Invertebrate Macrofossils

Lecture 5

Bivalves

Primitive features

- Unicellular
- Radial symmetry
- Diploblastic
- Incomplete digestive tract
- Protostome
- Acoelomate
- No head region

Advanced features

- Multicellular
- Bilateral symmetry
- Triploblastic
- Complete digestive tract
- Deuterostome
- Coelomate
- cephalization

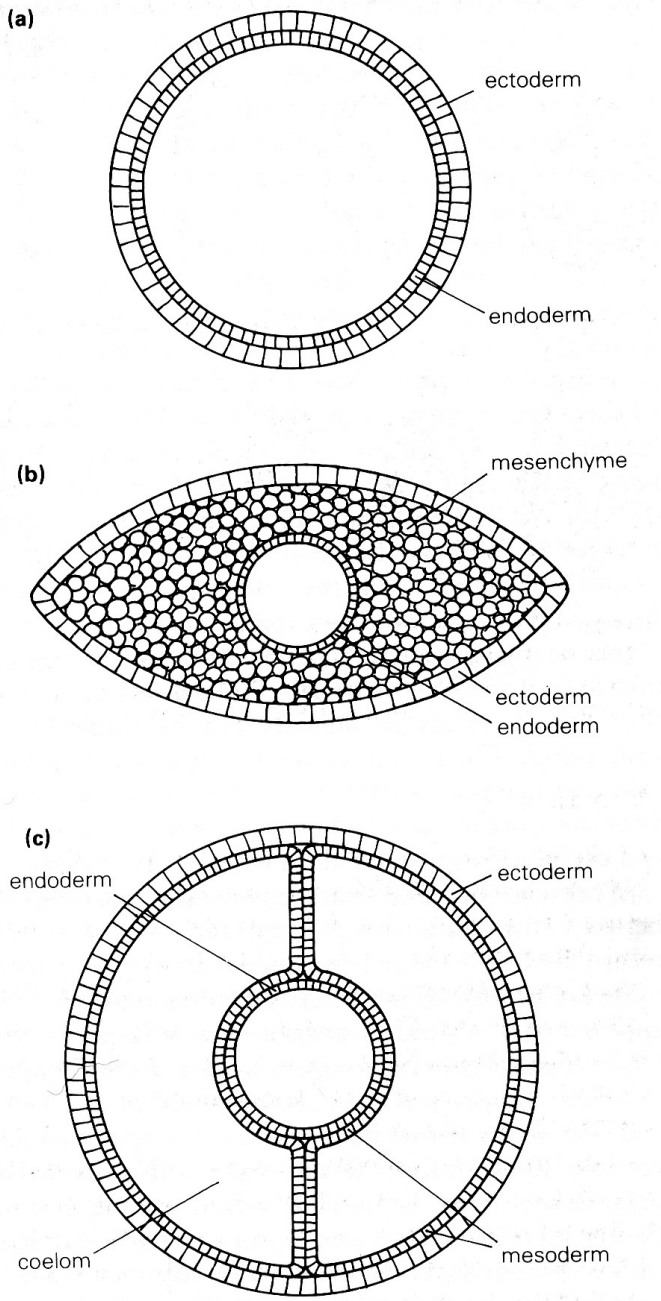


Figure 3.4 Grades of organization in metazoans: (a) diploblastic: (b) acoelomate triploblastic; (c) coelomate triploblastic

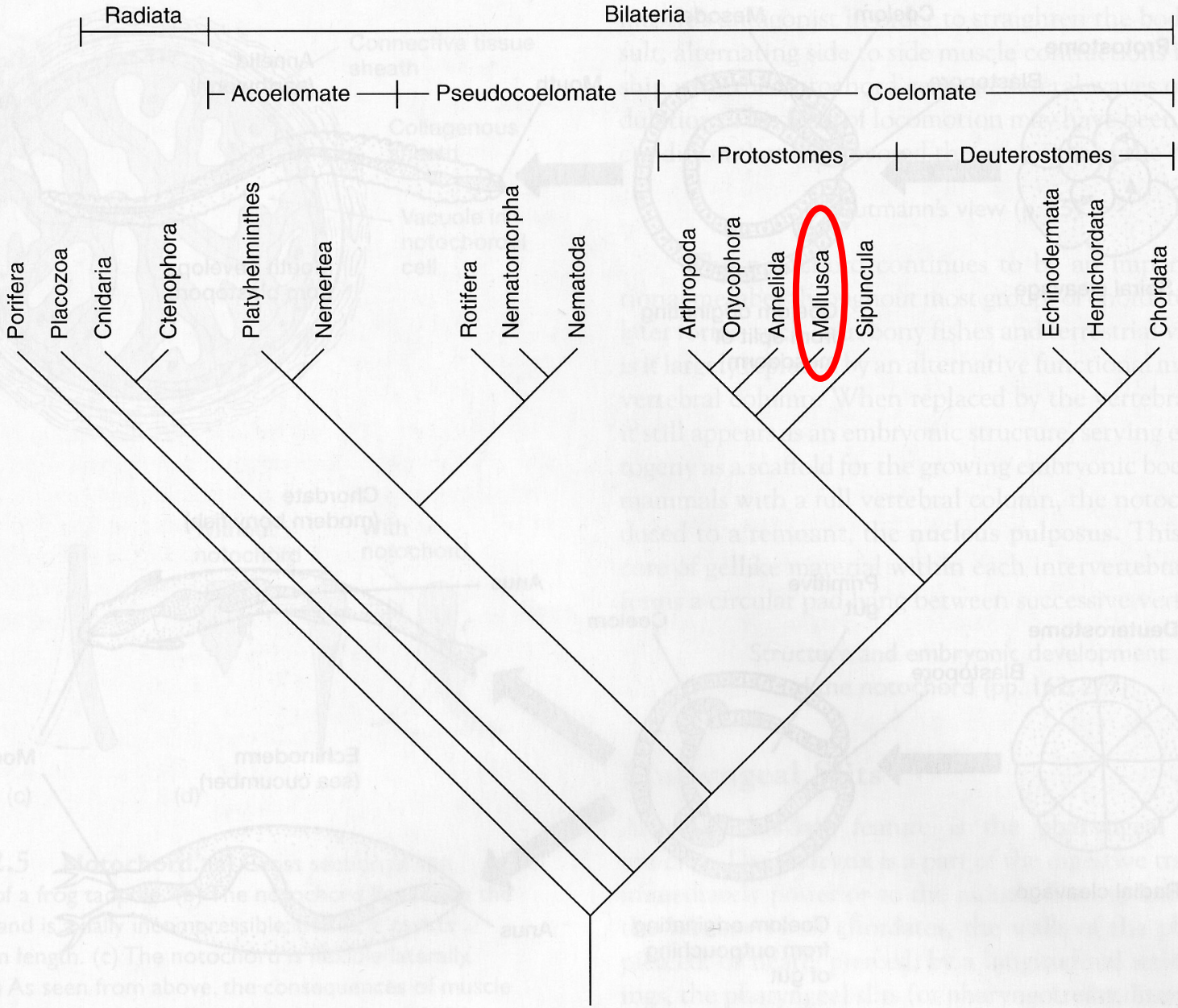


FIGURE 2.2 **Phylogenetic relationships within major animal groups.** Note that chordates are coelomate deuterostomes along with hemichordates and echinoderms. The protostomes are a separate lineage.

Molluscs

- Aquatic (marine and fresh water) and terrestrial
- Soft bodies mith mantle that secrets shell
- Bilateral symmetry
- Triploblastic
- Coelomate
- Protostome
- Complete digestive cavity
- Mantle cavity with respiratory structures
- Digestive, excretory, reproductive system
- Circulatory system (heart and blood vessels)
- Developed nervous system
- Dioecious
- Three major groups: gastropods, bivalves, cephalopods

Molluscs

- One of the most diverse phyla
- Fossil and living representatives
- Fossil record starts at the earliest Cambrian (540 my)
- Size: from microscopic to gigantic (giant squid 20m)
- Mostly marine but a few bivalves and gastropods fresh water, one group of gastropods (palmonates) terrestrial

Mollusc classification

1. Monoplacofora (Cambrian-Recent)
   primitive marine, univalved limpet-like shells, ventral foot, today in deep waters
2. Amphineura (Upper Cambrian-Recent)
   marine, bilaterally symmetrical shell, 7-8 calcareous plates, ventral foot, rare as fossils
3. Scaphopoda (Ordovician-Recent)
   marine, small tapering shells open in both ends, anterior wider opening with mouth, anus at posterior end
4. Bivalvia (Lamellibranchia or Pelecypoda) (Ordovician-Recent)
   marine and freshwater bivalved molluscs
5. Rostroconchia (Lower Cambrian-Permian)
   extinct marine, bivalved-like, probably ancestral form of bivalves, juvenile shells univalved and coiled
6. Gastropoda (Cambrian-Recent)
   marine, freshwater and terrestrial, with coiled shell
7. Cephalopoda (Upper Cambrian-Recent)
   marine, with external or internal shells, cephalisation

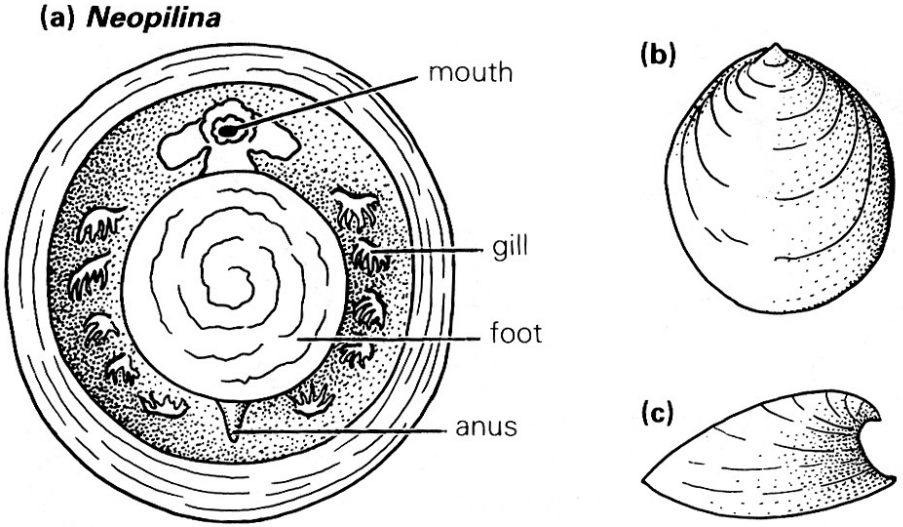


Figure 8.2 *Neopilina* (Monoplacophora): (a) ventral view, showing central foot and serially arranged gills (× 2 approx): (b) dorsal view (× 1); (c) lateral view (× 1). [(a) based on an illustration by Lemche in *Treatise on Invertebrate Paleontology*. Part I]

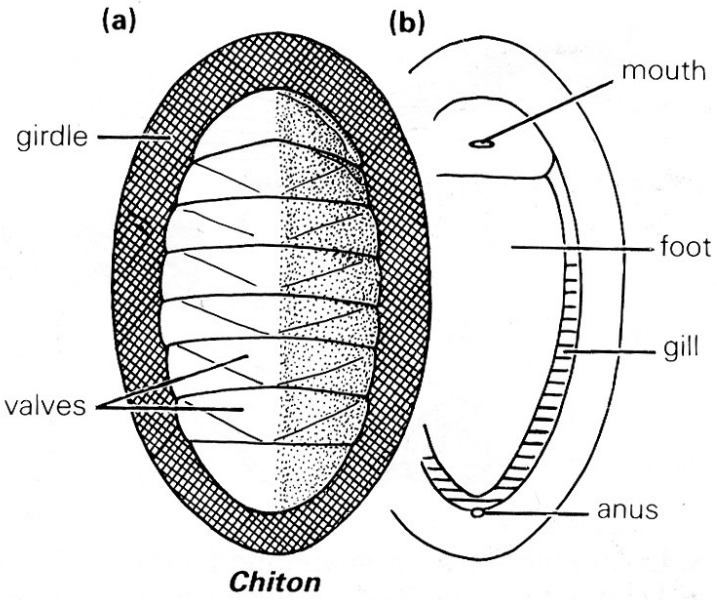


Figure 8.3 *Chiton* (Amphineura): (a) dorsal view; (b) ventral view (× 2)

Fundamental organisation of molluscs

- Molluscan shell varies but basic body plan similarly organised in every group
- Primitive ancestral hypothetical archimollusc
- Rather similar to monoplacophora
- Basic body plan
    a. head (mouth which leads digestive tract)
    b. visceral mass (contains internal organs, dorsal)
    c. foot (muscular organ used for locomotion)
    d. mantle (two tissue folds that form mantle cavity which contains the gills)
- Soft parts covered by cap-like calcium-carbonate shell secreted by the mantle (internal, external or lost)

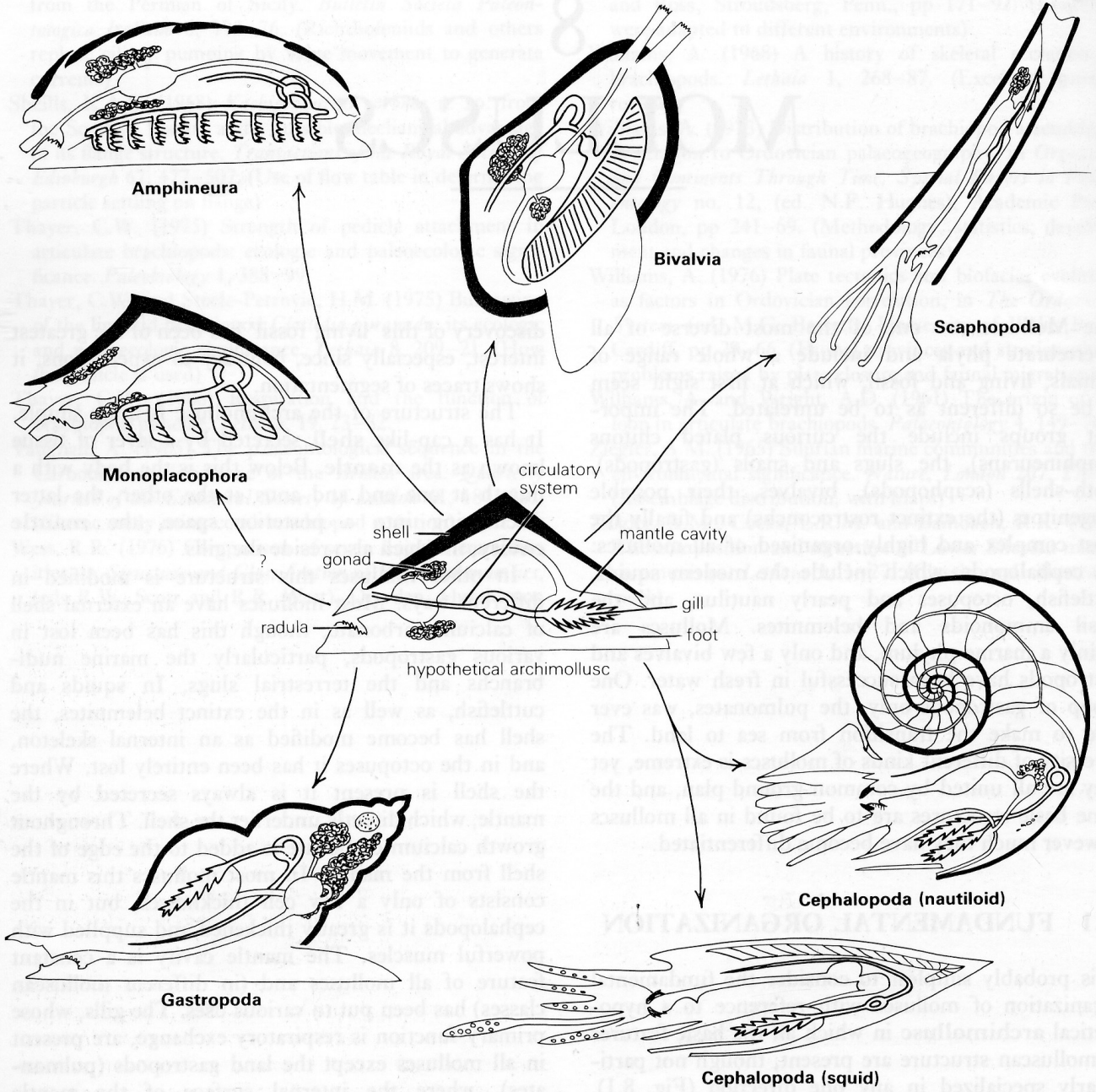


Figure 8.1 Morphology and relationships of molluscan classes with reference to a 'hypothetical archimollusc'

- Diversification of molluscs probably due to different modes of feeding, from simple creeping forms to advanced swimming cephalopods with head (cephalisation) and highly advanced sense organs and brain

Bivalves

- A pair of calcareous valves that enclose the laterally compressed body
- Valves united dorsally by elastic ligament
- Bilaterally symmetrical (usually axial plane between the two valves)
- Shallow to deep water, marine and fresh water
- Most benthic, infaunal or epifaunal
- Size: from microscopic to more than 1 meter
- Earliest genera in Cambrian, but become diverse in Ordovician

Bivalve morphology

- Shell: support, muscle attachment, protection
- Two valves: Left and Right
- Dorsally united by ligament
- Opposite side ventral
- Anterior side where mouth is situated
- Posterior opposite where anus is found

Bivalve morphology (cont)

- Umbo (pl. umbones): earliest formed part of the valve, prominent convex area at dorsal side
- Concentric growth lines: growth lines seen on the external surface, merging towards hinge line
- Ornament: radial or concentric markings
  radial: ribs or grooves
  concentric: growth lines
  spines and tubercles
- In some genera depression at the anterior of umbo, lunule

Inner surface of the valves

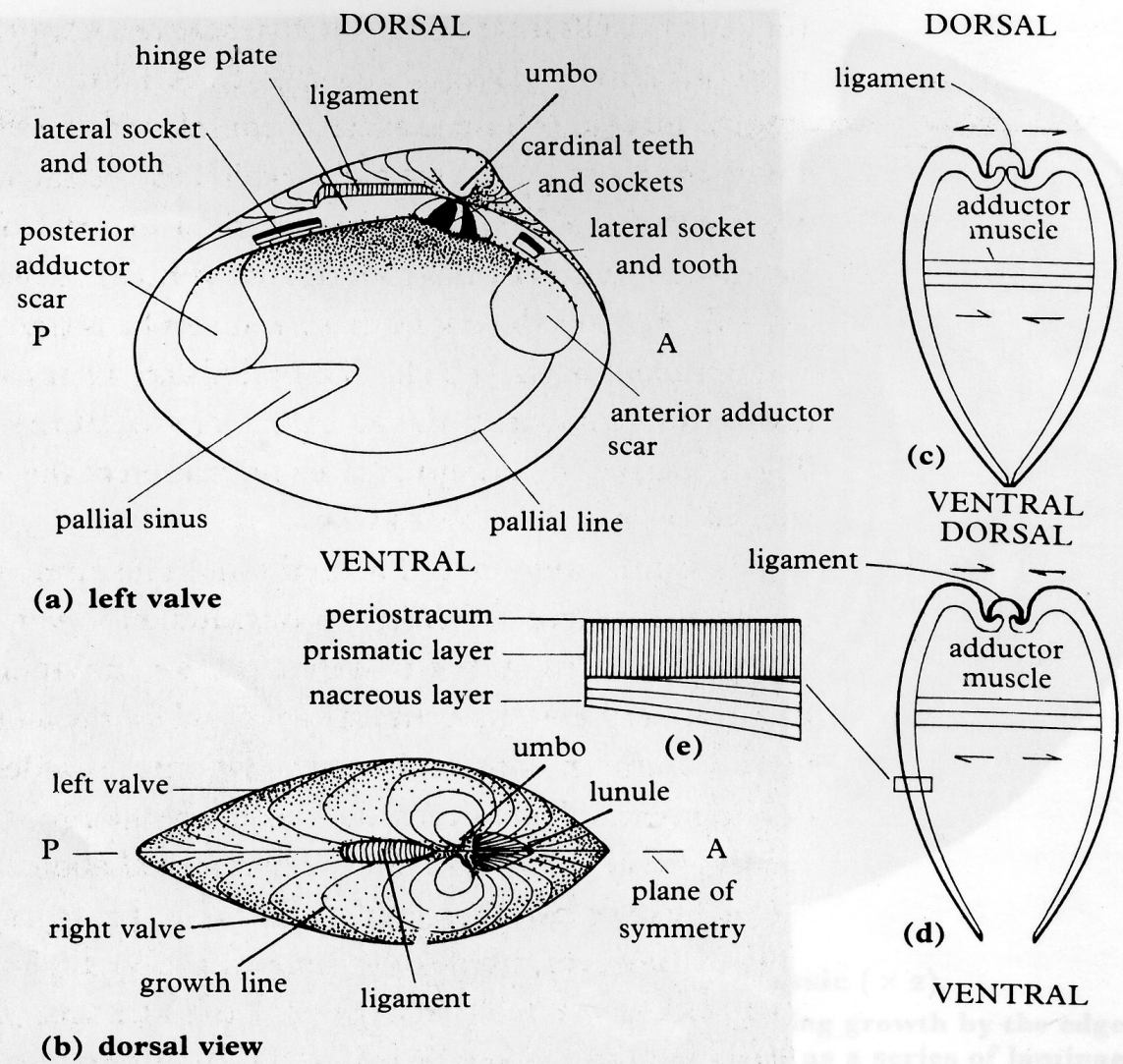
- Hinge plate: flattened, vertical and thickened area bellow umbo
- Each plate bears teeth which fit in sockets in the opposite hinge plate. Secure and tight fit for the two valves
- Dentition: the type of teeth projections
- Teeth are found under the umbo (Cardinal teeth)and/or at its posterior and anterior (lateral teeth)

Inner surface of the valves

- Ligament: connects the two valves dorsally, consists of conchiolin
    a. internal (between hinge plates)
    b. external (above hinge plates)
        1. opisthodetic (in a pit behind umbo)
        2. amphidetic (extends in front of umbo)
- Scars of the adductor muscles: two large oval areas at the anterior and posterior of the shell where the muscles (adductor muscles) that “close” the valves are attached. Separated into anterior and posterior
    a. isomyarian: scars of equal size
    b. anisomyarian: anterior scar smaller
    c. monomyarian: lacks anterior scar
- Ligament pulls apart, adductor muscles shut the valves

Inner surface of the valves

- Pallial line: faint groove or line parallel to the ventral margin of shell, connecting anterior and posterior scars
- Pallial sinus: small engulfment in the pallial line in burrowing species with retractable siphons for respiration
- Gape: permanent opening in some of these species at the posterior end for siphons

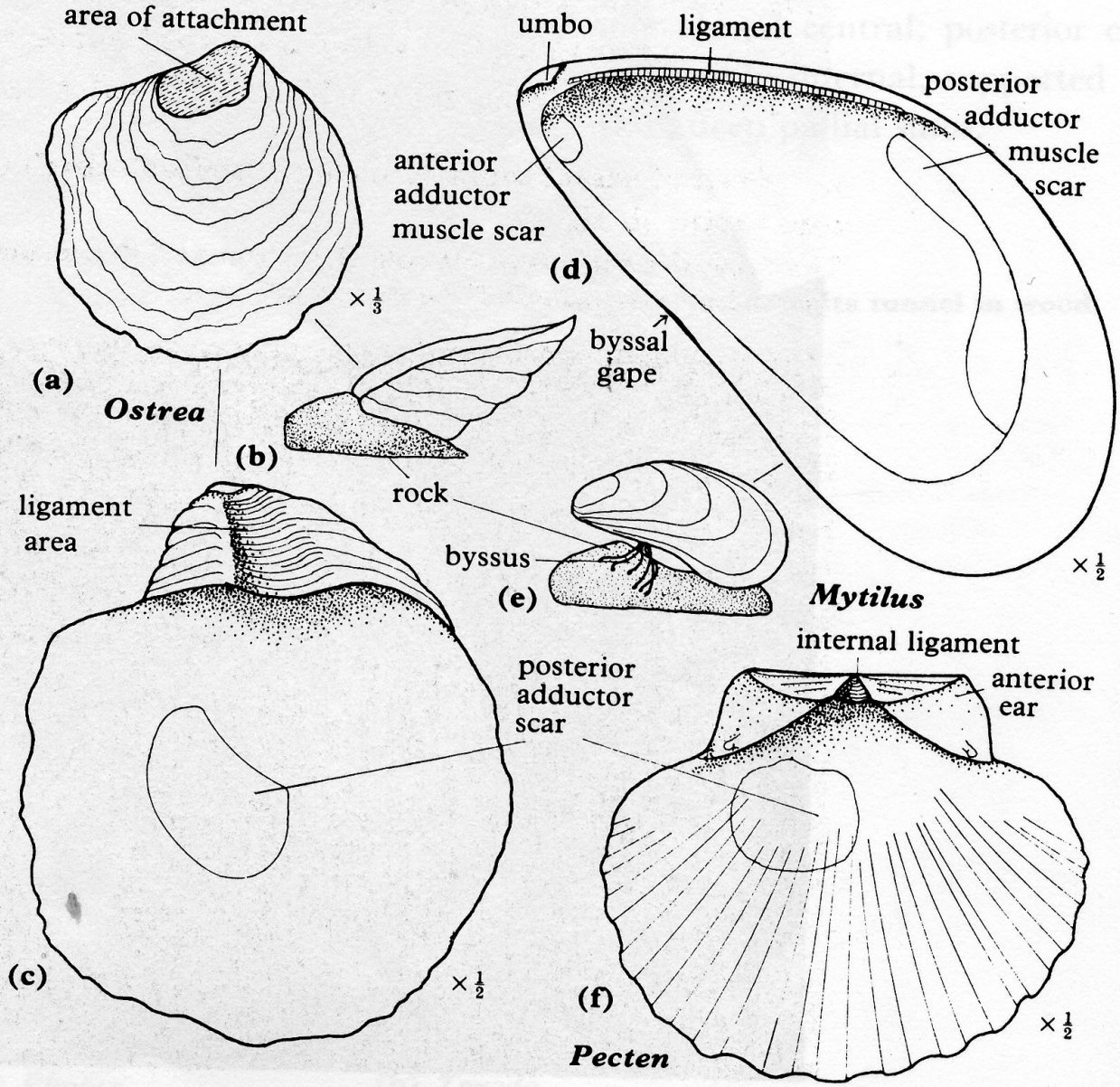


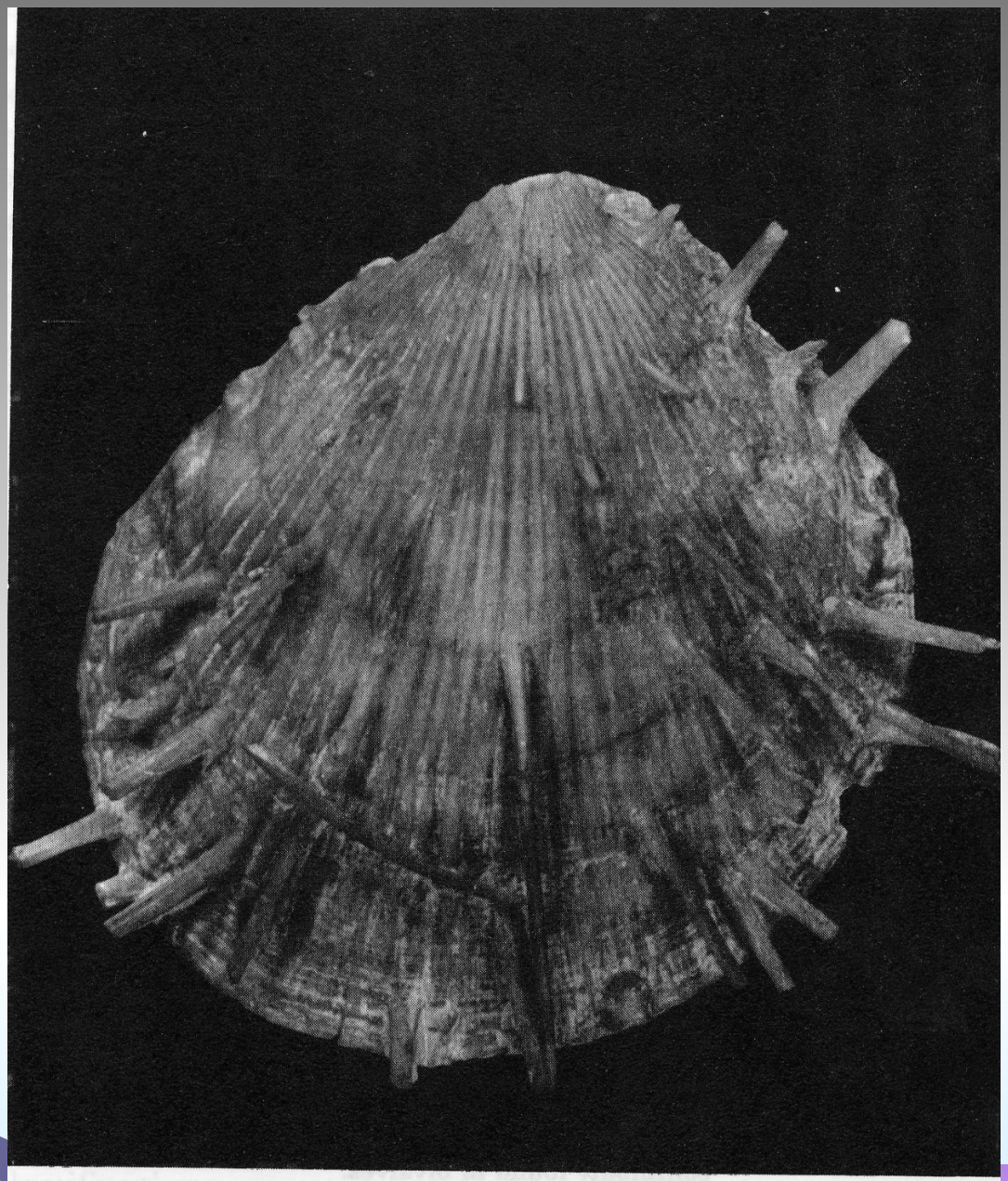
18 Morphology of the bivalves.

a, interior 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, transverse section of a closed shell showing the adductor muscles contracted and the ligament stretched; and d, of an open shell with the adductor muscles and ligament relaxed. e, diagrammati transverse section of a shell fragment, enlarged, showing a layered structure commonly found in bivalves.

23 Anisomyarian and monomyarian bivalves.

a–c, *Ostrea*: a, external view of the left valve; b, a shell attached to rock; c, interior of the left valve. d, e, *Mytilus*: d, interior of the right valve; e, a shell attached to rock by its byssus. f, *Pecten*: interior of left valve.





17 A spinose bivalve: *Spondylus*, Cretaceous (× 1.5).

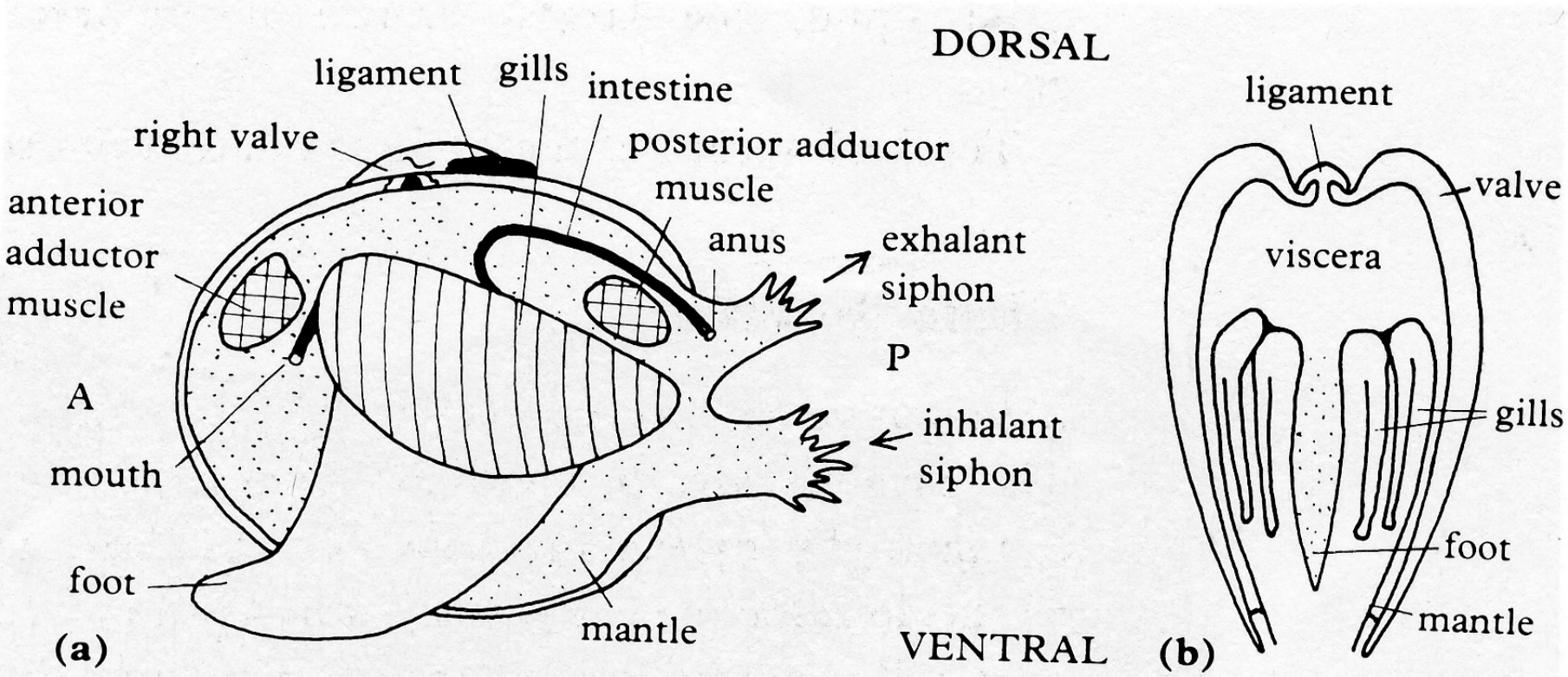
- Plane of symmetry the commissure line
  Equivalve: symmetrical valves
  Inequivalve: asymetrical valves

- Plane of symmetry perpendicular to one valve
  Equilateral: symmetrical valve
  Inequilateral: asymmetrical valve

- Prosogyral: Umbones anterior to the midline (most bivalves)
  Opisthogyral: Umbones posterior to the midline

Soft parts

- Rudimentary head with mouth and radula (toothed tongue) at the anterior
- Viscera (visceral mass) at dorsal region that contains organs
  - well developed circulatory, nervous, excretory systems
- Foot lies between mantle lobes at ventral side. Muscular organ which can lengthen and contract, extend outside and used for locomotion
- Mantle, two tissue layers that form mantle cavity, which contains the gills
- Dual role of gills: respiration and food gathering
  - gill filaments bear cilia
- Two open folds or tubes (siphons)
  - a. inhalant siphon (water and food)
  - b. exhalant siphon
- Anus tube at the posterior



15 Morphology of the bivalves.

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

Gill morphology

1. Protobranch
2. Filibranch
3. Eulamellibranch
4. Septibranch (in a single family of burrowers)

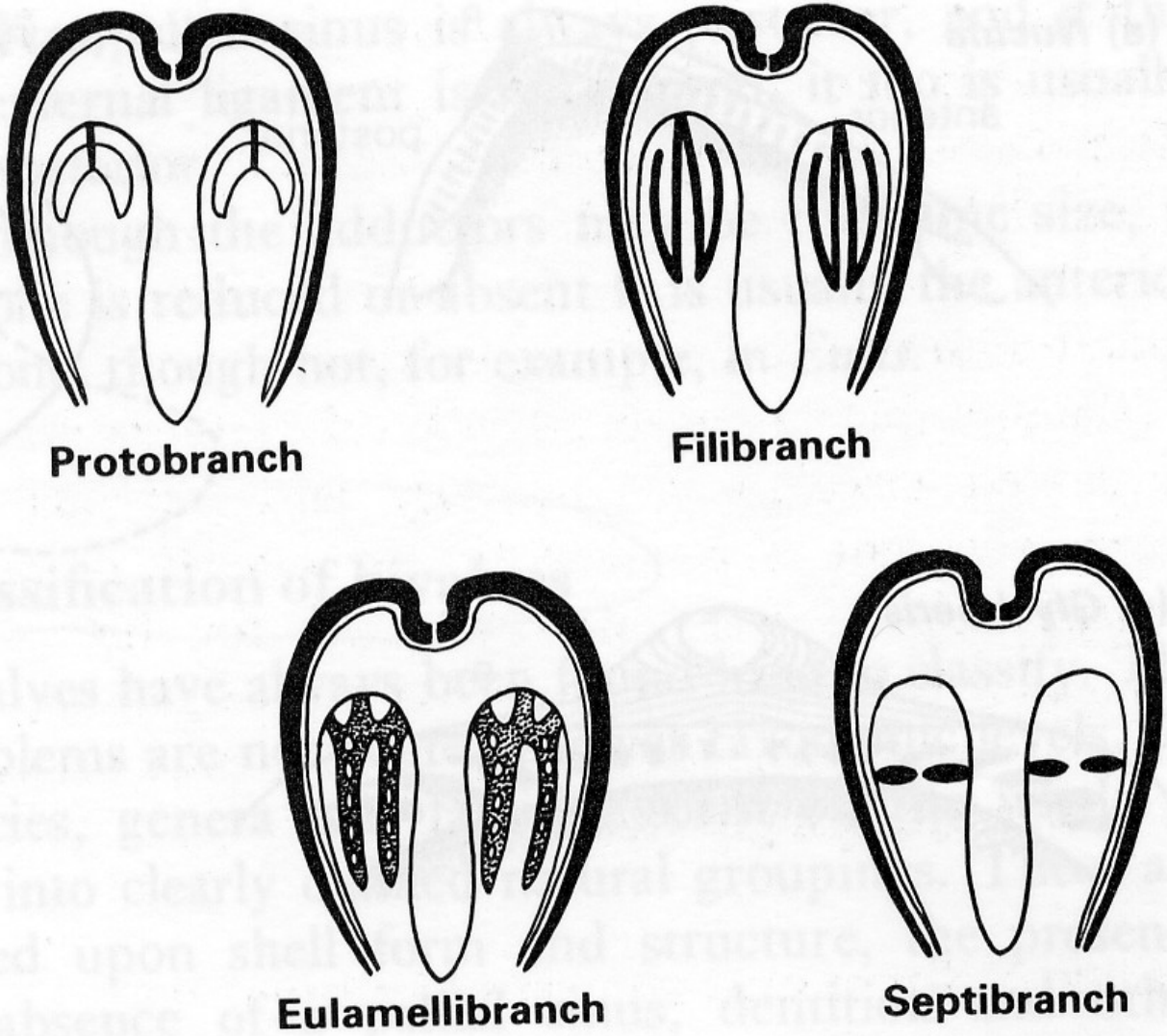


Figure 8.9 Bivalve gill morphology four basic types shown by transverse sections: shells are shown in black with the foot projecting centrally. (Redrawn from Moore *et al*. 1953)

Dentition

1. Taxodont (numerus subparallel or radially arranged teeth)
2. Dynodont (small simple teeth near the edge of the valve)
3. Isodont (symmetrical, equal, large, located on each side of a central ligament pit)
4. Schizodont (large with parallel grooves normal to the axis of the tooth)
5. Heterodont (2-3 cardinal teeth, elongated lateral teeth)
6. Pachydont (very large, heavy and blunt in rudists)
7. Desmodont (reduced or absent teeth replaced by hinge structure of accessory ridges)

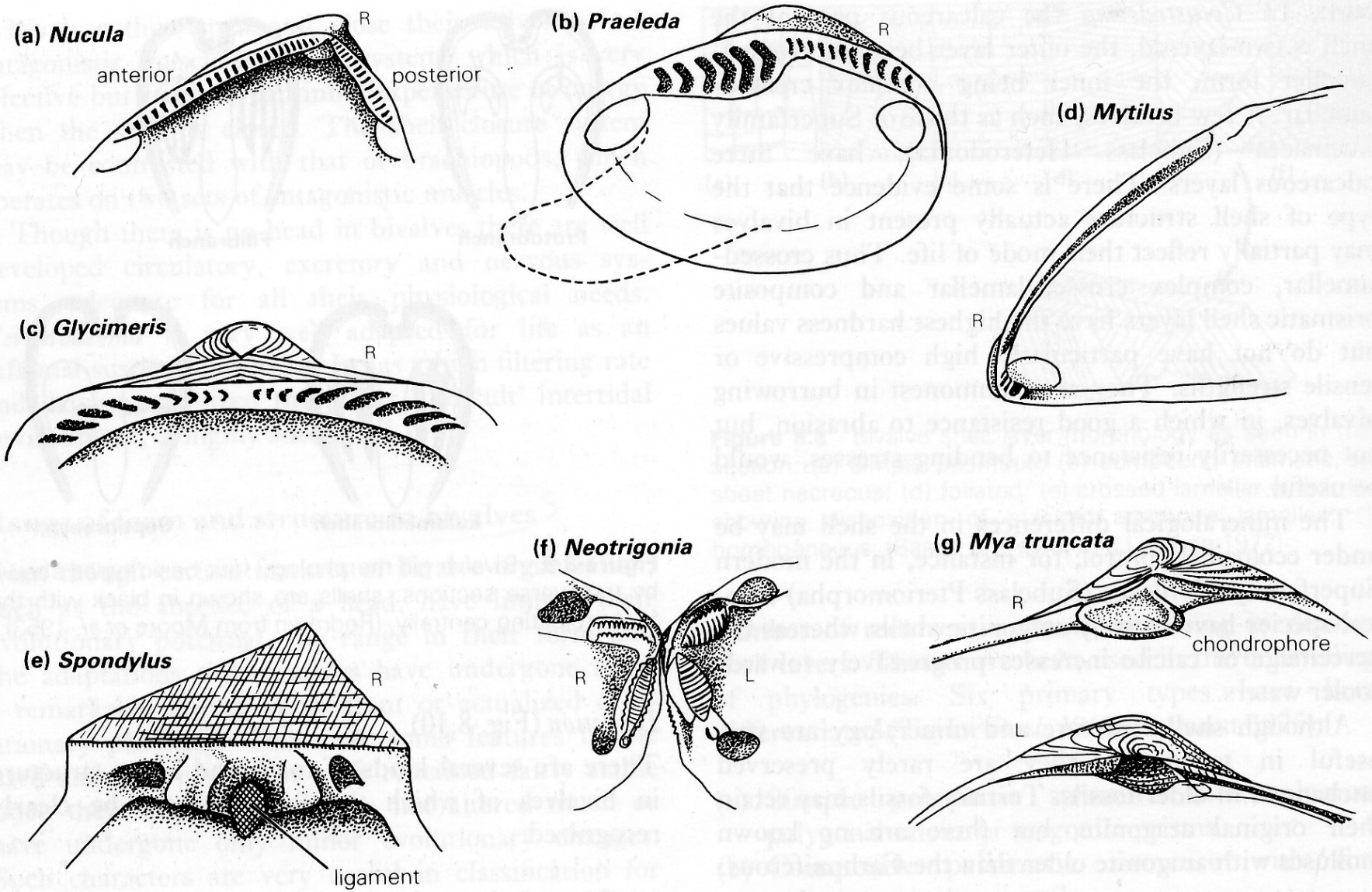
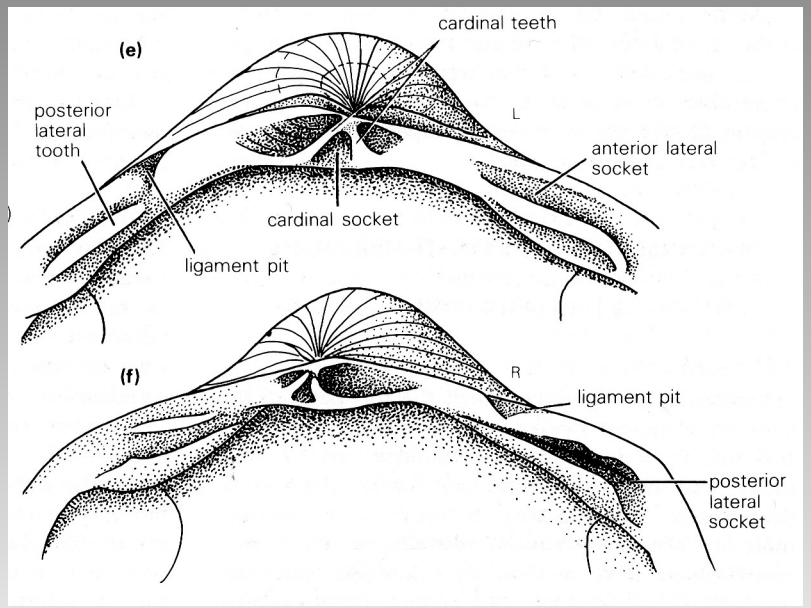


Figure 8.10 Bivalve hinge-lines and dentition (not to scale): (a) *Nucula* (Tert.-Rec.), right valve (note that the umbones face posteriorly), taxodont hinge; (b) *Praeleda* (Ord.), right valve, modified taxodont hinge, foot position inferred; (c) *Glycimeris* (Tert.-Rec.), right valve, taxodont hinge; (d) *Mytilus* (Rec.), right valve, dysodont hinge; (e) *Spondylus* (Cret.), right valve, isodont hinge; (f) *Neotrigonia* (Rec.), schizodont hinge; (g) *Mya truncata* (Rec.), desmodont hinge with chondrophore. [(b) redrawn from Bradshaw 1970; (c) redrawn from Woods 1946]



Heterodont

Pachydont

Ecology

- Shape and general morphology of shell reflects mode of life
- Studying modern forms we can infer to the mode of life of extinct

Ecology of bivalves

1. Infaunal
   a. shallow burrowing
   b. deep burrowing
2. Epifaunal
   a. cemented
   b. attached by byssus
3. Free-living
4. Swimming
5. Boring

Byssus

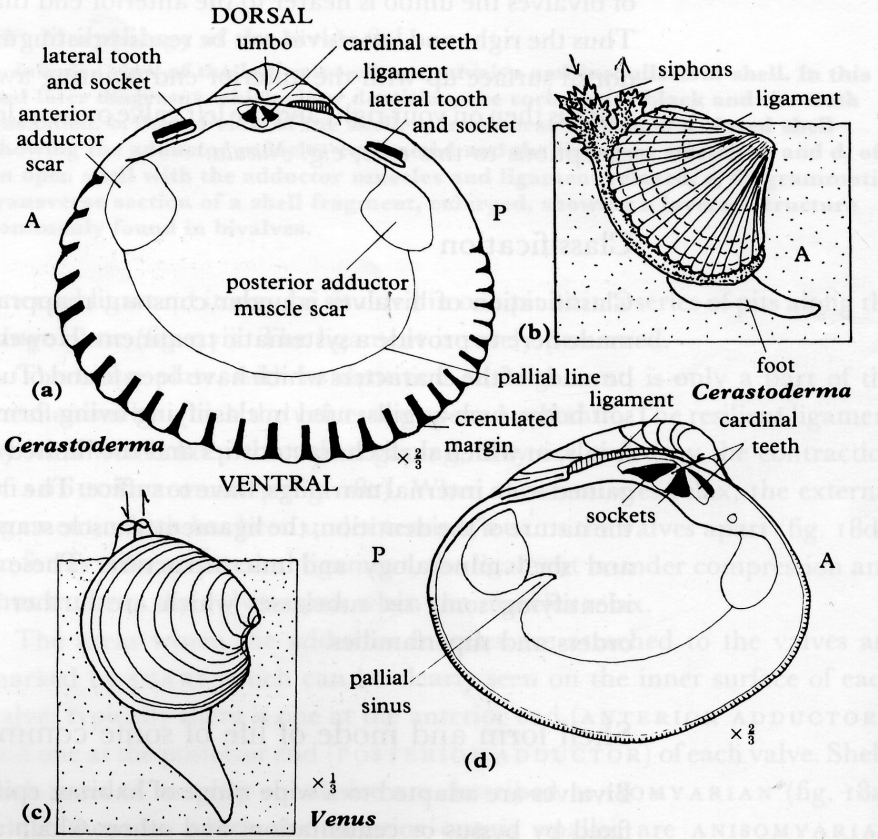
- Horny, fibrous outgrowth of the body made of protein collagen, by which in some forms the animal is attached on a firm substrate. A gape or notch is usually present at the anterior to accommodate byssus when valves are closed.
- It is secreted from a glad at the foot

Infaunal

- Equivalved shells
- Two adductor muscle scars (isomyarian or anisomyarian)
- Pallial sinuses
- Ventral wall parallel to hinge line
- Possibly presence of gape
- In deep burrowers shells are quite elongated and have pronounced gape

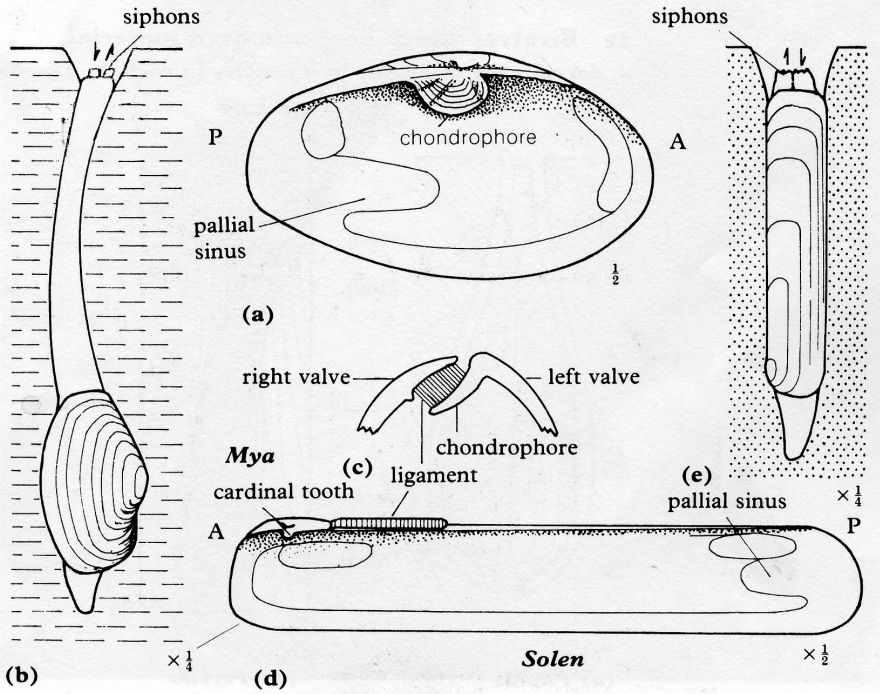
19 Shallow-burrowing bivalves.

a, b, *Cerastoderma*: a, interior of right valve; b, in feeding position in sandy sediment. c, d, *Venus*. c, in feeding position; d, interior of left valve. Arrows indicate the direction of the incurrent and excurrent flow of water.



20 Deep-burrowing bivalves.

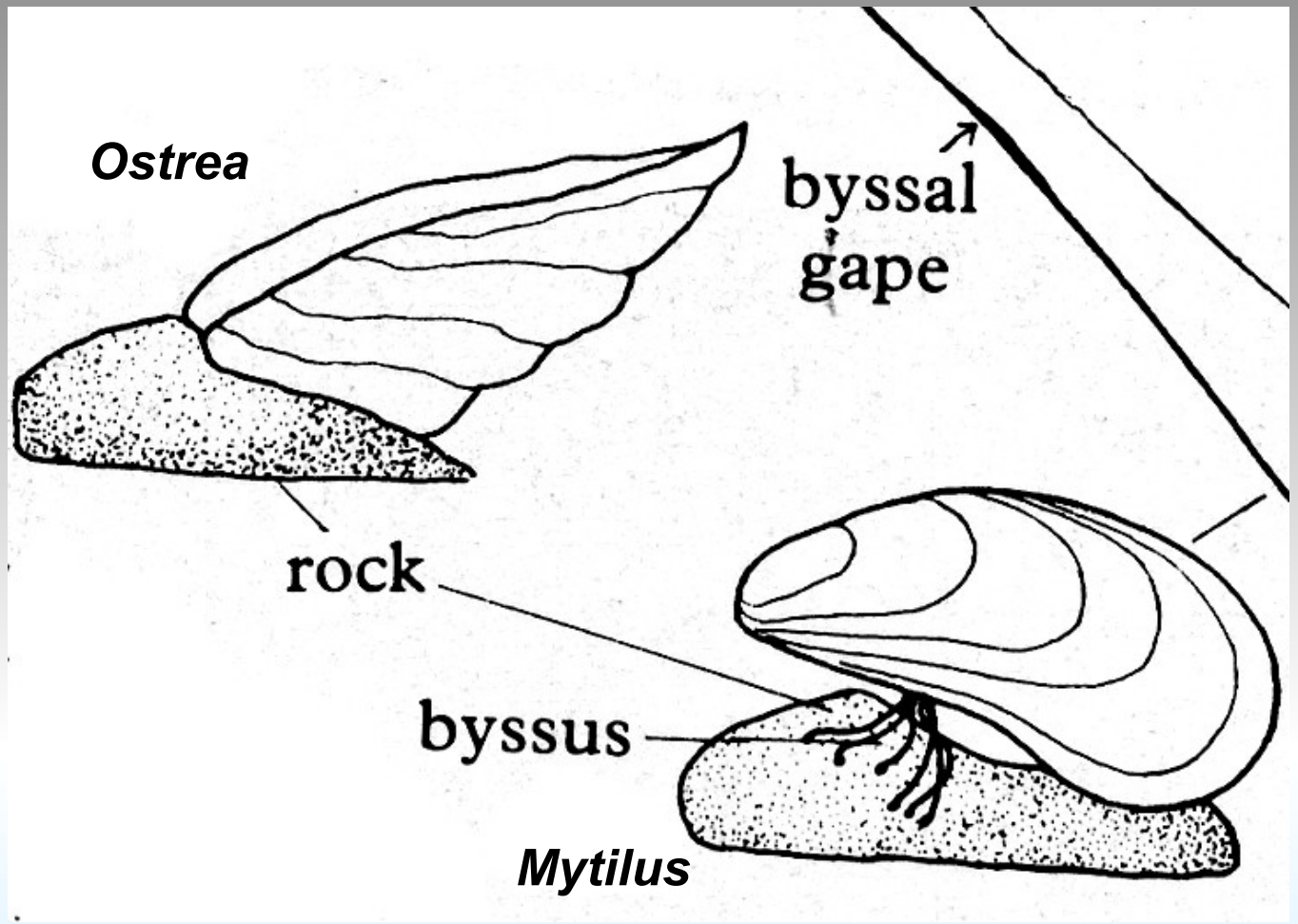
a–c, *Mya*: a, interior of left valve; b, the animal in its burrow in muddy sand with the siphons extended; c, transverse section through the ligament and chondrophores. d, e, *Solen*: d, interior of right valve; e, the animal in its feeding position at the top of its burrow in sand.



Epifaunal

A. With byssus
- Elongated shell
- Flattened ventral surface
- Byssal notch (gape)
- Anterior part reduced
- Anterior adductor muscle also reduced

A. Cemented
- Attached on hard substrate when larvae
- Attached with left valve
- Left valve gets cemented on substrate


Ostrea
byssal gape
rock
byssus
Mytilus

Free lying

- Lay flat on the sea floor

Swimming

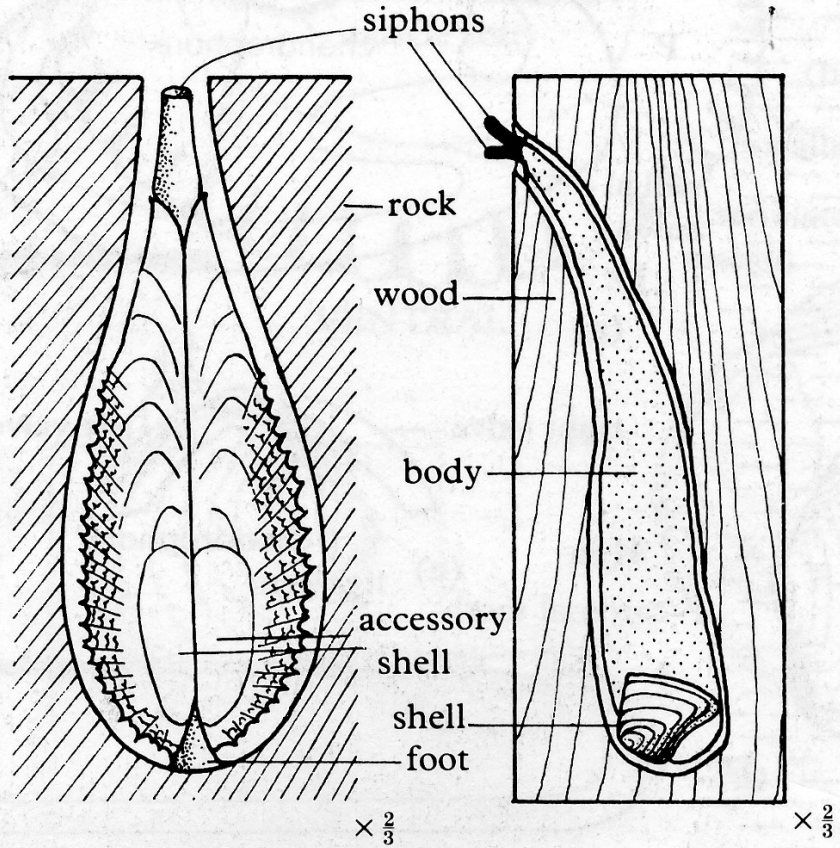
- Swim by rigorous repeated clapping of the valves which expels water on both sides
- Relatively flat and thin shell

Boring

- Elongated cylindrical cells
- Very thin cells
- Scrap with valves (abrasion resistant)
- Scraping spines for digging
- Usually found in these borings
- Some species use cavities for nestling

21 Bivalves which bore into hard material.

a, dorsal view of *Pholas* in its cavity in rock. b, *Teredo* in its tunnel in wood.



(a) ***Pholas*** (b) ***Teredo***