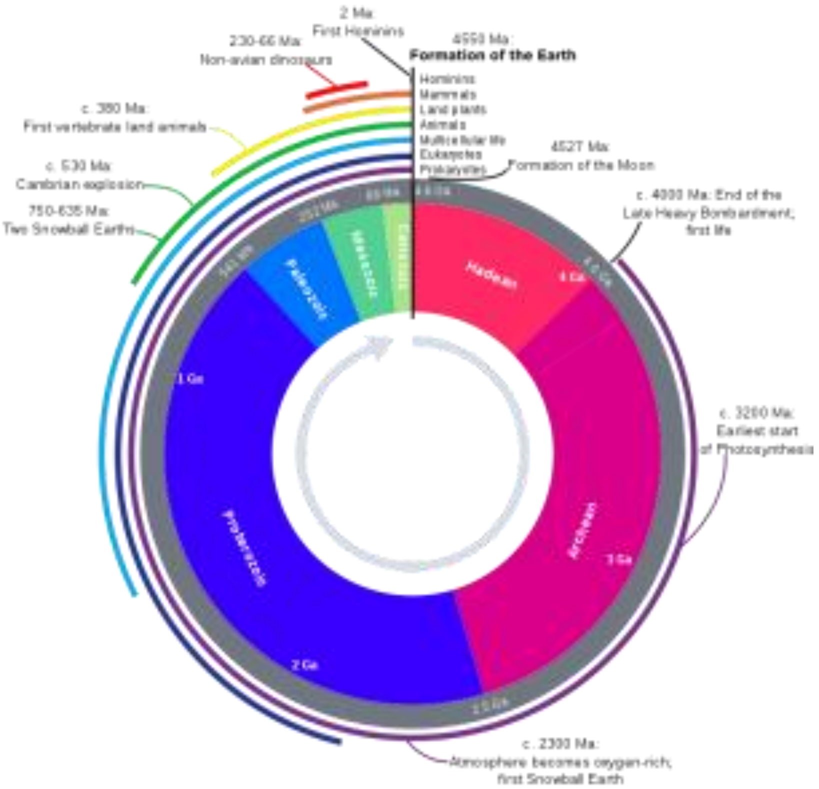
Paleontology material

Unit :I

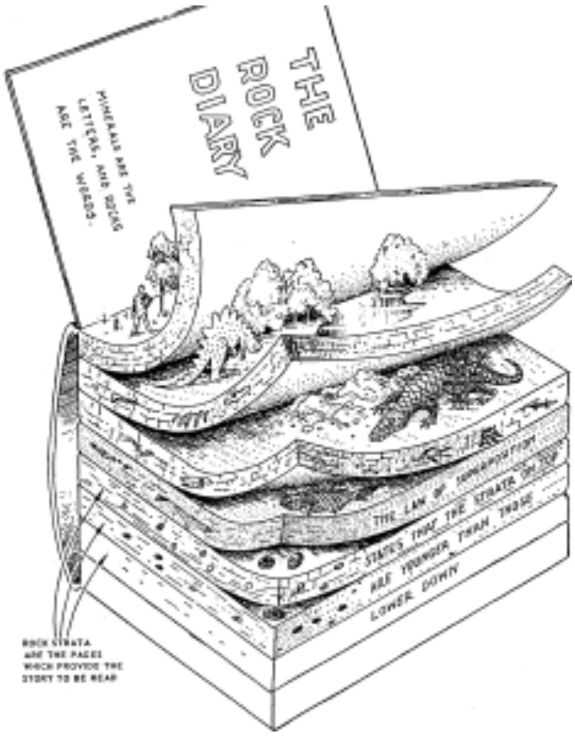
Outline of geological time

The geological time scale (GTS) is a system of chronological dating that classifies geological strata (stratigraphy) in time. It is used by geologists, paleontologists, and other Earth scientists to describe the timing and relationships of events in geologic history. The time scale was developed through the study of physical rock layers and relationships as well as the times when different organisms appeared, evolved and became extinct through the study of fossilized remains and imprints. The table of geologic time spans, presented here, agrees with the nomenclature, dates and standard color codes set forth by the International Commission on Stratigraphy (ICS).



This clock representation shows some of the major units of geological time and definitive events of Earth history. The Hadean eon represents the time before fossil record of life on Earth; its upper boundary is now regarded as 4.0 Ga (billion years ago).Other subdivisions reflect the evolution of life; the Archean and Proterozoic are both eons, the Palaeozoic, Mesozoic and Cenozoic are eras of the Phanerozoic eon. The three million year Quaternary period, the time of recognizable humans is too the time of recognizable humans, is too small to be visible at this scale.

more 'modern' group of organisms.



Fossil Evidence

The study of fossils (palaeontology),together with other geological and biological evidence, provides information on the history of Earth and the evolution of life. Fossils provide evidence about the relative ages of rock strata, palaeo environments and evolution of life.The fossil record has been used to develop the worldwide geological time-scale.Organisms may leave traces of their existence in the sediments formed during, or shortly after their lifetime.

FOSSILS are preserved remains of living organisms. (Minerals have replaced the carbon-based structure within the mould, or the organism has left an impression in the rock.) They may be preserved in rocks formed from sediments that were deposited in a wide variety of environments. TRACE FOSSILS are disruptions of sediments caused by the normal activities of animals. Examples are footprints, feeding traces, worm burrows or coprolites (fossilised faeces).

Features of the Fossil Record

Below is a list of some of the significant features of the fossil record as we know it today:

1. The oldest known fossils, of single-celled organisms, are from about 3800-3500Ma

2. Evolution proceeded very slowly at first. The oldest known fossils is multicellular organisms are the Ediacaran fauna (580 to 550 Ma) of the Flinders Ranges, South Australia.

   The first organisms with hard parts evolved during the Cambrian era, when there was a 'sudden' increase in the number and diversity of living organisms — the Cambrian Explosion

3. The rate of evolution has been ever-increasing. More organisms have evolved in the 60 million years of the Cainozoic era than in the whole of geological time before the beginning of the Cainozoic.

4. Evolution has not proceeded at a uniform rate. There have been intervalsduring which a large number of new life forms has evolved (e.g. the Cambrian Explosion), and periods of 'sudden' extinction of many life forms.

5. Life forms have evolved from the simple to more complex: from single celled organisms to humans.

   Within a group of organisms, such as ammonites, the same tendency hasbeen noted. The earliest members of the group to evolve were much simpler in form and structure than those that evolved later.

6. Increasing diversity — from a few species of single-celled organisms to the enormous variety of life on earth today.

7. Organisms have succeeded each other in a sequence that is the same in all parts of the world.

   (e.g.) Trilobite fossils are always older than ammonite fossils, no matter where these fossils are found.

Once an organism disappears from the fossil record, it never reappears in younger strata. It has gone forever! A group became which extinct, may have been replaced by another.

Definition of fossils.

A fossil is any preserved remains ,impression ,or trace of any once-living thing from a past geological age.Examples include bones ,shells ,exoskeletons ,stones imprints of animal or microbes,object preserved in amber,hair,petrified wood,oil,coal ,and DNAremnants .

Modes of preservation of fossils.

Fossils are preserved in two main ways: with and without alteration. Preservation with alteration includes carbonization, petrifaction, recrystallization and replacement. Preservation without alteration includes the use of molds and the collection of indirect evidence.

Carbonization : Carbonization often occurs in the preservation ofplants and soft organisms. The remains of the plant or animal are crushed beneath the weight of the rock. The gases, including hydrogen, nitrogen and oxygen, are off gassed through the process of heat and compression. What is left behind is a carbon film, an impression of the former living thing.

Petrifaction : Sometimes referred to as permineralization, petrifaction occurs when a porous material such as a bone or shell becomes filled with preserving material such as calcium carbonate or silica. The original shell or bone becomes buried below the ground and water penetrates the surface. The groundwater contains the calcium carbonate that fills the empty spaces in the material, which over time, hardens and fills the pores full of minerals that preserve the item.

Recrystallization : Recrystallization often occurs in shell fossils and is the process by which the small molecule crystals inside a shell often formed of one type of calcium carbonate can transform to another type of calcium carbonate. This stabilizes the shell and turns it into a fossil.

Replacement : Occurring in both shellfish and wood, replacement is when the atomic composition of the original living thing is replaced cell by cell by a new chemical structure. Typically, the chemical that replaces the original is determined by the groundwater the fossil is lying in. A common type of replacement is silification. This is when the original living remains are replaced with silica as in the case of petrified forests.

Casting : Casting and molding are an indirect way of preserving fossils. In this case, indirect means that the chemical composition of the organic matter does not change, rather it lays in a substance that makes an impression of the matter. Common examples include castings of fern leaves and snail shells.

Trace Fossils : Trace fossils are another type of indirect preservation of fossils. Examples of trace fossils are footprints and trails. Dinosaurs and other prehistoric animals moved through the undergrowth and along top soil that was later covered with other debris. In some cases their tracks were preserved and can be dug up and cut out of the ground. Another example of a trace fossil is animal dung. Preserved, fossilized dung provides fossil experts with evidence of ancient food sources and the structure of prehistoric digestive system.

Types Fossil Types

Casts and Molds : In many instances the original, organic remains of an organism are destroyed by natural processes over long periods of time. Sometimes, if the remains became encased within rock, a hole can be left in the shape of that organism. This type of fossil is called an external mold. If the hole is ever filled in by other minerals, it is called a cast. Other times, minerals can fill an internal cavity of an organism, such as a skull, and create an internal mold of that part of the organism.

Trace Fossils :A trace fossil is made in a rock by an organism during its daily activities. Trace fossils include the remains of activities such as burrowing, footprints, teeth marks, feces and cavities left by plant roots. These fossils are usually created in sandstones due to the size of the grains in the stones. These fossils act as evidence of life in the past and give a record of activity of an organism. Some trace fossils provide information as specific as the speed and weight of the organism that produced them or how wet sand was when the trace impressions were being created.

Petrification : Petrification of an organism can occur in a couple of different ways. The first of these is permineralization, a process where there is a constant flow of water through some remains that leaves minerals behind to harden within dead cells. An example of permineralization is petrified wood. The other process is called replacement. Fossils formed by replacement form when water dissolves away dead tissue and leaves minerals in its place. An example of a replacement fossil is a prehistoric seashell.

Micro-fossilization : Micro fossils are plant or animal remains that are microscopic in size, generally less than 1 millimeter in length. They may be either small organisms, such as viruses or bacteria, or small bits of larger plants or animals. They're considered to be the most important group of fossils since they are useful in dating surrounding rocks and other fossils and are the most numerous and accessible of all fossils.

<u>Uses of fossil</u>

In geology there are two main uses to which fossils are put. These are biostratigraphic correlation and environmental interpretation. Before discussing these two points, I should say that these two utilities of fossils are not necessarily those that are most interesting to a paleontologist who studies fossils. Evolutionary studies are important because of the light they shed on the mechanism of evolution and the interaction between evolution and extinction, not necessarily because evolution indirectly provides a powerful tool for matching up rocks of the same age but of different composition in widely separated areas. Deciphering ancient environments is important, but the paleontologist is concerned with the ancient communities of life that once inhabited those environments, about the interactions, competition, and predation among members of the community, and how food supplies are gathered, partitioned, and utilized by community members.

Biostratigraphic Correlation

The matching up of rocks of the same age from place to place is called correlation of the rock layers. If a particular rock layer was deposited continuously over an area, correlation can be done by physically matching the rock layer from place to place.

(For Example) the fossils I can determine which rock unit in Missouri contains the closest match of the species of fossils I have found in Indiana. This indicates that the greatest proportion of species were alive at the same time in Indiana and Missouri, and that the rock layer in Missouri that contains these fossils is very close to, or the same age, as the rock layer in Indiana. Use of fossils in this way, to determine the relative ages of rocks, is ultimately based on evolution. Through time, new species have appeared and older species have become extinct

This results in a succession of fossil types through ages of rocks. This is called faunal succession as applied to animals, or floral succession for plant fossilsIt helps if the particular group of organisms, whatever they are, is evolving rapidly. Thus, more species useful for discriminating small periods of time occur more closely spaced in the rocks

Environmental Interpretation

Suppose you find a thick layer of sandstone. You study the texture--size of the sand grains, rounding, sorting, the mineral composition of the sand grains. From all this you can determine the agent of transport, whether the sand was deposited in water, and so on. But, you now go on and ask--Was this sandstone deposited in the ocean or in fresh water? If you find fossil brachiopods, bryozoans, and echinoderms, the rock was surely deposited in the ocean. Here are some simple generalities that will aid in making environmental interpretations of fossils. You should realize that these are not 100% perfect. There are exceptions. But these rules will work about 95% of the time:

1. A rock with plant fossils (leaves, stems, etc) and with fossil bones, is almost certainly laid down on land or in fresh water. An exception is fish bones--these may be either freshwater marine, but bones of mammals, reptiles, and so on are usually preserved on dry land.

2. Any rock with lots of shells--brachiopod, snail, clam, bryozoans, sponges, corals, cephalopods, etc. was surely deposited in the oceans. We can distinguish two or three sub-environments for the marine condition.

3. Thin-shelled fossils are more common in deep water than they are in shallow water. Conversely, thick-shelled fossils are more common in shallow water than they are in deep water. Thus, in marine environments you can sometimes distinguish deep from shallow water.

4. Fossil graptolites are usually in fine-grained dark shales that were deposited in deep water.

5. Colonies of corals are typically associated with coral reefs, all of which grew in shallow water.

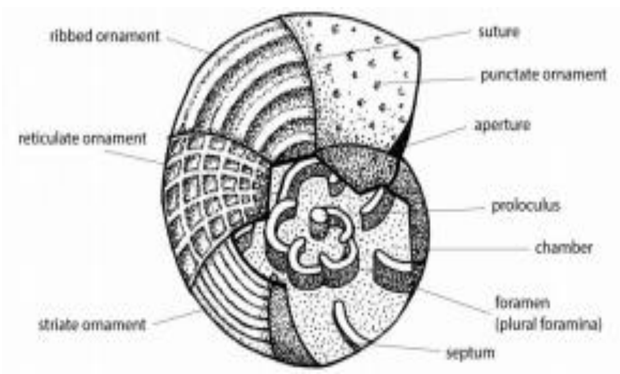
6. Algae or seaweed that lived in the oceans would be found in shallow water rocks, because these are photosynthetic and need sunlight to flourish.

Morphology and geological history of Foraminifera

Morphology:

Foraminifera are amoeba-like, single-celled protists (very simple micro-organisms). They have been called 'armoured amoebae' because they secrete a tiny shell (or test) usually between about a half and one millimetre long. They get their name from the foramen, an opening or tube that interconnects all the chambers of the test. Fossilised tests are found in sediments as old as the earlist Cambrian (about 545 million years ago) and foraminifera can still be found in abundance today,living in marine and brackish waters Cross sections of foraminiferal walls (highly magnied) showing the dierent structures). Agglutinated wall made of cemented sand grains (top left) (textulariids). Microgranular wall made of granular calcite crystals (top right) (fusulinids). Porcelaneous wall made of three layers of calcite (bottom left) (miliolids). Hyaline wall made of calcite or aragonite crystals (bottom right) (rotaliids and robertinids).

The test of allogromiids is made out of tectin a soft, exible organic material. Other foraminiferal tests are composed of organic matter, together with agglutinated particles of sand, silt or occasionally echinoid spines, radiolaria or diatoms, cemented together with calcite or silica. The tests of many foraminfera are made of aragonite or calcite, when the shell may be milky white (porcelaneous taxa), grey (microgranular taxa) or glassy (hyaline taxa).



An imaginary planispiral foraminifer with some of the dierent kinds of ornament, and broken to show the internal structure. BGS ©UKRI. All rights reserved.

Types of test: The test, which is the part that is preserved as a fossil, can take many dierent shapes.

Simple tests :The simplest is a sphere or a tube with an aperture (an opening) at on

In some types of foraminifera, the chambers are added in a spiral and take a number of forms. The simplest is a sphere or a tube with an aperture (an opening) at one end: Tubular Rhizammina (top left). Chambers may be added in a single row, like a string of beads (uniserial): Uniserial Nodosaria (bottom left). Two rows of chambers (biserial): Biserial Loxostomum (centre). Three rows (triserial): Triserial Bulimina (far right). BGS ©UKRI. All rights reserved.

Spiral tests: In some types of foraminifera, the chambers are added in a spiral and take a number of forms. Planispiral, like a Catherine wheel: Planispiral Cornuspira (left). Trochospiral, like a tiny snail: Trochospiral Asterigerinata (centre). Streptospiral, where each chamber is half a whorl: Streptospiral Quinqueloculina (right).

Complex tests :The last chamber of the test has one or more small openings (apertures). Protoplasm extrudes through the aperture to engulf the test of the living organism. That on the outside of the test makes long laments which it uses for locomotion and capturing food particles. That inside the test is where the food is ingested and where the nucleus of the cell is found. Foraminifera feed on diatoms, algae, bacteria and detritus. The proloculus is the rst chamber of the test. It is small when the foraminifera has formed by sexual reproduction, but large when reproduction has been asexual. Protoplasm is the soft, jelly-like material that forms the living cell of the foraminifera.

Geology

The most important factors that control living foraminifera are salinity and temperature, but other things like the substrate (weed, rock, silt, mud, sand, etc), the amount of light, and the amount of oxygen dissolved in the water are important. Many foraminifera that live in river estuaries and coastal waters are hyaline (e.g. Elphidium) or agglutinated types. In shelf seas, the porcelaneous species (such as Quinqueloculina) become more numerous. In the deep seas agglutinated forms predominate, mixed with the dead tests of planktonic species (e.g. Globigerina) which live near the surface of the ocean waters and rain down to the ocean oor on death.

Foraminifera that lived in the geological past were also controlled by the environment. Thus, fossils can be used to identify the conditions in which the enclosing sediments accumulated. They can be used, for example, to recognise glacial and warm episodes during the Quaternary; changes in salinity in the Cretaceous; variations in the oxygen content of the water in the Jurassic; sea level oscillations during the Carboniferous, and so on. Foraminifera from dierent geological periods as if seen down a microscope. All are between 0.5 and 1 millimetre long except the abyssal species that grow up to several centimetres.

The geologists' tool

Peneroplis pertusus, reproducing by division to form many small juveniles. These will grow to produce the next generation. Although they formed asexually, they will, in their turn, reproduce sexually; sexual and asexual reproduction alternates. Juveniles are about 0.1 mm across.

Stratigraphy: The stratigraphical range of some foraminiferal species is very short and they can be used to give a relative age to the rocks in which they are found. The rocks can be assigned to foraminifera zones, which equate with periods of time. Zones may vary in length from a few thousand to several million years. They allow correlation of geographically separate rocks. This is very important when making geological maps, exploring for oil or gas and building large civil engineering projects.

Uses of micro fossil

MICROFOSSILS are tiny remains of bacteria, protists, fungi, animals, and plants. Microfossils are a heterogeneous bunch of fossil remains studied as a single discipline because rock samples must be processed in certain ways to remove them and microscopes must be used to study them. Thus, microfossils, unlike other kinds of fossils, are not grouped according to their relationships to one another, but only because of their generally small size and methods of study. For example, fossils of bacteria, foraminifera, diatoms, very small invertebrate shells or skeletons, pollen, and tiny bones and teeth of large vertebrates, among others, can be called microfossils. But it is an unnatural grouping. Nevertheless, this utilitarian subdivision of paleontology, first recognized in 1883, is very significant in geology, paleontology, and biology.

Microfossils are perhaps the most important group of all fossils — they are extremely useful in age-dating, correlation and paleoenvironmental reconstruction, all important in the oil, mining, engineering, and environmental industries, as well as in general geology. Billions of dollars have been made on the basis of microfossil studies. Because they usually occur in huge numbers in all kinds of sedimentary rocks, they are the most abundant and most easily accessible fossils. Indeed, some very thick rock layers are made entirely of microfossils. The pyramids of Egypt are made of sedimentary rocks, for example, that consist of the shells of foraminifera, a major microfossil group.

Microfossils can also be very useful in teaching science at all levels. Students are commonly fascinated by things they cannot see with their naked eyes, especially when the objects are beautiful or interesting in their own right. Furthermore, collection of microfossils is usually possible close to many schools — in fact, some schools are built right on top of microfossil-bearing sedimentary rocks! Processing the rock samples is usually easy and safe enough for children to do themselves, or at least to watch. Prepared samples can be purchased or obtained from museums and some universities. Because so many microfossils are usually found in any sample, the students can even keep their own finds!

Phylum porifera-Sponges.

Phylum Porifera is a group of simple animals that includes the sponges. Porifera have no internal organs, nervous tissue, circulatory system, or digestive systems, making them the most primitive of the multicellular animals. To support and protect their soft bodies, sponges produce skeletons of calcium carbonate, silica, or a soft organic material called spongin. The most common fossil sponge in the Cretaceous sediments of Delaware is the genus Cliona. Cliona sponges lived on rocks and shells of the seafloor and commonly bored holes in these objects, in which it lived. To obtain food, the sponges filtered the water around them as it passed through tiny pores located on their outer walls. The sponge is common in the Mount Laurel Formation along the Canal.They're also among the oldest, with a fossil record extending back to the last part of the Precambrian, (about 550 million years ago. Sponge fossils occur in rocks all over the world. In Kansas, fossil sponges can be found in the Pennsylvanian and Permian rocks in the eastern part of the state.

Unlike most larger multicellular animals, sponges lack tissues, organs, and respiratory or circulatory systems. Instead, they rely on specialized cells to perform the different functions necessary for survival. Some cells, for example, equipped with flexible tails, or flagella, create one-directional currents that draw nutrient- and oxygen-bearing water into the sponge and help eliminate waste products. Other cells perform tasks associated with support, reproduction, or protection.

This Pennsylvanian sponge, belonging to the genus

Maeandrostia, is an example of a branching form; note also the raised pores on the surface of the branches. These fossils were collected from the Hickory Creek Shale Member of the Plattsburg Limestone in Wilson County.

.

Sponges come in many different colors, shapes, and sizes. Some sponges have irregular shapes, or look like encrusting sheets, while others take the form of mounds, or tubes, or even a series of spheres reminiscent of beads on a necklace. They range in size from 1 cm to more than 2 meters. Many of the differences in size and shape are due to environmental factors, such as temperature, salinity, turbulence, and the amount of sediment in the water. This means that members of a single sponge species may look very different from each oth sponges have a long fossil record, they are not common fossils. This is partly due to their relatively delicate skeletons and to the low-sediment environments that ancient sponges seemed to prefer (which precluded the quick burial necessary for preservation). Most fossil sponges are known solely from mineralized spicules and are differentiated by the chemical composition of these spicules. Sponges are relatively inconspicuous fossils in the Pennsylvanian and Permian rocks of eastern Kansas: for example, chaetetid sponges are found in Labette, Crawford, Bourbon, and Neosho counties. They are, however, locally common in the Pennsylvanian Hickory Creek Shale Member of the Plattsburg Limestone in Wilson County and the Hartford Limestone Member of the Topeka Limestone, in Greenwood County.

Phylum Brachiopoda

Morphology

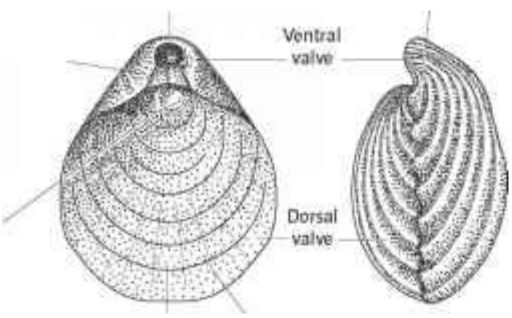
Brachiopod shells grow by accretion. Mineralized material is secreted from the mantle lining the shell. Linguliforms are phosphatic, and craniiforms and rhynchonelliforms are calcareous. In the latter group the shell is multilayered and may have thin, tubular structures perpendicular to the layering. These are called punctae and are a useful diagnostic feature of brachiopods in thin section. Key aspects of the brachiopod external morphology are shell shape, shell sculpture, and the form of hinge area

Brachiopod shape is determined by the curvature of the valves. In order to accommodate the soft parts, at least one valve is always convex (has a rounded shape in cross-section). Both valves may be convex (biconvex) and the degree of roundness may be the same or unequal. Alternatively, one valve may be flat or concave (curves inwards), producing variations in the shell profile. Brachiopods commonly have an exterior surface texture. This may be in the form of ribs radiating from the beak, growth lines, or wrinkles.

The line of closure of the valves (commissure) may be straight or corrugated. It may also have a deep medial depression (sulcus) and a corresponding elevation (fold). The hinge area is very important in brachiopod classification. The hinge line may be straight (strophic) or curved (astrophic). The pointed extremity marking the start of valve growth is known as the beak and each valve has one. The area between the beak and the hinge line is known as the interarea. This may be flat or curved. In some brachiopods the beak is more prominent and curves over. In this case the posterior extremity is called the umbo.

The hole for the pedicle is called the pedicle foramen. It is sometimes closed by a single plate (deltidium) or plates (deltidial plates). Rather than a rounded hole, in some brachiopods the opening for the pedicle is more of a notch (delthyrium). This gap may be extended to the dorsal valve (notothyrium) to enlarge the opening.

In epifaunal brachiopods, as well as protection, the main functions of the shell are to guide the food-bearing water into the mantle cavity, to limit the contamination of these nutrient-rich currents by expelled waste-bearing water, and to prevent sediment from entering the shell through the open valves. In most brachiopods the incoming feeding currents and discharged waste water are drawn in and expelled through separate parts of the shell. Specific flow patterns occur in brachiopods depending on the shell shape and orientation of the lophophore. The development of a central fold and sulcus in the brachiopod shell may have helped separate the incoming currents from the discharged waters, reducing the risk of refiltration of the exhalent water Another modification seen in brachiopod shells is the development of a crenulated, or zig-zag, commissure. With the valves open this has the effect of increasing the length of the gape, without over-opening the shell and allowing larger particles of unwanted suspended sediment to enter the mantle cavity.



Brachiopod external morphology: (a) astrophic, and (b) strophic.

Classification

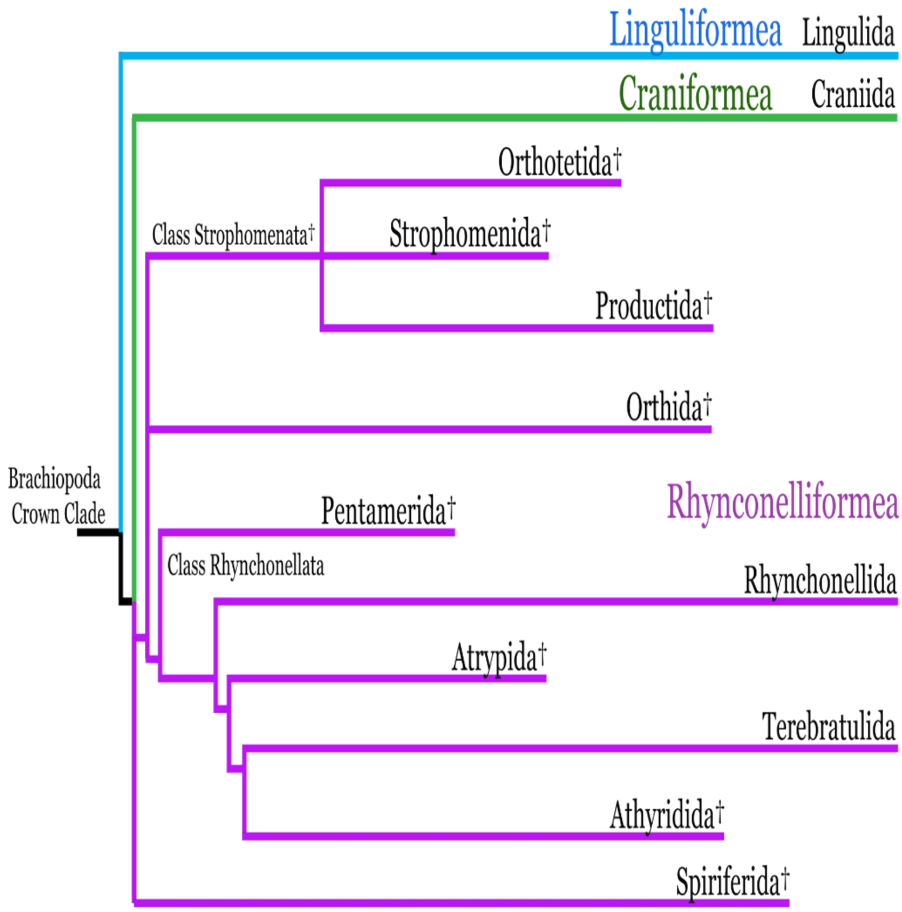
With very few living representatives, brachiopod classification has primarily come from a paleontological perspective, with substantial consideration given to the morphology of the shell. Traditionally, brachiopods have been separated into two major groups: the **Inarticulates** (brachiopods with phosphatic shells) and **Articulates** (everything else). However, recent advances in molecular phylogenetics has forced researchers to revamp their classification scheme, which now recognizes three subphyla of Brachipoda: **Linguliformea**, **Rhynchonelliformea**, and **Craniiformea**.

classification: inarticulates vs. articulates

Inarticulates: shells lack defined hinges and are made of calcium phosphate (phosphatic). Example: Order Lingulida.
Articlulates: shells with articulated hinges (with teeth and sockets) and made of calcium carbonate. Examples: all brachiopods other than Lingulida.

Modern classification: Subphyla Linguliformea, Rhynchonelliformea, and Craniiformea

Linguliformea: organo-phosphatic shells, no teeth or sockets along hinge, pedicle present. Examples: Order Lingulida.
Craniiformea: calcium carbonate shells, no teeth or sockets along hinge, pedicle absent. Examples: Order Craniida.
Rhynchonelliformea: calcium carbonate shells, both teeth and sockets along hinge, pedicle sometimes present. Examples: Order Strophomenida, Rhynchonellida, Spiriferida etc.

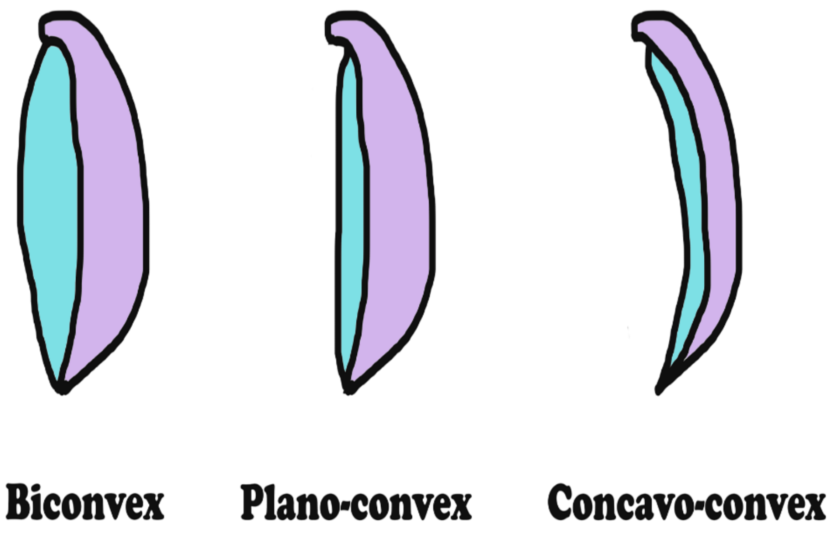


P

Important Classification Terms

Brachiopods come in all shapes and sizes. Here are a few common shapes:

- **Biconvex:** both valves are rounded (convex)
- **Plano-convex:** brachial valve is flat, while the pedicle valve is rounded (convex)
- **Concavo-convex:** both valves are cup-shaped and the brachial valve fits inside the pedicle valve



Schematic of brachiopod shell shapes. Blue represents the brachial valve while purple represents the pedicle valve.

Geological and stratigraphic importance

Brachiopods have a very long history of life on Earth (at least 550 million years). They first appear as fossils in rocks of earliest Cambrian age, and their descendants survive, albeit relatively rarely, in today's oceans and seas. They were particularly abundant during Palaeozoic times (248 to 545 million years ago), and are often the most common fossils in rocks of that age.

Brachiopods vary considerably in size. The aptly named Carboniferous genus *Gigantoproductus* may grow up to 30 centimetres across. In contrast, the Jurassic rhynchonellid genus *Nannirhynchia* is minute, generally only two or three millimetres across, or the size of a large pin head.Brachiopods are marine animals belonging to their own phylum of the animal kingdom, Brachiopoda. Although relatively rare, modern brachiopods occupy a variety of sea-bed habitats ranging from the tropics to the cold waters of the Arctic and, especially, the Antarctic.

Brachiopods are virtually defenceless and their shell, enclosing the animal's organs, is the only protection against predators. Most are permanently attached by a fleshy stalk (the pedicle) to a hard, sea-floor surface, and are incapable of actively pursuing food. A few species can attach themselves directly to soft sediment and others remain unattached. Opening and closing of the shell allows food-bearing currents of water to pass through it.

The shell comprises two valves that are composed of calcite or chitinophosphate (calcium phosphate plus organic matter). The pedicle (or ventral) valve is typically externally convex. The other valve (the brachial or dorsal valve) may be similar but, in some brachiopods, it is extremely concave or more rarely conical.
Brachiopods are characteristic of shallow marine environments, and in some Palaeozoic rocks they are the main rock-forming component. Brachiopods are also particularly suitable for palaeoecological analyses. Influenced by such factors as water depth, salinity, oxygen levels and static lifestyle, the distribution patterns of fossil brachiopods provide a useful tool in deducing the position of ancient shorelines and the past distribution of land and sea. Through the rapid evolution of some brachiopod lineages, they can be useful for understanding the relative ages of rock successions, and for correlation.
Cambrian rocks characteristically contain a diverse and abundant brachiopod fauna that preludes a dramatic diversification, making brachiopods, together with trilobites, the primary stratigraphical guide fossils in the shallow-water facies of the Ordovician They are also important in the Silurian and Devonian, and more locally in. the Carboniferous, but many major groups became extinct at the end of the Palaeozoic.The main divisions of Earth history in which brachiopods have lived, showing the relative diversity of the phylum through time. Maximum diversity is seen in the Devonian. BGS ©UKRI. All rights reserved.The genus *Lingula* has survived virtually unchanged from the Cambrian to the present day. Unlike most brachiopods, it lives successfully in brackish water environments such as tidal mud flats. *Lingula* uses its pedicle to move up and down in the vertical burrow in which it lives. The pedicles of *Lingula* are a delicacy in some Asian countries, and are known as 'lamp shells'.

References

- **www.britannica.com..>fossils and geological time**
- **Digitalatlas.cose.ISU.edu>geo>basics>fossil**
- **Course.lumenlearning.com>earthscience>chapter>fossil**
- **www.britannica.com>animal>sponge**
- **Ucmp.berkeley.edu>foram>forammm**
- **www.bgs.ac.uk>...>fossil and geological time**
- **Ucmp.berkeley.edu>fosrec>lippsi**
- **Manoa.hawali.edu>biological>invertrbrates>phylum.p**
- **www.fossils.facts and finds.com>brachia**
- **www.ncbi.nim.nih>pmc>articles>pmc4**