Lecture 2

PHYLUM MOLLUSCA

The molluscs rival the arthropods in their diversity of body forms and sizes, as well as their ecological success. The phylum also provides some of the most familiar animals, such as snails , clams , mussels , squids , and octopus (which, like the arthropods , are well known because they're good to eat). The phylum Mollusca also includes lesser known forms such as the chitons , tusk shells, solenogasters , among others. Approximately 50,000 species of Molluscs have been described, and because of the shelled forms they have left a rich fossil record. However, the earliest molluscs probably arose in the Precambrian , and nothing is known about what they were like.

Systematic summary for the phylum Mollusca :

- **Class Pelecypoda (=Bivalvia: clams, mussels, oysters, scallops)**
- **Class Gastropoda (snails, sea slugs)**
- **Class Cephalopoda (squids, octopus, nautilus, cuttlefish)**
- **Class Aplacophora**
- **Class Monoplacophora**
- **Class Polyplacophora (chitons)**
- **Class Scaphopoda (tusk shells)**
- **Class Caudofoveata**

PHYLUM MOLLUSCA (clams, oysters, snails, slugs, *Nautilus*, squid, octopus, cuttlefish)

Name: Mollusca means "soft bodied".
Chief characteristics: Soft body enclosed within a calcium carbonate shell (a few, like slugs, have no shell).
Geologic range: Cambrian to Recent.
Mode of life: Marine, freshwater, or terrestrial. Some swim, some float or drift, some burrow into mud or sand, some bore into wood or rock, some attach themselves to rocks, and some crawl.

A. CLASS BIVALVIA [or PELECYPODA] (clams, oysters, scallops, mussels, rudists)

Name: Bivalvia means "two" (bi) + "shells" (valvia).
Chief characteristics: Skeleton consists of two calcareous valves connected by a hinge. Bilateral symmetry; plane of symmetry passes between the two valves.
Geologic range: Early Cambrian to Recent
Mode of life: Marine and freshwater. Many species are infaunal burrowers or borers, and others are epifaunal.

A


B

C

A-C = Bivalves or pelecypods.
B = *Arca*. This shell has a circular, countersunk hole, drilled by a predatory gastropod.
C = *Chesapecten*. Miocene. Chesapeake Bay, Maryland. The circular markings on the upper left are barnacle scars.

B. CLASS GASTROPODA (snails and slugs)

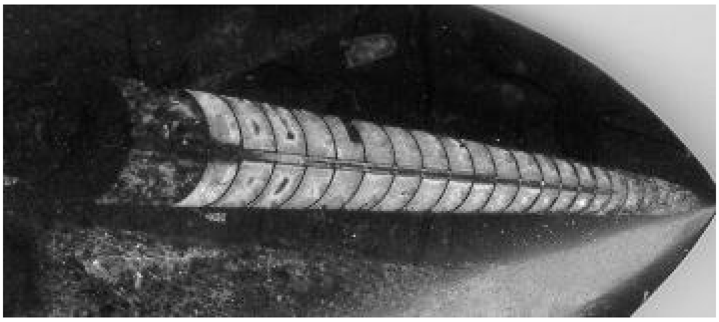
Name: Gastropod means "stomach" (gastro) + "foot" (pod).
Chief characteristics: Asymmetrical, spiral-coiled calcareous shell.
Geologic range: Early Cambrian to Recent.
Mode of life: Marine, freshwater or terestrial.

C. CLASS CEPHALOPODA (squid, octopus, Nautilus, cuttlefish)

Name: Cephalopod means "head" (kephale) + "foot" (pod).
Chief characteristics: Symmetrical cone-shaped shell with internal partitions called septae (singular = septum). Shell may be straight or coiled in a spiral which lies in a plane. Smooth or contorted sutures visible on the outside of some fossils mark the place where septae join the outer shell.
Geologic range: Late Cambrian to Recent.
Mode of life: Marine only; carnivorous (meat-eating) swimmers.

1. ORDER NAUTILOIDEA

Nautiloid cephalopods have smoothly curved septa, which produce simple, straight sutures.
Geologic range: Cambrian to Recent.



Nautiloids. Model of living *Nautilus*, shell of modern *Nautilus* cut to show septae, and fossil of a straight-cone nautiloid.

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2. ORDER AMMONOIDEA

Ammonoid cephalopods have complex, wrinkled septa, which produce angular or wrinkled sutures. Fossil ammonoids may be found in the floor tiles in the Fernbank Museum of Natural History in Atlanta.
Geologic range: Devonian to Cretaceous - all extinct.

There are three basic types of sutures in ammonoid shells:

- **Goniatite** (relatively simple undulations),
- **Ceratite** (smooth "hills" alternating with saw-toothed "valleys"),
- **Ammonite** (complexly branching and tree-like)



Ammonoids

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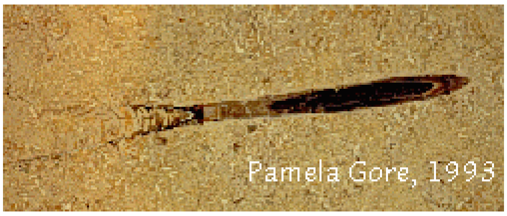
3. ORDER BELEMNOIDEA (belemnites)

The belemnoids have an internal calcareous shell (which resembles a cigar in size, shape, and color) called a rostrum. The front part of this shell is chambered, as in the nautiloids and ammonoids. The rostrum is made of fibrous calcite, arranged in concentric layers. These fossils may be easily seen in the floor tiles at the Fernbank Museum of Natural History in Atlanta.
Geologic range: Mississippian to Eocene - all extinct.



Fossil belemnoid, Jurassic Solnhofen Formation, Bavaria, Germany.

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4. ORDER SEPIOIDEA (cuttlefishes)
Geologic range: Jurassic to Recent

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5. ORDER TEUTHOIDEA (squids)
Geologic range: Jurassic to Recent

Fossil squid, *Acanthoteuthis* sp., Lower Jurassic (145-140 my), Germany.

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6. ORDER OCTOPODA (octopi)
Geologic range: ?

D. CLASS SCAPHOPODA (tusk shells)
Chief characteristics: Curved tubular shells open at both ends.
Geologic range: Ordovician to Recent.
Mode of life: Marine.
Dentalium is a common genus.


Scaphopods, *Dentalium sexangulare*, Pliocene, Piacenzia Blue Clay, Castellarquato, Italy.

E. CLASS MONOPLACOPHORA

Name: Monoplacophora means "one plate".
Chief characteristics: Cap-shaped shell. Animal is segmented and bilaterally symmetrical.
Geologic range: Cambrian to Recent. Fairly common in certain lower Paleozoic strata; not known after Devonian until the Recent. *Neopilinia*, dredged from deep water near Central America, is one of the best examples of a "living fossil".
Mode of life: Marine.

F. CLASS POLYPLACOPHORA or CLASS AMPHINEURA (chitons or amphineurans)
Name: Polyplacophora means "many plates".
Chief characteristics: Shell consists of eight separate calcareous plates.
Geologic range: Cambrian to Recent. Rare in fossil record; represented only by isolated plates.
Mode of life: Marine. Live on rocks or hard substrate in the surf zone.

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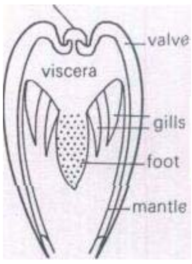
CLASS **BIVALVIA**

Morphology

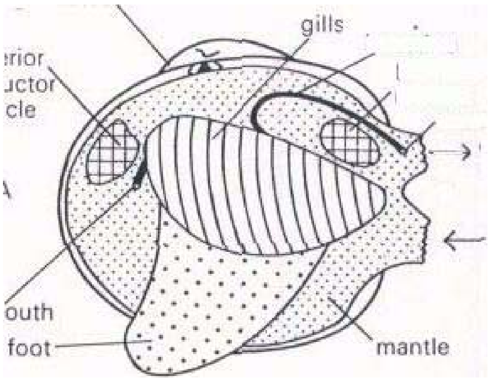
Usually the bivalve shell completely encloses the soft body. The shell, consisting of two valves united by an elastic ligament, is secreted by the mantle; this is a fleshy tissue which hangs down as two folds, one on the right side of the body, and one on the left. The valves are described as RIGHT and LEFT. They are united on the DORSAL surface of the body by the LIGAMENT and they separate along the other margins, these are distinguished as the ANTERIOR (where the mouth is

DORSAL

ligament



right valve



mtestine
posterior adductor
muscle anus _) exhalant
siphon P
inhalant siphon

VENTRAL

15 Morphology of the bivalves.

a, simplified diagram of a bivalve shell with the left valve and the left flap of the mantle removed. A, anterior; P, posterior, b, simplified section through a shell transverse to the plane of symmetry.

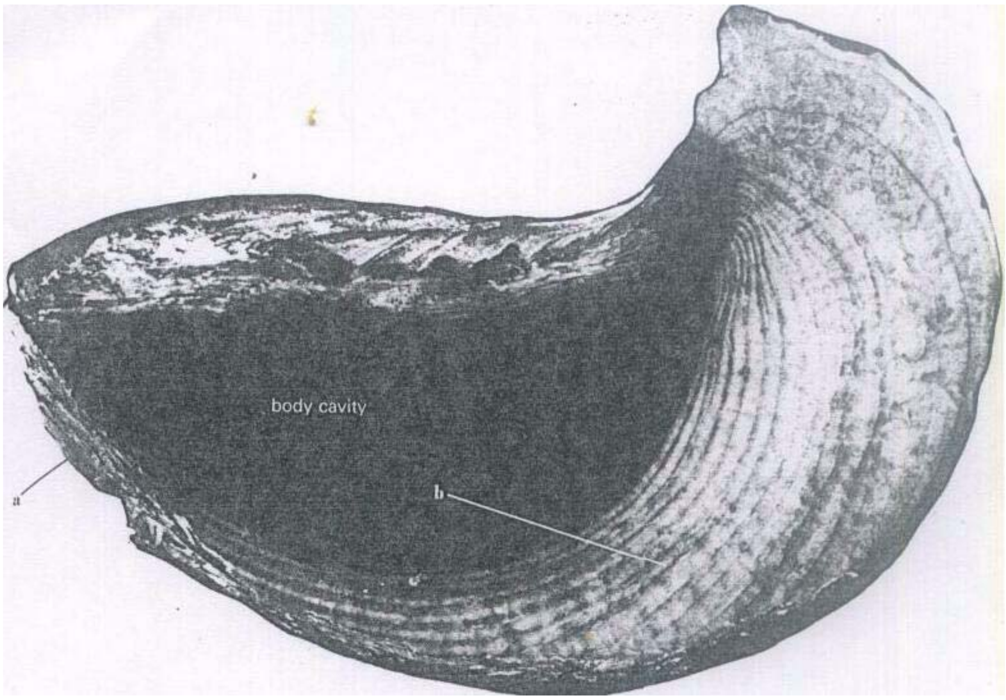
situated), the VENTRAL (opposite the dorsal), and the POSTERIOR (where the anus opens).

SOFT PARTS. The main mass of the body, including the viscera and organs such as the heart, lies in the dorsal part of the shell (fig. *15*). The foot, lying between the mantle lobes on the ventral side of the body, is a muscular organ which can be extended outside the shell and by alternately lengthening and contracting can pull the shell through soft sediment. Also within

the mantle cavity lie the gills. Typically these function not merely as a respiratory organ, but also as a mechanism to collect food. On the surface of the gills are tiny cilia (filaments) which by beating backwards and forwards cause a current of water to pass through the mantle cavity. Incoming water is separated from the outgoing water because the mantle margins, which may be fused locally, open posteriorly at two points to form two SIPHONS. The current of water enters via the lower, the INHALANT siphon and particles of food (microscopic plants and animals) are sieved out by the gills and passed forwards in strings of mucus to the mouth at the anterior end. The outgoing current with waste products is passed out through the EXHALANT siphon.

SHELL. The substance of the shell is partly calcareous, partly organic (conchiolin, a proteinaceous material); a thin section shows it to consist of three layers (fig. 18e). On the outside is a thin horny layer, the PERIOSTRACUM. The inner layers consist of crystals of either calcite or aragonite, or both. Their structure varies in different bivalves. A common structure found in the middle layer consists of prisms lying transverse to the periostracum. The innermost layer in many shells is made of NACRE, otherwise known as mother-of-pearl. Nacre is made of alternate, very thin lamellae of aragonite and conchiolin lying parallel to the outer layers. A structure seen in many other shells consists of lath-shaped lamellae arranged in a regular alternating series, these shells have a dull porcellanous appearance. The outer two layers are secreted by the edge of the mantle; the innermost layer is laid down by the whole surface of the mantle and continues to grow during the life of the animal so that it may be quite thick compared with the outer two layers (fig. 16).

The soft parts affect the form of the shell to a minor extent only and while the shell itself may vary in shape it shows few structures. The apex of each valve, the UMBO, is on the dorsal side and typically lies in front of the ligament (fig.18). The umbones represent the earliest parts of the shell and, as the animal grows, additional increments of shell are laid down by the mantle and these are visible on the outer surface as concentric lines of growth (fig.18). While the surface of most bivalve



16 Section of a **bivalve** shell. a, the outer, relatively thin layer of shell secreted during growth by the edge of the mantle;
b, the inner, thick layer of shell laid down as a series of laminae by the whole surface of the mantle. *Gryphaea*^ Lower Jurassic (X 2).

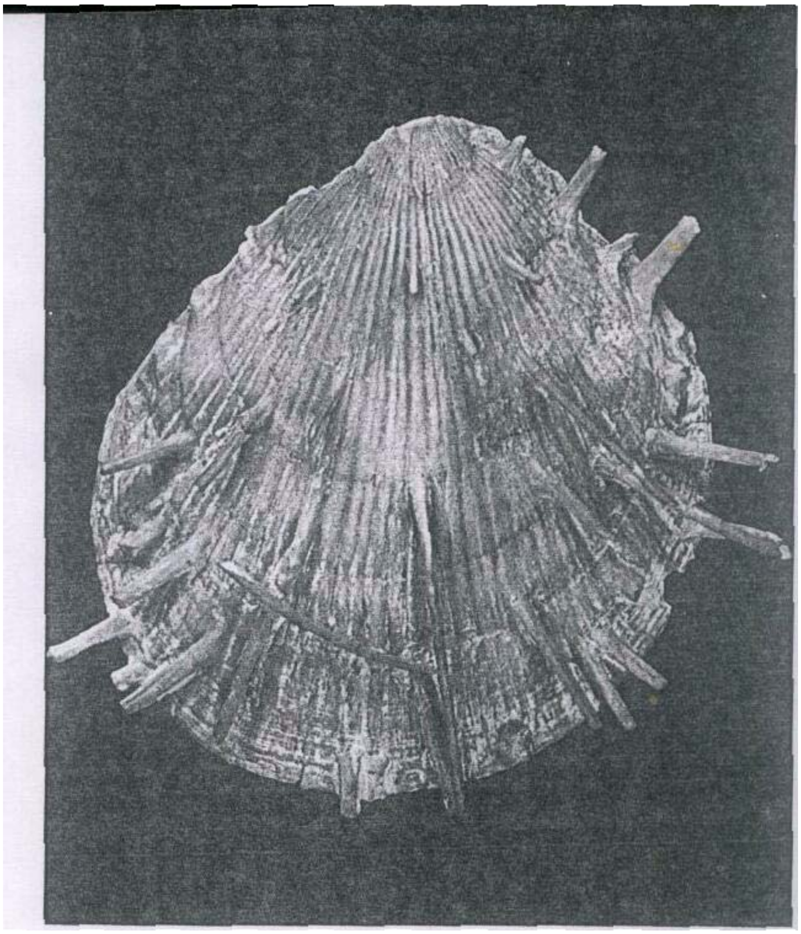
shells is relatively smooth apart from the fine lines of growth, in many there is an ORNAMENT consisting of radial or concentric markings or a combination of these. Concentric markings vary from fine growth lines to quite coarse lamellae of regular or sometimes quite irregular appearance. Radial ornament varies from fine lines to coarse ribs and grooves. Sometimes the radial and concentric elements are combined to produce a reticulate pattern; occasionally spines or tubercles are present (fig. 17).

On the INNER surface of the valves is the HINGE PLATE which is a thickening of the dorsal margin just below the umbo (fig. l8a). On each plate are projections, TEETH, which fit into SOCKETS in the opposite hinge plate. The teeth under the umbo are the CARDINAL teeth and those beyond it are the LATERAL teeth. The teeth and sockets together

make up the DENTITION and form a simple mechanism which guides the valves to their correct positions relative to one another as they open and shut.

The remaining feature of the hinge apparatus is the LIGAMENT which consists of resilient conchiolin. It is dorsal in position and it may be EXTERNAL, lying above the hinge plate, or INTERNAL lying between the hinge plates. In general, an external ligament lies behind the umbo, a condition described as OPISTHODETIC (fig.18); in some forms it extends in front of as well as behind the umbo, and this condition is described as AMPHIDETIC . In those forms with an internal ligament it may be situated in one pit or in a series of pits along the hinge plate .

The hinge plate, with its dentition and ligament, is only a part of the mechanism by which the valves are opened and shut. The resilient ligament by itself would keep the valves gaping; they are closed by the contraction of ADDUCTOR muscles (fig. 18c). When these muscles relax, the external ligament, which has been under tension, pulls the valves apart (fig. 18d). In forms with an internal ligament, the ligament is under compression and thus pushes the valves open when the muscles relax.



17 A spinose bivalve. Spondylus, Cretaceous (xl'5).

DORSAL

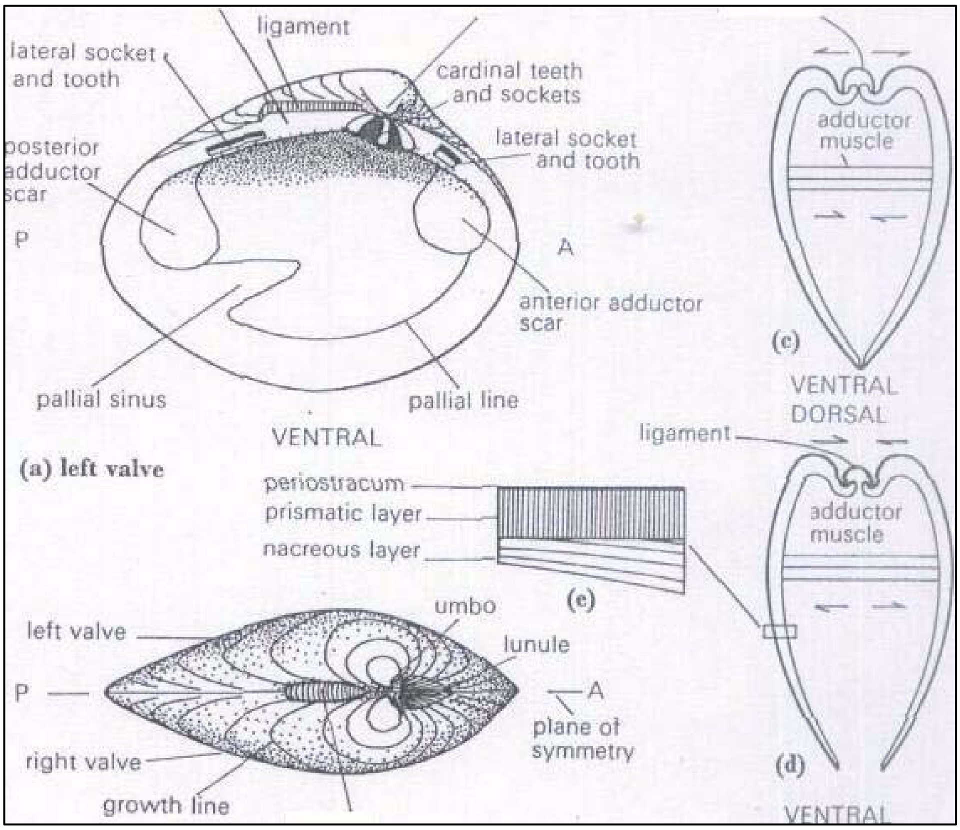
DORSAL ligament^

umbo

hinge plate

ligament

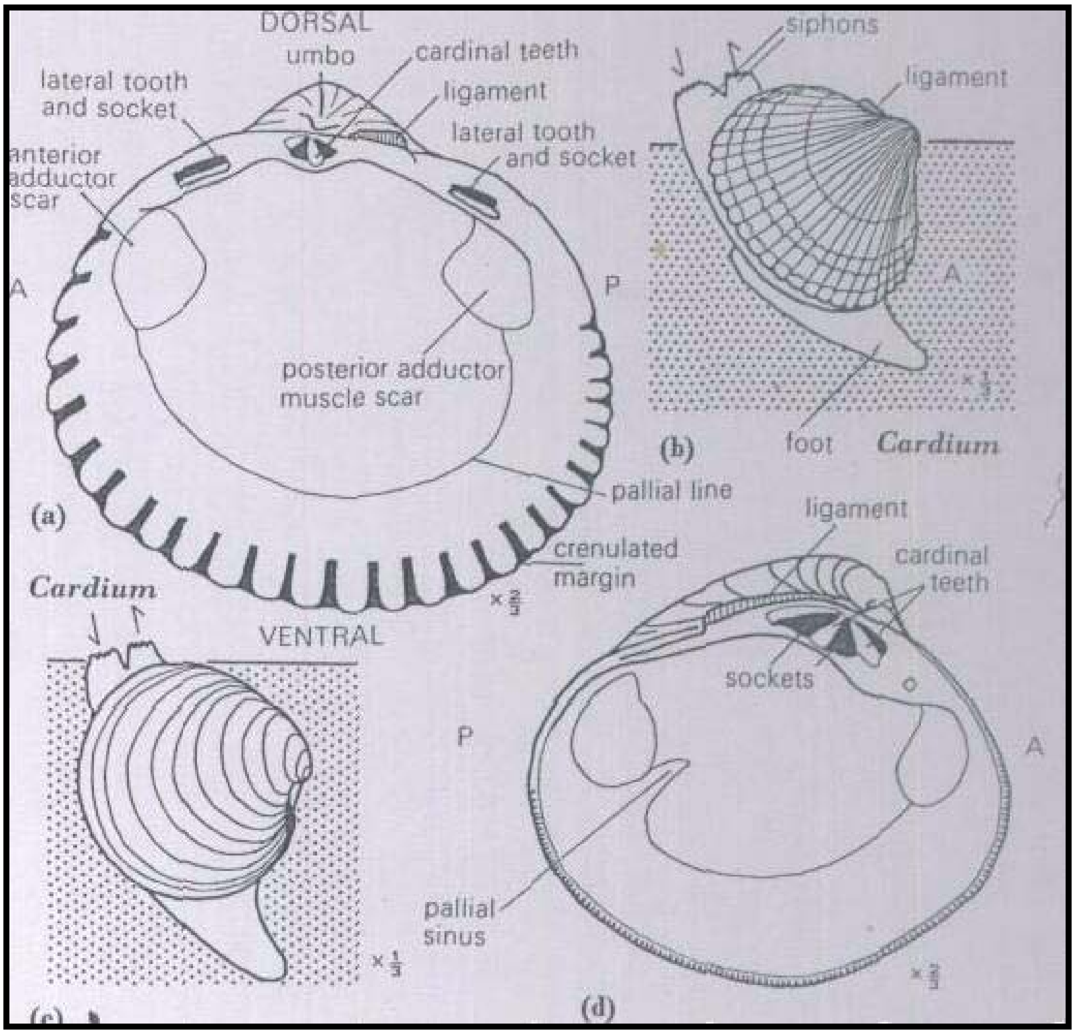
(b) dorsal view



18 Morphology of the bivalves.

a, ulterior view of the left valve of an equivalve and inequilateral shell; in this and later diagrams •which show dentition, the sockets are black and the teeth unshaded, b, dorsal view of the shell, c, section through a closed shell showing the adductor muscles contracted and the ligament stretched, d, through an open shell with the adductor muscles and ligament relaxed. e, diagrammatic section of a shell fragment, much enlarged, to show a type of microscopic shell structure commonly found ia bivalves.

The points where the adductor muscles are attached to the valves are marked by SCARS which can be clearly seen on the inner surface of each valve; typically there is one at the anterior end (ANTERIORADDUCTOR), and one at the posterior end (POSTERIOR ADDUCTOR) of each valve. Shells with scars of roughly equal size are described as ISOMYARIAN (fig.18a) while those in which the anterior one is smaller are AN ISOMYARIAN; shells lacking the anterior scar are MONOMYARIAN and in these the posterior scar is enlarged. A thin groove runs parallel to the ventral margin from the anterior muscle scar to the posterior muscle scar: this is the PALLIAL LINE along which the mantle is attached to the valves (pallium is another name for mantle) (fig. 18a).



Venus 19 Mode of life of two common bivalves.

a, b, Cardium, a vagrant bivalve; a, interior of right valve; b, animal in feeding position in sandy sediment, c, d« *Venusy a* shallow-burrowing bivalve; c, animal in feeding position; d, interior of left valve. Arrows indicate the directioa of the mcurrent and excurreat flow of water.

retracted into the shell quickly if the animal is disturbed. The pallial line in such forms is not entire but shows an embayment, the PALLIAL SINUS, at the posterior end (fig. 18a). The depth of the sinus gives some indication of the length of the siphons and thus of the depth of burrowing.

When the valves are closed, typically the margins are pressed tightly together. Bivalves which live in burrows, however, may have a permanent opening, a GAPE, at the posterior end for the siphons, and there may **be a** similar gape **at the** anterior end for the foot. The valve margins are usually quite smooth, but accurate closing' is aided in some forms by the development of small crenulations of the margin (fig. 19a).

Most bivalves are bilaterally symmetrical about a plane passing between the two valves and these shells are said to be EQUIVALVE (fig.18b). Each **valve is, however,** usually asymmetrical about a line from the umbo to the ventral margin and is said to be INEQUILATERAL (fig. 18a); in the majority of bivalves the umbo is nearer to the anterior end than to the posterior end. Thus the right and left valves can be readily distinguished; if the shell is held dorsal surface up and the anterior end pointing away from you, the right valve is then on your right and the left valve on your left. There are, however, exceptions **to** this **rule,** e.g. *Nucula.*