of the pebbles were transported back southwards by ice sheets. From the area around the edge of the ice sheets the River Thames took them as far as Reading. This pebble is included in this box to remind us of the very different climate and landscape that existed in the Reading area at the end of the last ice age - not so long ago!

## Belemnite

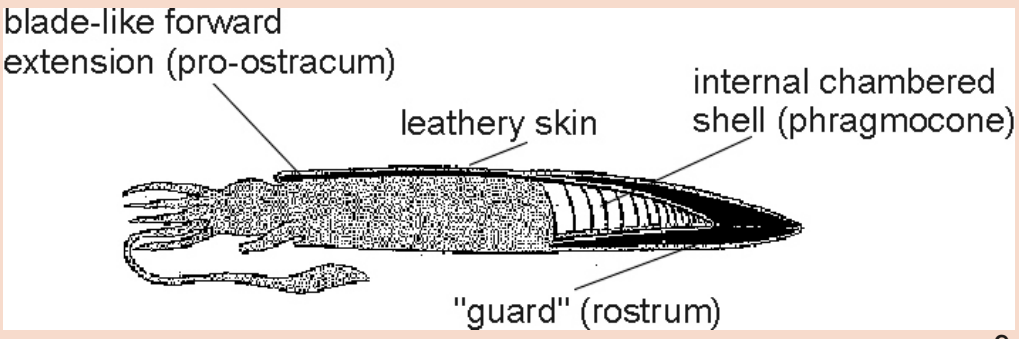


Belemnites are an extinct group of marine animals, similar in many ways to the modern squid and cuttlefish. Like them, the belemnites possessed an ink sac, but, unlike the squid, which has eight arms and two tentacles, they possessed ten arms and no tentacles. Also, unlike the modern squid, whose arms 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.



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FOSSILS X1/E

## Plesiosaur Vertebra



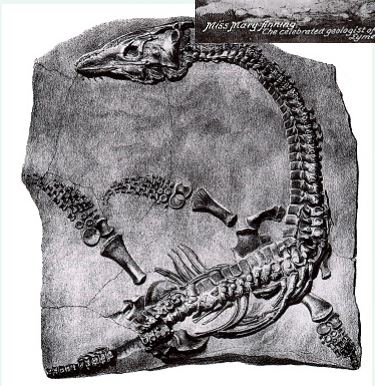
Plesiosaurs were aquatic reptiles that existed from the end of the Triassic Period 220 million years ago until the end of the Cretaceous 65 million years ago. Their remains have been found on every continent.

A typical plesiosaur had a long neck, a broad body, four large flippers and a relatively short tail. The smallest were about 2m long as adults, the largest were up to 20m long, comparable in size to sperm whales.

Occasionally stomach contents are found inside well-preserved fossil specimens. This evidence shows that some fed on belemnites and ammonites. There is also a wide range in tooth shape, showing that they were adapted to feeding on different types of prey. Long, slender teeth may have been used to rake through sea-floor sediments in the way a swan dabbles on pond bottoms. Larger, more robust teeth seem to be adapted for feeding on armoured fish and cephalopds (squid, octopuses etc.). Some of the bigger members of the family had enormous, dagger-like teeth which were probably used to attack their smaller relatives. Other specimens show bite marks from larger predatory forms.



Plesiosaurs were discovered by Mary Anning in 1821, the famous professional fossil collector from Lyme Regis, Dorset. The fossil she found was subsequently described, by William Conybeare as *Plesiosaurus dolichodeirus* and is the holotype - the defining example - of the species. Mary Anning can be seen on the right, along with the specimen she found. Specimens are still found in south-west England and in 2002 possibly the finest ever known was discovered on the coast of Somerset by someone fishing from the shore.





*Above: An illustration of what one of the many species of plesiosaur - Cryptocleidus - may have looked like.*

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### Wood Fragment

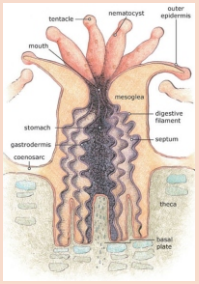
This is a good example of fossil wood formed by permineralisation.



### 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 millimetres 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.



One of these coral fragments has been polished to bring out its complex beauty. It dates from the Devonian Period. The two unpolished pieces of coral date from the Silurian Period.

### Wooly Rhinoceros Tooth

The woolly rhinoceros lived during the Neogene Period, surviving into the last ice age. It lived in northern Europe. It had a flat horn that enabled it to push aside snow in order to graze, thick fur and a layer of thick fat to keep it warm in the cold conditions it endured. Early humans painted pictures of it on cave walls, but they may also have contributed to its extinction through hunting. This tooth was found in Kent.



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### Ichthyosaur Vertebra & Tooth



Ichthyosaurs were giant marine reptiles resembling fish and dolphins. They appeared about 250 million years ago (earlier than the dinosaurs, who put in an appearance about 230 million years ago) and 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 metres 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 vertebra in this box is indented at the end, which suggests it belonged to a more fish-shaped ichthyosaur from later in their history.