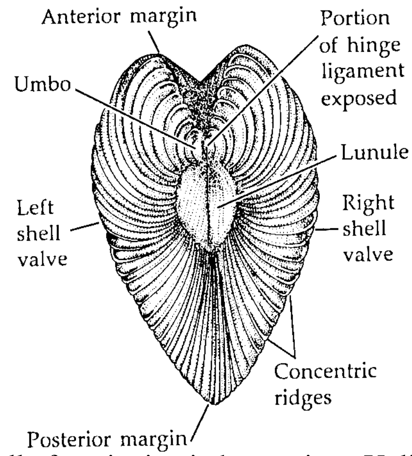
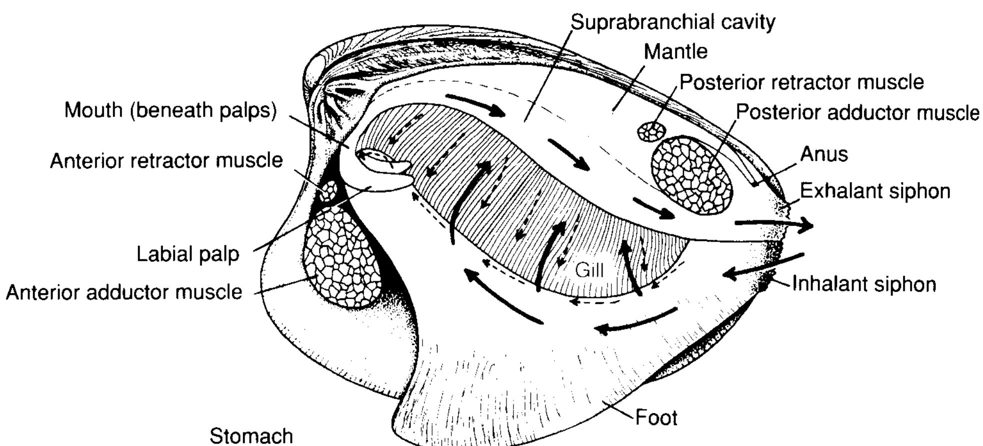
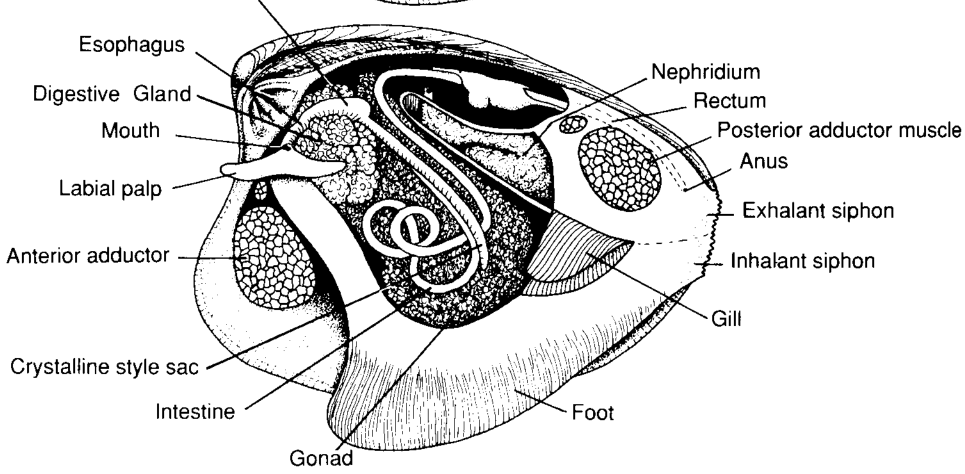
CLASS BIVALVIA (BIVALVES)
GEOLOGICAL AGE RANGE: CAMBRIAN-RECENT

Bivales are molluscs in which the body is completely enclosed by a calcareous shell composed of two valves (**right** and **left** valves). At one end, the two valves are attached by an elastic **ligament**. The **umbo** is the point of maximum curvature of the valve and is close to the incurved apex or **beak**. The beak is closest to the **anterior** end of the shell and the opposite end is **posterior**. Bivalves grow by accretion and usually display fine growth lines. Additional types of shell sculpture may include coarse **concentric ridges** and **ribs**. Bivalves are bilaterally symmetrical but, unlike the superficially similar brachiopods, the plane of symmetry passes **between** the valves, rather than through the valves.



The head is reduced to a **mouth** and the **foot** is well-developed, typically functioning in burrowing. Unlike most of molluscan groups, the radula is absent. As in other molluscs, the shell is lined by the **mantle** and there is a cavity at one end, the **mantle cavity**, which houses the gills. The majority of bivalves are suspension feeders and the **gills** are modified into feeding structures (they also retain their respiratory function). The gills possess tracts of cilia. Some cilia set up currents in and out of the shell (through tubular structures termed **siphons**), whereas other tracts of cilia are responsible for trapping food (typically with the aid of mucus) and transporting it towards the mouth via flap-like structures termed **palps** (in the diagram below, the solid black arrows show the path of the water over the gills and the dashed arrows show the direction of food transport). A structure called the **crystalline style**, housed in a tubular sac behind the stomach plays an important role in getting food particles to the stomach. Cilia lining the style sac rotate the style, which reels food-laden mucus through the esophagus and into the stomach. The **adductor muscles** are used to close the shell (usually 2 are present [**dimyarian** condition] but in some groups there is a only a single adductor) and the **retractor muscles** run between the foot and the shell (important in burrowing).

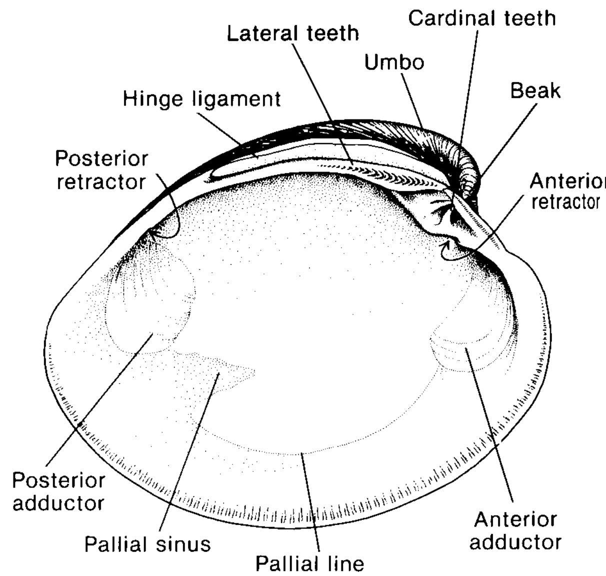




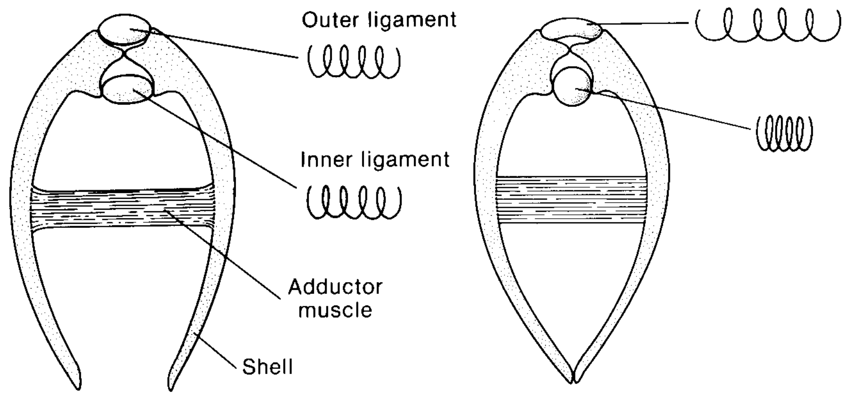
Internal anatomy of a bivalve. The upper diagram shows a typical bivalve with one valve and the mantle removed. The lower diagram shows a partial dissection.

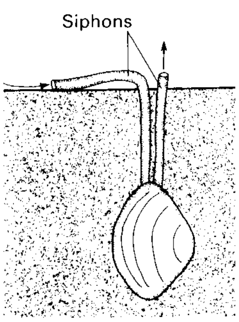
The adductor muscles usually leave well-developed muscle scars on the interior of the shell. In cases where there are two adductors, there maybe a fine line running between them (**pallial line**), which marks the attachment point of the mantle to the shell. An embayment in the pallial line (**pallial sinus**) may be present and marks the attachment point of the muscles used to withdraw the siphons into the shell. The pallial sinus is associated with the long siphons of deep burrowing bivalves. In the beak region are interlocking calcareous **teeth** and **sockets** that prevent lateral motion of the shell. **Cardinal teeth** are present below the beak with **lateral teeth** off to the side; size, shape and number of cardinal and lateral teeth varies considerably between various species of bivalve.

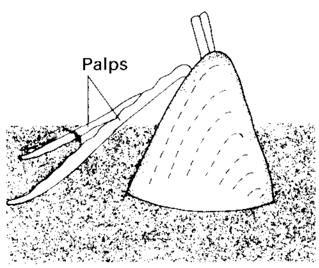
Right diagram: Interior of a typical bivalve shell

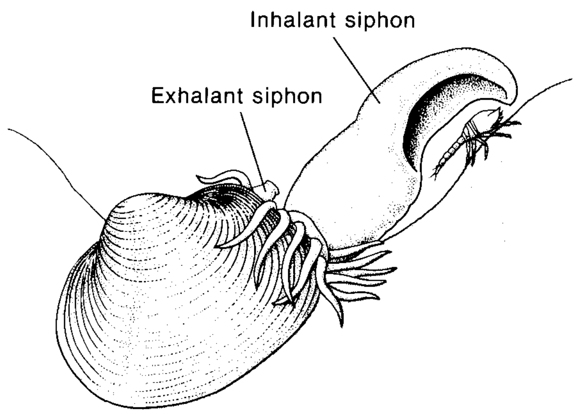


Cross sections through a bivalve showing the opening and closing of the shell by the action of the adductors and ligament. The adductor muscles **contract** to **close** the shell; the inner ligament is **compressed** and the outer ligament is **stretched**. When the adductors relax, the natural elasticity of the ligament slowly springs the valves apart to allow water in and out of the shell.



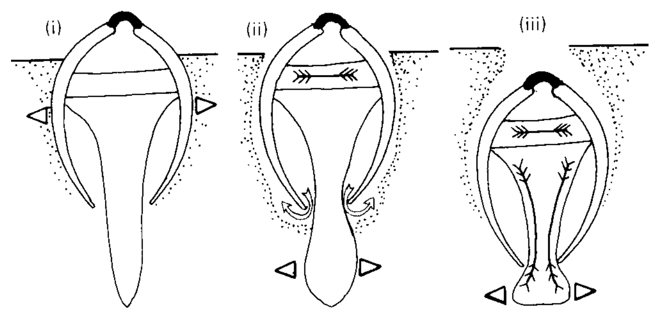


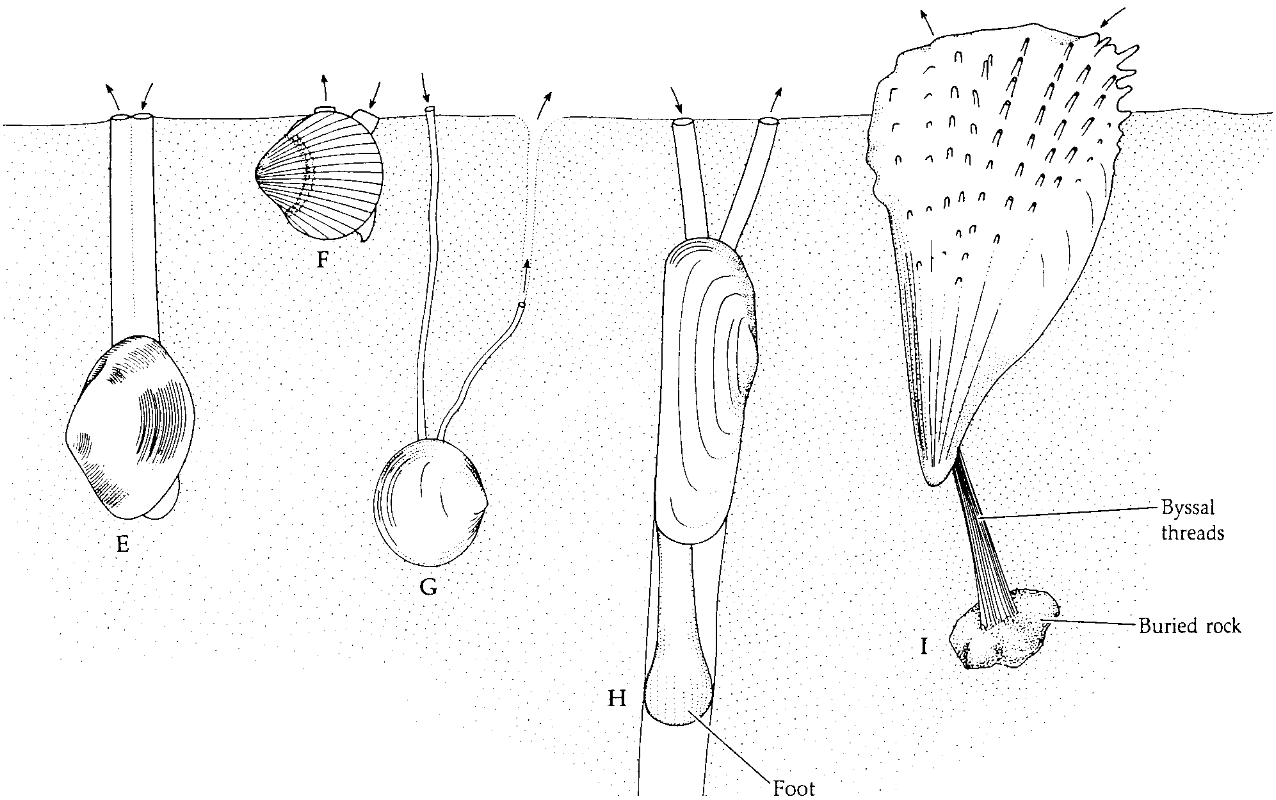




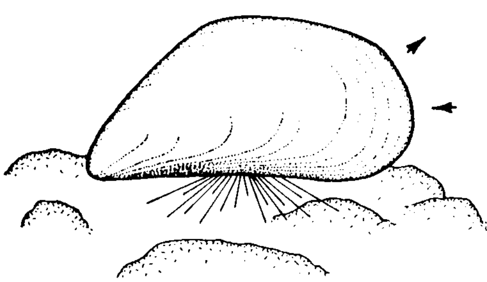
Although the majority of bivalves are suspension feeders, some groups are deposit feeders, ingesting sediment either through the inhalent siphon (above left) or with tentacles associated with the palps (above centre). A few living species are carnivores or scavengers. In one species (above right), vibrations of small moving animals, such as crustaceans, are detected with tentacles associated with the siphons. The greatly enlarged inhalent siphon is everted as a hood-like trap over the prey, which is then sucked into the mantle cavity by the inhalent water current. The prey is then siezed by the palps and transported to the mouth.

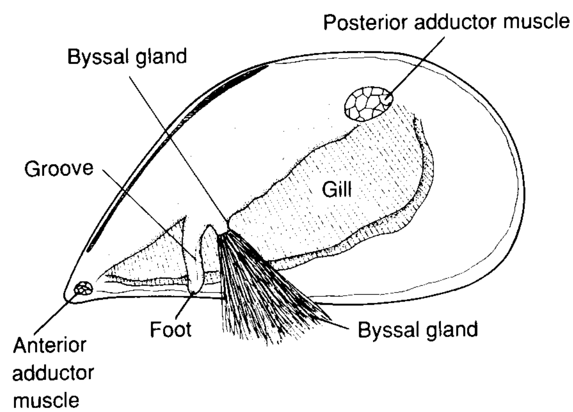
Most modern bivales are burrowers. (i) The shell gapes open and forms an anchor (if coarse concentric ribs are present, they help the shell grip the sediment) as the foot is extended down into the sediment. (ii), (iii). The tip of the foot is expanded by an influx of blood and, at the same tip the adductors close the shell, pumping water out of the mantle cavity and into the sediment (this helps to loosen the sediment). The rectractor muscle then contract, pulling the shell down into the sediment. This 3-step process is repeated until the animal reaches its normal living depth.





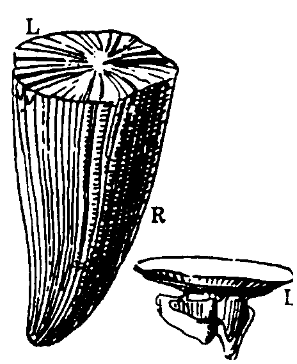
Examples of burrowing bivalves: E, deep burrower with long, fused siphons (pallial sinus usually **well-developed** and valves may **gape** open permanently at the posterior end of the shell); F, shallow burrower with short siphons (this type **lack** a pallial sinus); G, deep burrower with long, separated siphons (pallial sinus usually **well-developed**); H, The razor clam lives in unstable sands and maintains a burrow into which it can rapidly escape; I, some species live partly buried and are attached to buried objects by organic threads of the byssus.

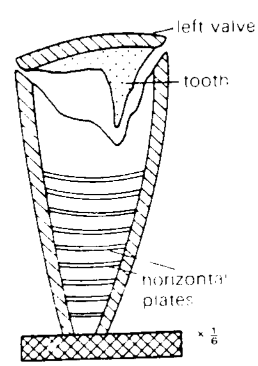




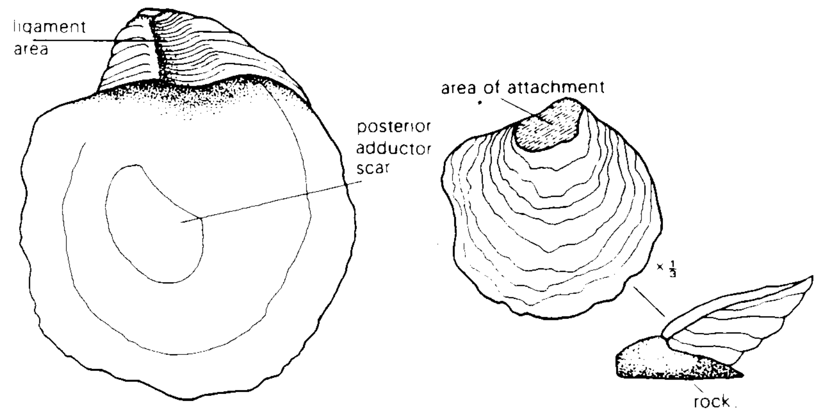
Some species, such as the common mussel, live attached to rock surfaces by organic threads termed the **byssus** which are produced by a gland in the foot. Not surprisingly, the foot becomes reduced in these and other attached forms.

Rudists were a group of bivalves of Cretaceous age that possessed a **tall, conical right valve** and a **small, lid-like left valve**. They were gregarious and actually formed organic **reefs** (i.e had a similar ecological role to that of hermatypic corals in modern shallow marine ecosystems).





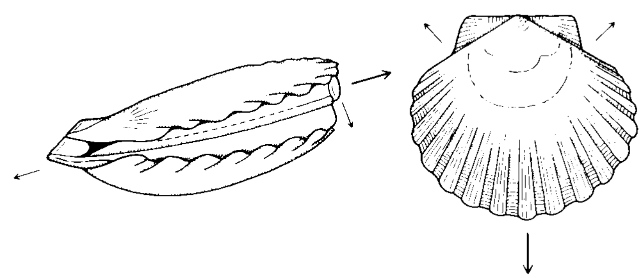
Modern oysters live **cemented** on to hard substrates such as rock surfaces (below left). There is commonly a distinct scar on the shell which marks the attachment point to the substrate. One group of Mesozoic oysters developed **epifaunal free-lying** habits on soft sediment substrates. The left valve is **strongly curved** and the right valve forms a "**lid**". Stability is enhanced by thickening of the left valve. Free-lying oysters of this type are extinct. All oysters typically possess only a single adductor muscle (**monomyarian** condition); hinge teeth are rudimentary or absent, but there is normally a well-defined depression in the hinge area that housed the ligament.



Modern cemented oyster

Free-lying epifaunal oyster

Scallops are among the few groups of modern bivalves that have an epifaunal, free-lying living position. Some modern scallops have developed a mode of "**swimming**" as a means of avoiding predators. The valves are "clapped" together by rapidly contracting the adductors. Water is expelled from the mantle cavity, producing a crude jet propulsion. In this way, scallops can avoid slow-moving predators such as star-fishes by "swimming" a metre or two.



Some species have developed the ability to **bore** their way into rock or even wood substrates for additional protection. Boring is accomplished either mechanically or, in some cases, chemically (by producing acidic secretions which dissolve calcium carbonate). The foot is usually reduced in size as is, in some cases, the shell.