Phylum Mollusca

Introduction

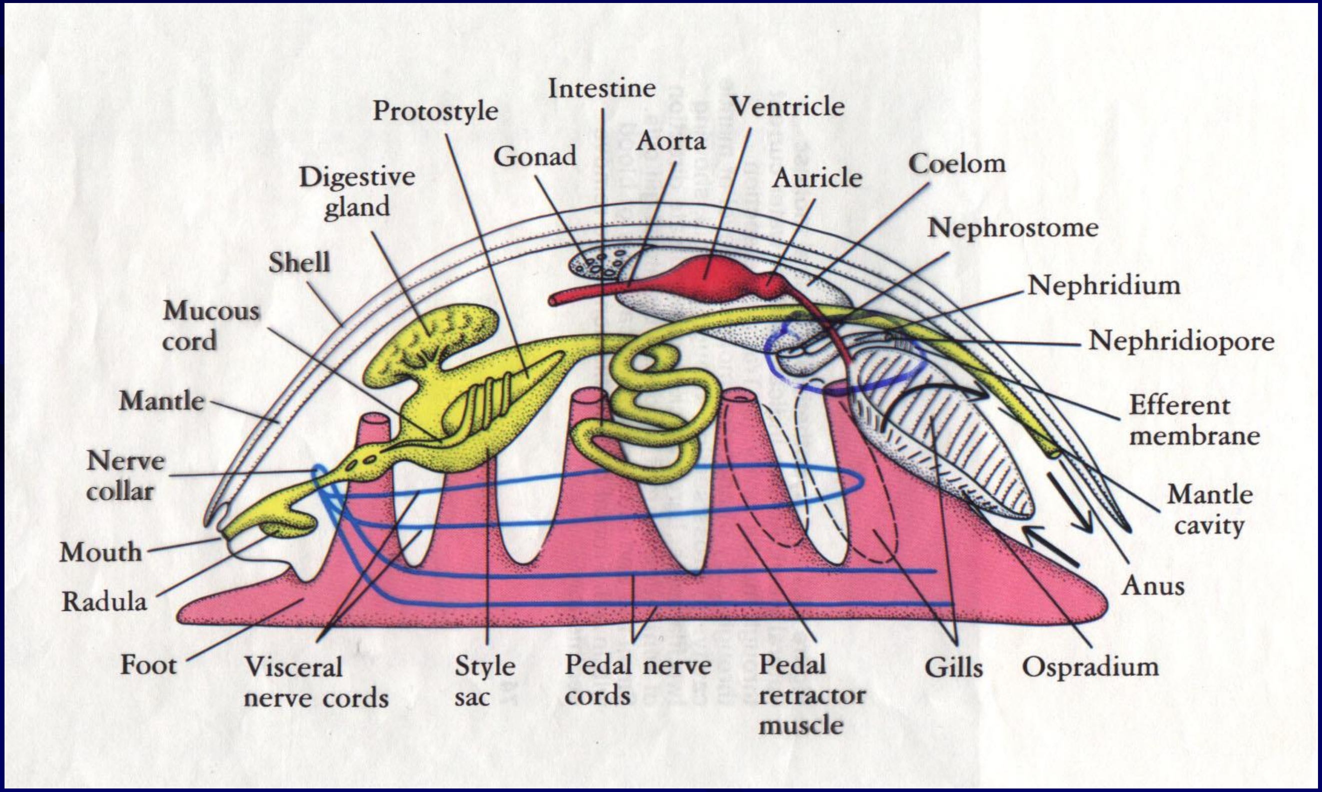
- Includes animals such as squids, snails, oysters, clams and slugs.
- Most are marine, but many are freshwater and some live on the land
- Despite the diversity of form and function among the molluscs, all members of this group have the same basic body plan.
- This is often indicated by presenting a **hypothetical ancestral mollusc (HAM)**
- HAM is hypothetical primitive ancestor that has characteristics that appear among most members of the mollusca

A Closer look at HAM

The foot - a broad, flat muscular organ that is adapted for locomotion and attachment

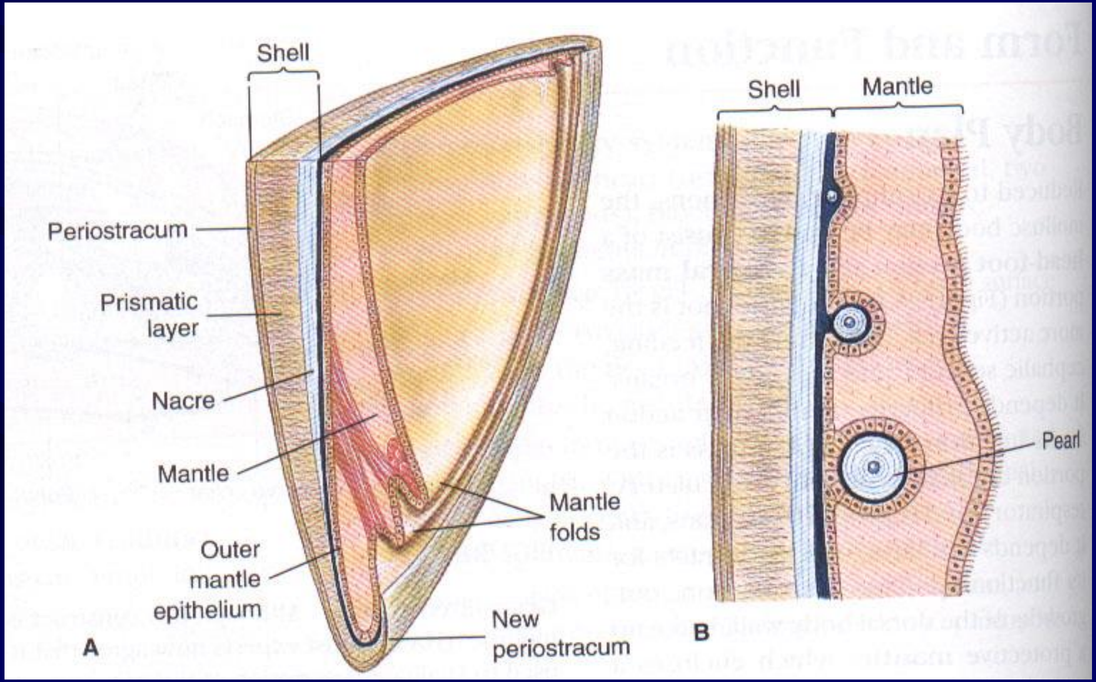
The visceral mass - contains the internal organs

The mantle - a fold of tissue that drapes over the visceral mass; space between the mantle and the visceral mass is called the **mantle cavity**



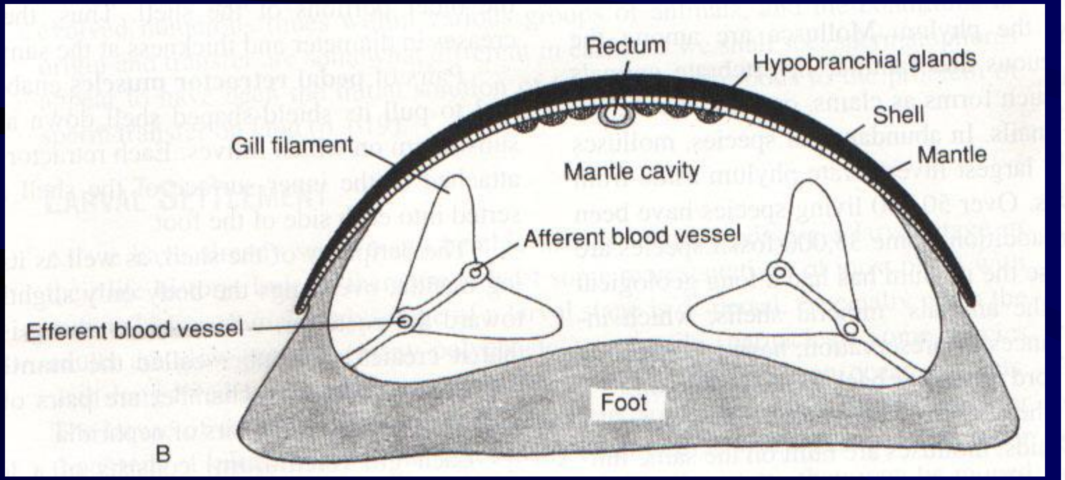
The Shell

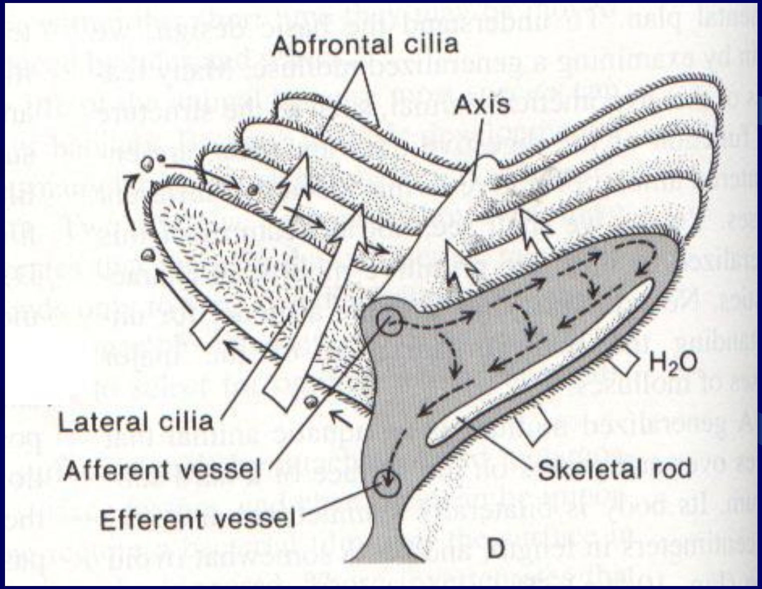
- The mantle is responsible for secreting the shell.
- The shell is comprised of three layers:
- The outside of the shell is covered by an organic layer - **periostracum**
- The middle **prismatic layer** is characterized by densely packed prisms of calcium carbonate laid down in a protein matrix
- The inner **nacreous layer** is composed of calcium carbonate sheets laid down over a thin layer of protein



Gills

• The gills of HAM are often indicated as one or more pairs of **bipectinate** gills, - flattened filaments attached to a longitudinal axis on either side

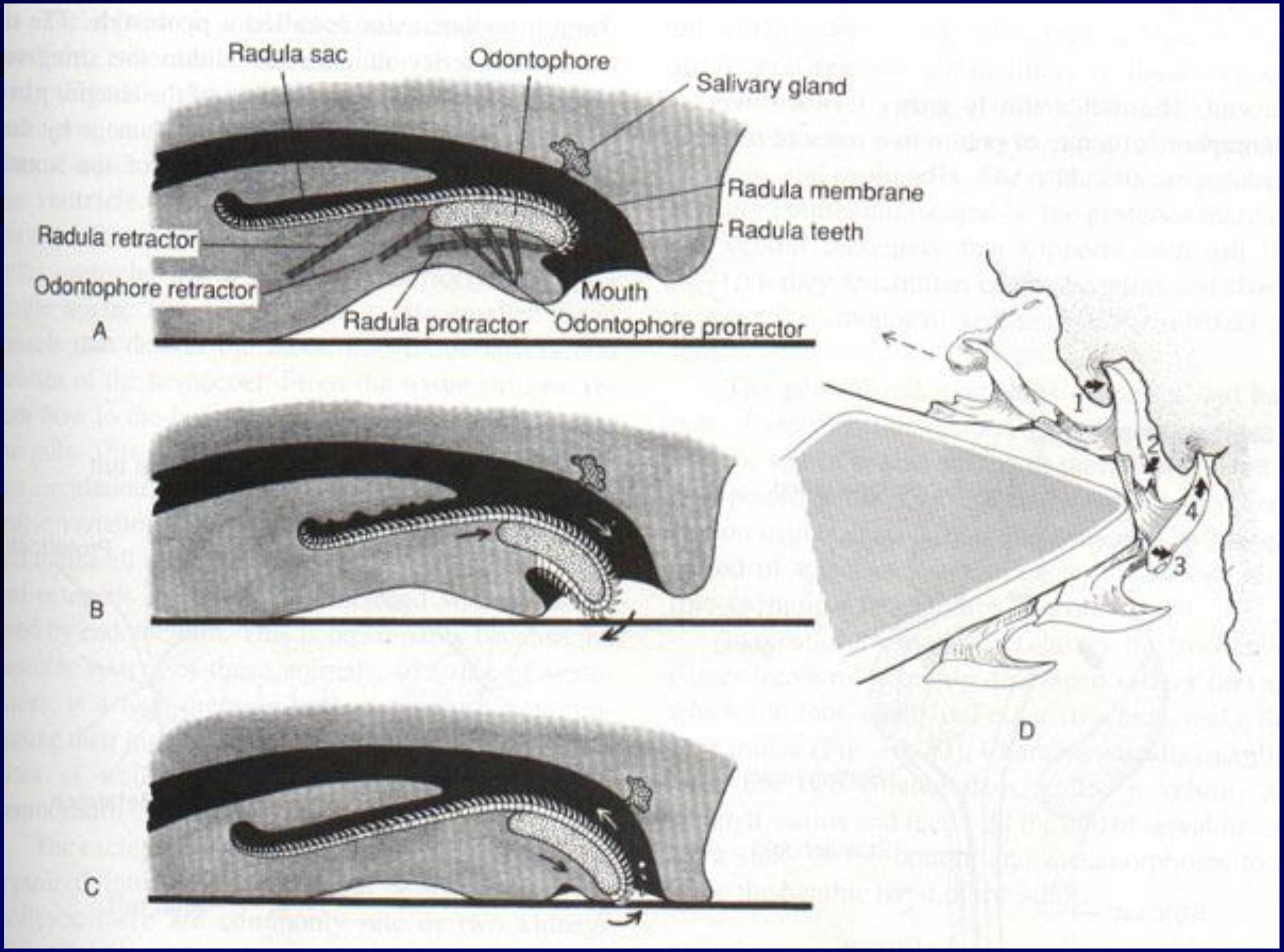




The Radula

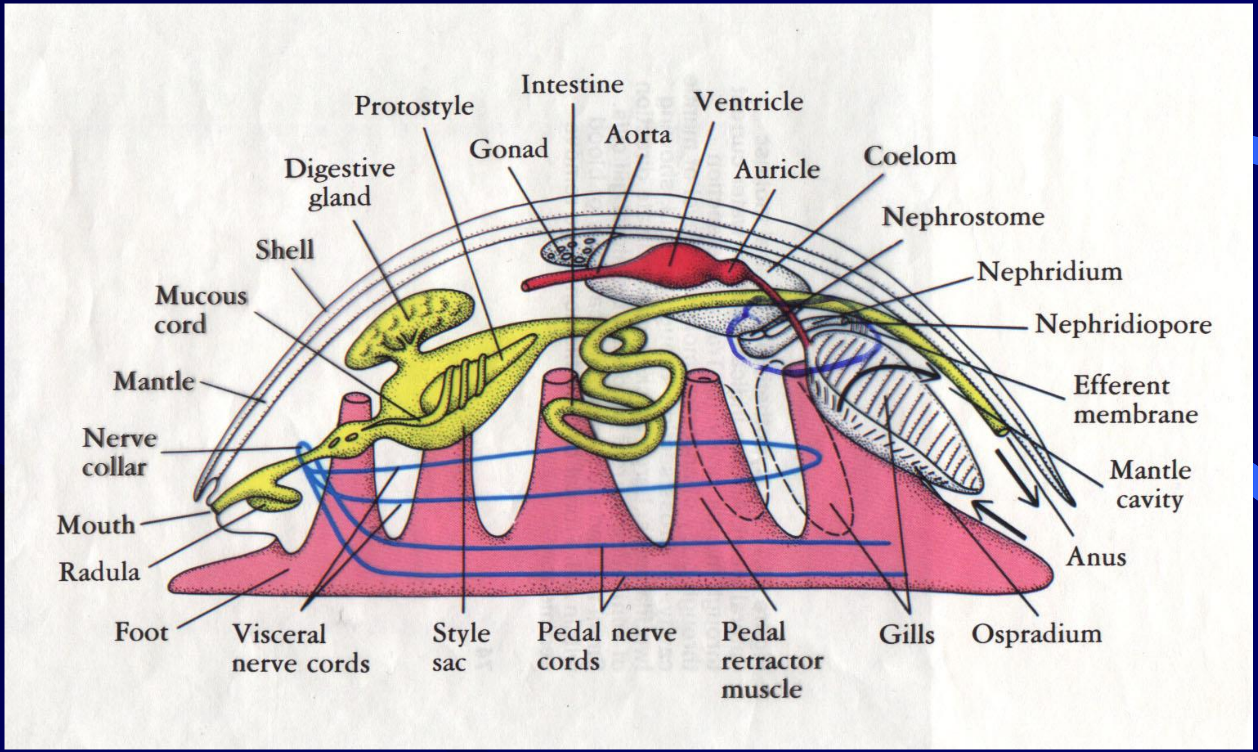
• The mouth cavity of HAM possesses a specialized rasping organ called the **radula**; sits on a cartilaginous structure - **odontophore**

• Particles of food brought into the mouth are bound in mucous secreted by the salivary glands



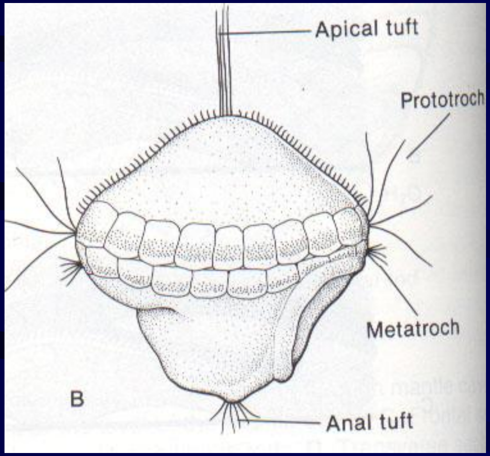
Other Features of HAM

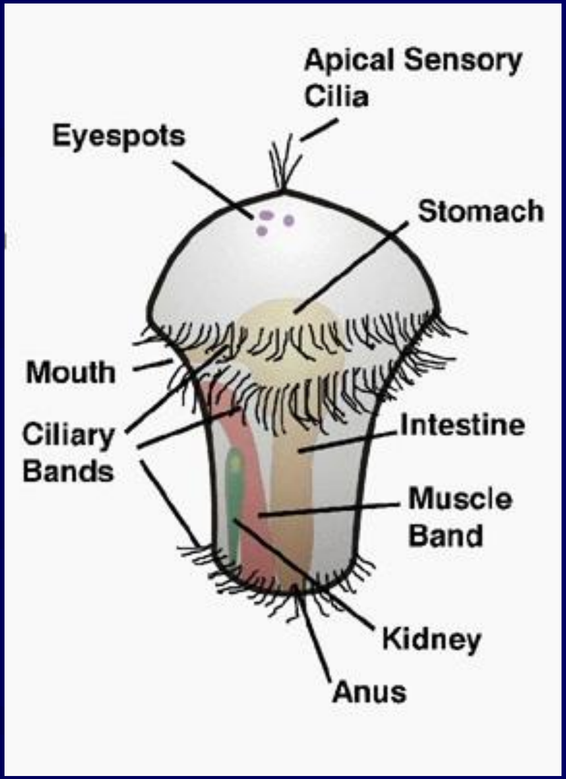
- Nervous system consists of a **nerve ring** and 2 **longitudinal nerve cords**
- Coelom is reduced
- **Open circulatory system**
- The excretory organs of the molluscs are **metanephridia;** inner ends open into the coelom via a ciliated funnel called the **nephrostome;** wastes leave the body via the **nephridiopore**



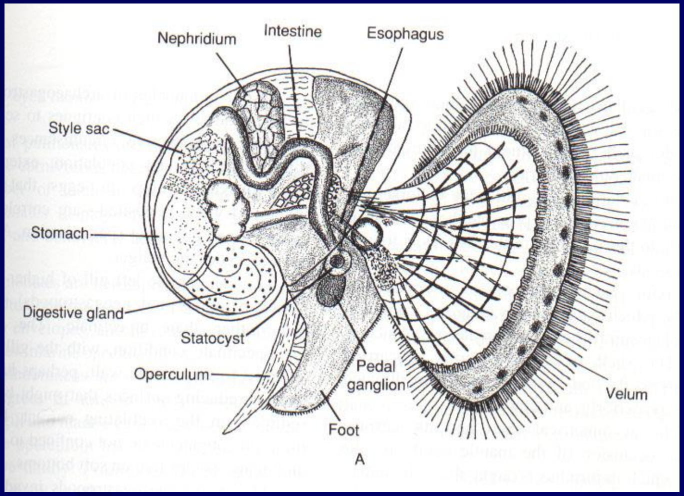
Molluscan Larval Stages

• Most molluscs produce a free-swimming ciliated larvae called the **trochophore larvae**





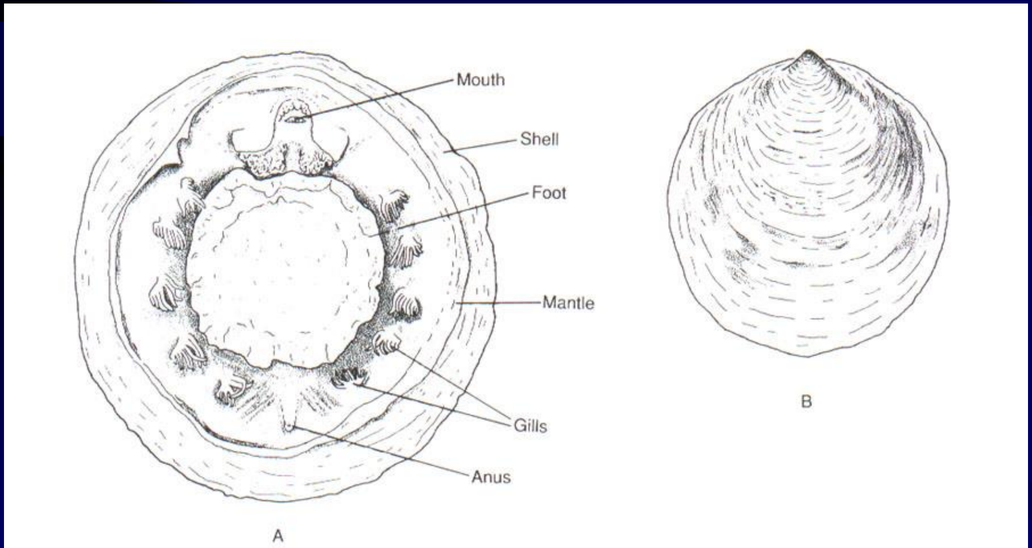
• In some molluscs the trochophore develops into the adult, but in other molluscs (e.g., gastropods) there is a second larval stage called the **veliger**

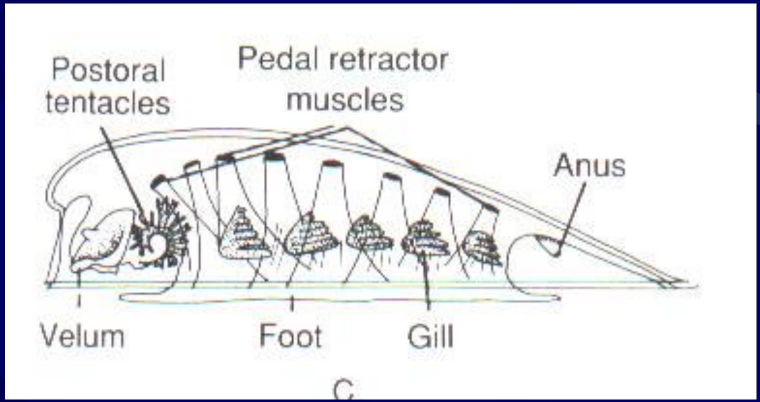


Molluscan Diversity

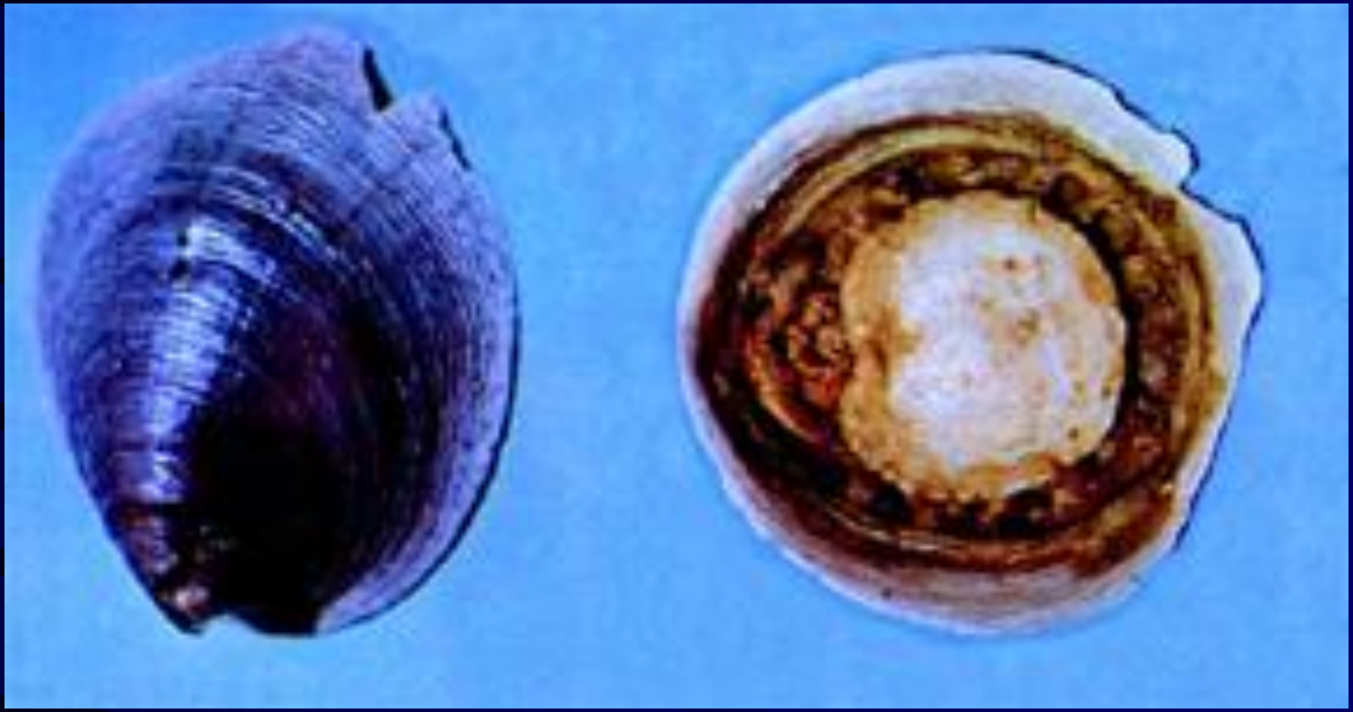
Class Monoplacophora

- A few centimeters in length
- Dorsal surface is covered with a shield-shaped shell; apex with slight anterior peak
- Ventral surface is broad and flat, with the mantle cavity in the form of 2 grooves located to either side of the foot
- Mantle groove with 5 or 6 pairs of **monopectinate** gills
- There is serial repetition of certain body parts
- It's unclear whether serial repetition (= *pseudosegmentation*)





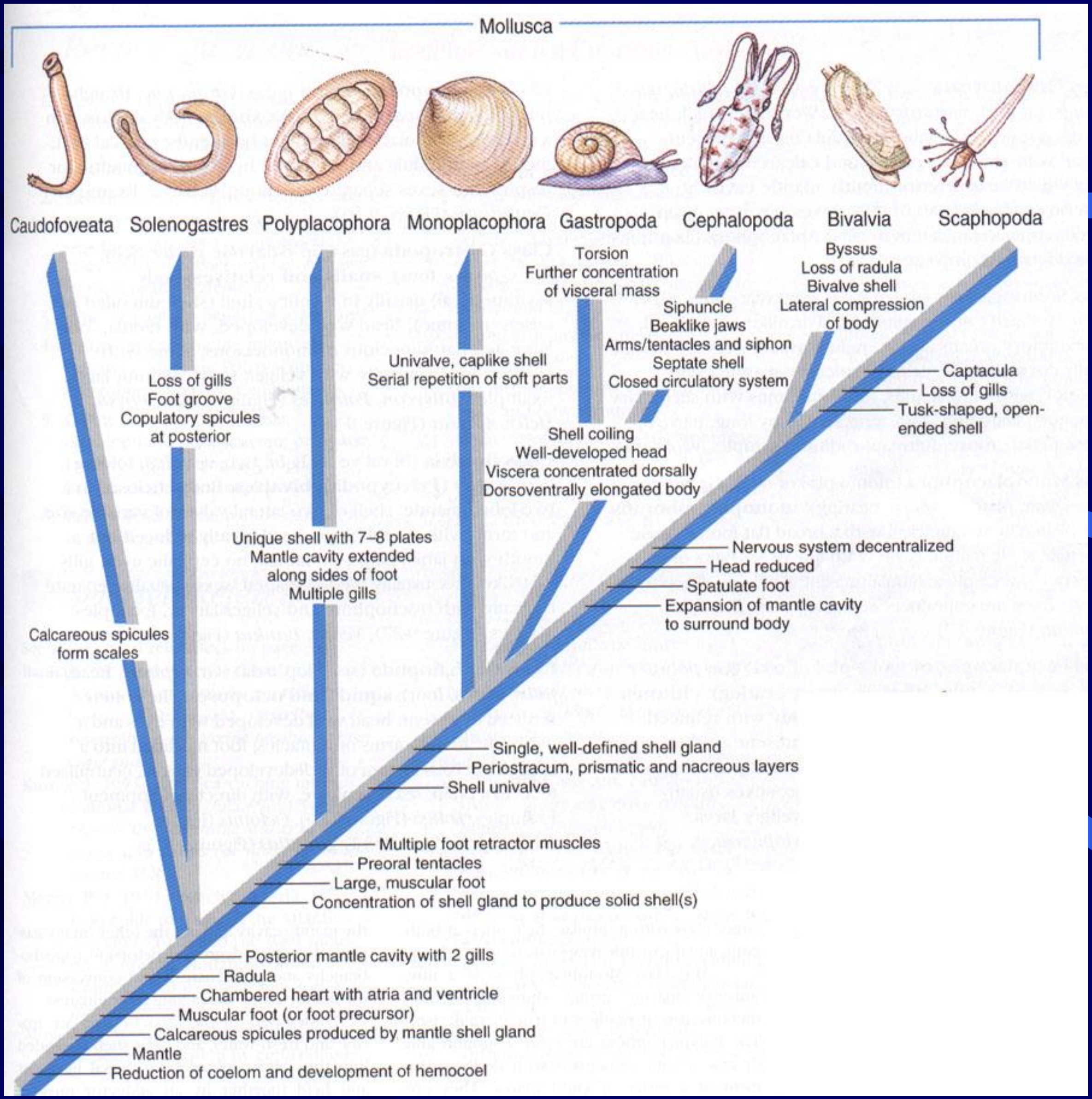
Class Monoplacophora cont.



Neopilina sp.

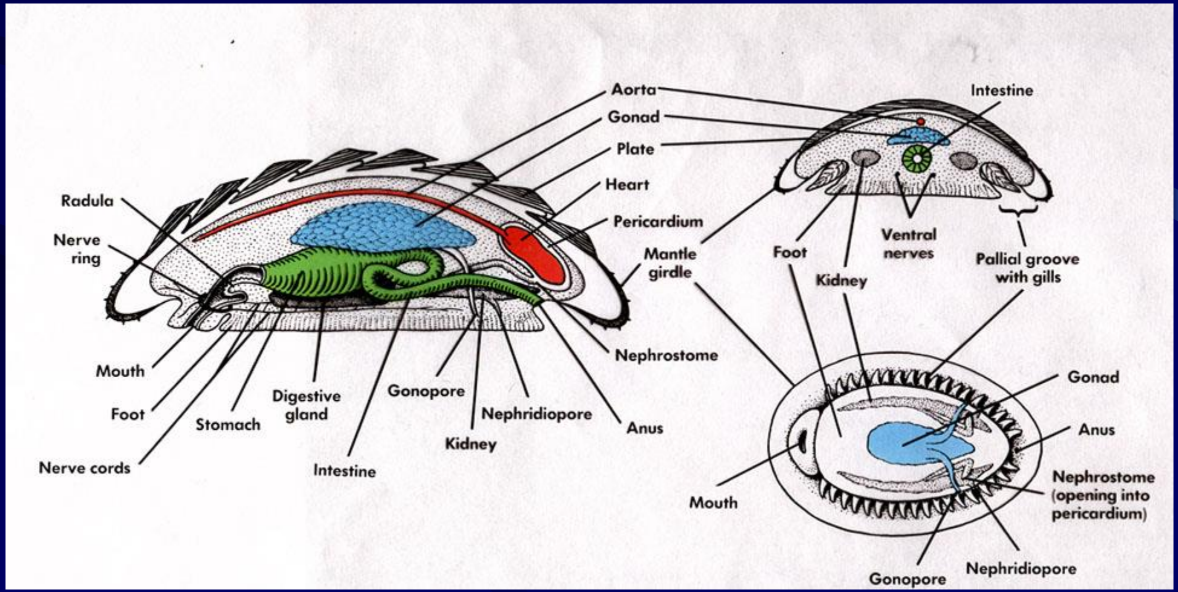
Evolutionary relations with other Molluscs

- Embryological data does hint to a phylogenetic relationship among the annelids and molluscs
- Monoplacophorans are thought to be ancestral to several other molluscan classes



Class Polyplacophora (Chitons)

- Common on the rocky surfaces of the intertidal zone
- Head is poorly developed; ventral surface occupied by a broad, flattened foot
- Has a dorsal shell composed of 8 overlapping plates, arranged linearly along the anterior-posterior axis
- Lateral margins of the plates are overgrown to varying degrees by the **girdle**
- Mantle cavity is limited to two lateral troughs between the foot and the mantle edge = **pallial grooves**
- Within the grooves lie many bipectinate gills



Class Gastropoda

• Three evolutionary innovations occurred among the gastropods: changes in the shell, increased development of the head, the embryonic process of torsion

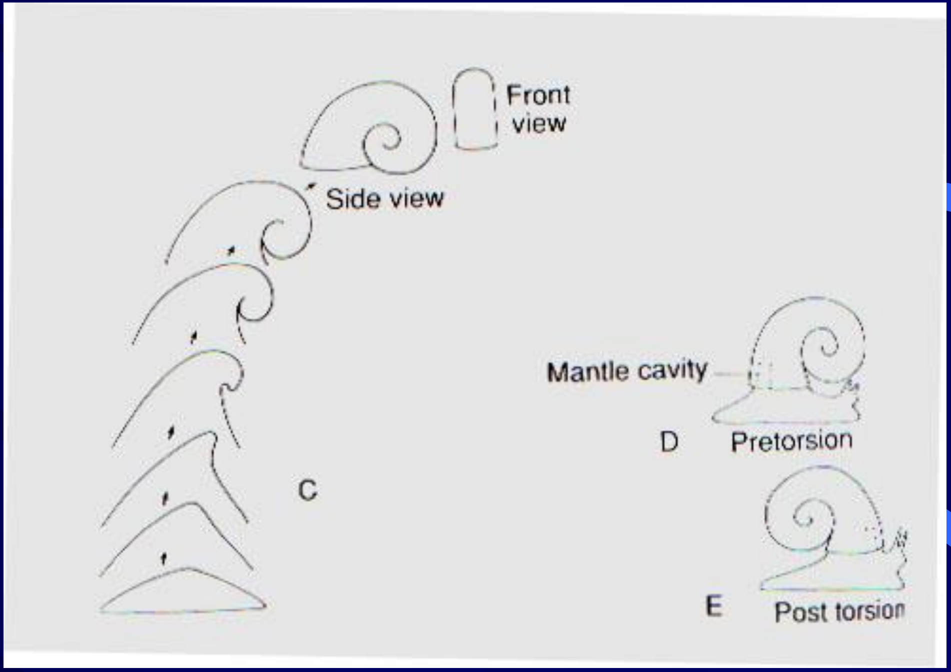
1. Changes in the Shell

• The shell became higher and conical with a reduced aperture

• The shell also became coiled

• Shells initially were **planospiral** - bilaterally symmetrical shell with the whorls lying in the same plane

• Modern day shells are asymmetrical - each successive coil is a little outside and offset a little above the one below



Why was there a change in shell architecture?

- Planospiral shell was not as compact as the asymmetrical shell
- But, this change in symmetry of the shell created a shift in the weight to one side of the animal
- To achieve a better weight distribution, the shell needed to shift upward and posterior
- The shell axis then became oblique to the longitudinal axis of the foot (= bilateral asymmetry)
- The weight and bulk of the main body whorl, pressed on the right side of the mantle cavity; thus, many of the organs on the right side became lost during evolution

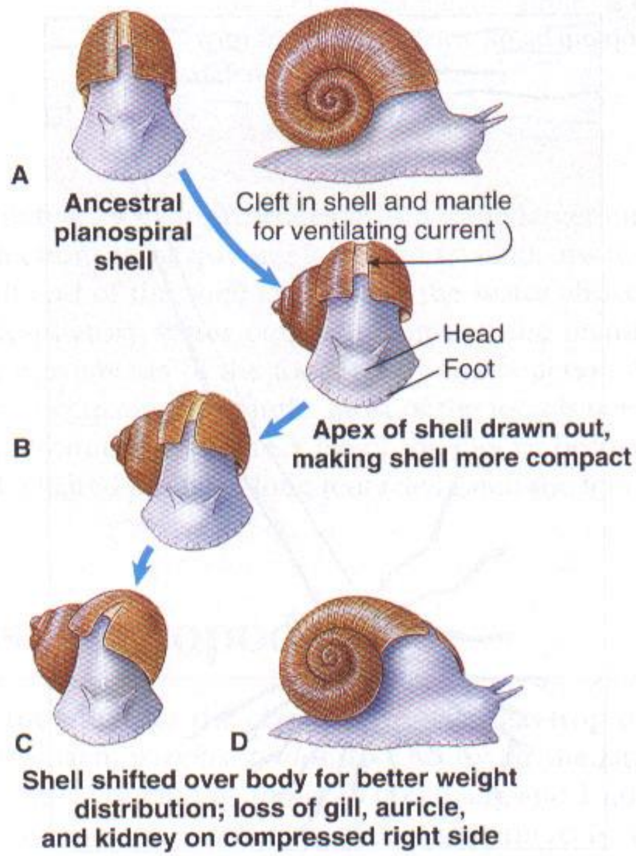


FIGURE 9-12

Evolution of shell in gastropods. **A,** Earliest coiled shells were planospiral, each whorl lying completely outside the preceding whorl. Interestingly, the shell has become planospiral secondarily in some living forms. **B,** Better compactness was achieved by snails in which each whorl lay partially to the side of the preceding whorl. **C** and **D,** Better weight distribution resulted when shell was moved upward and posteriorly.

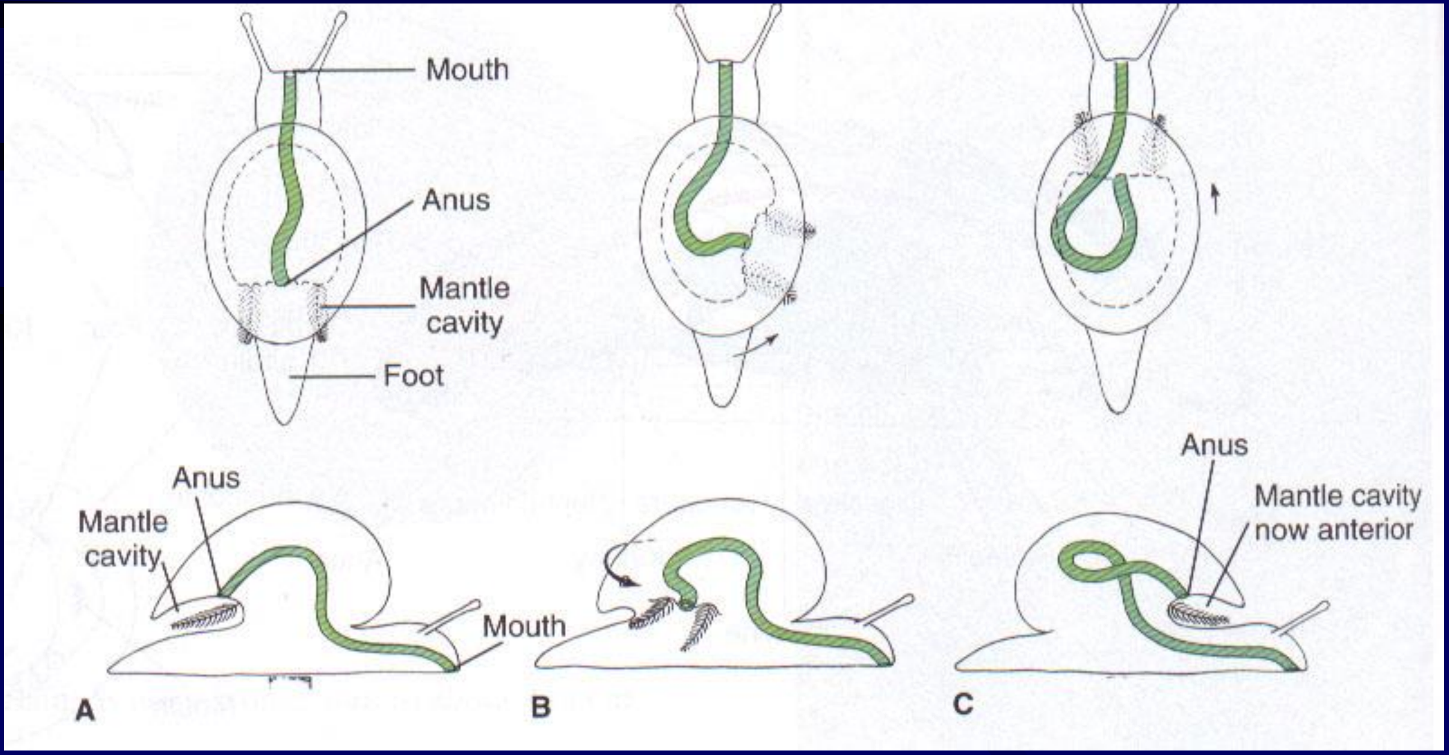
2. The Increased Development of the Head

- The head bears 2 pairs of tentacles, with the eyespots at the base of one pair

3. *The Embryonic Process known as Torsion*

During embryonic development, 1 side of the visceral mass grows at a much faster rate than the other.

- Causes the visceral mass to rotate 180 degrees relative to the head-foot.
- Advantages: head retracted first; gills receive water currents; the **osphradium** is now directed anteriorly
- Disadvantage: may cause **fouling**



Adaptations to Avoid Fouling

- Improved separation of inhalent and exhalent water flow
- In some of the more primitive gastropods (keyhole limpets), the shell contains a hole at the top through which the exhalent water stream exits
- In the more advanced gastropods, water is brought into the mantle cavity on the left side, passes over a single gill, and exits the right side

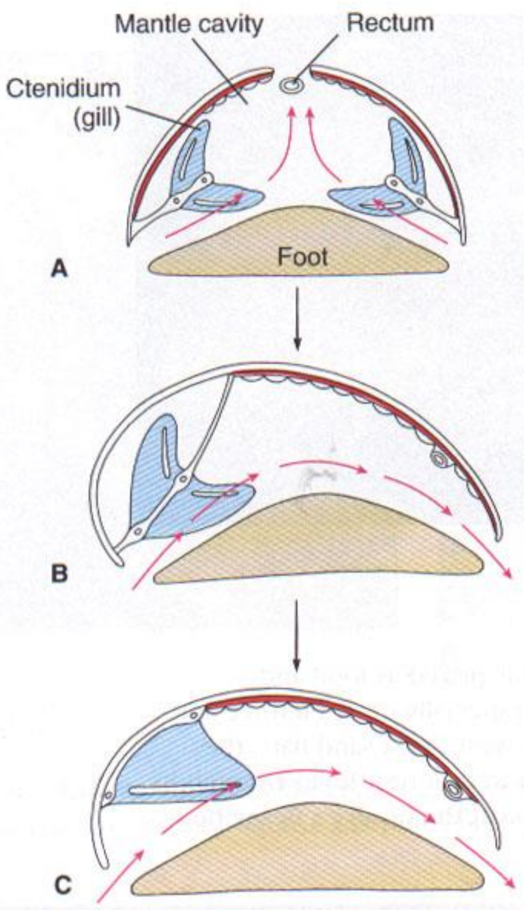


FIGURE 9-13

Evolution of the gills in gastropods. **A,** Primitive condition in prosobranchs with two gills and excurrent water leaving the mantle cavity by a dorsal slit or hole. **B,** Condition after one gill had been lost. **C,** Advanced condition in prosobranchs, in which filaments on one side of remaining gill are lost, and axis is attached to mantle wall.

Shell

• Most have a single, spiraled shell and can move the entire head and foot into this shell for protection.
• Also, many gastropods have a hardened plate called the **operculum** on the back of the foot that plugs the shell aperture when the body is withdrawn

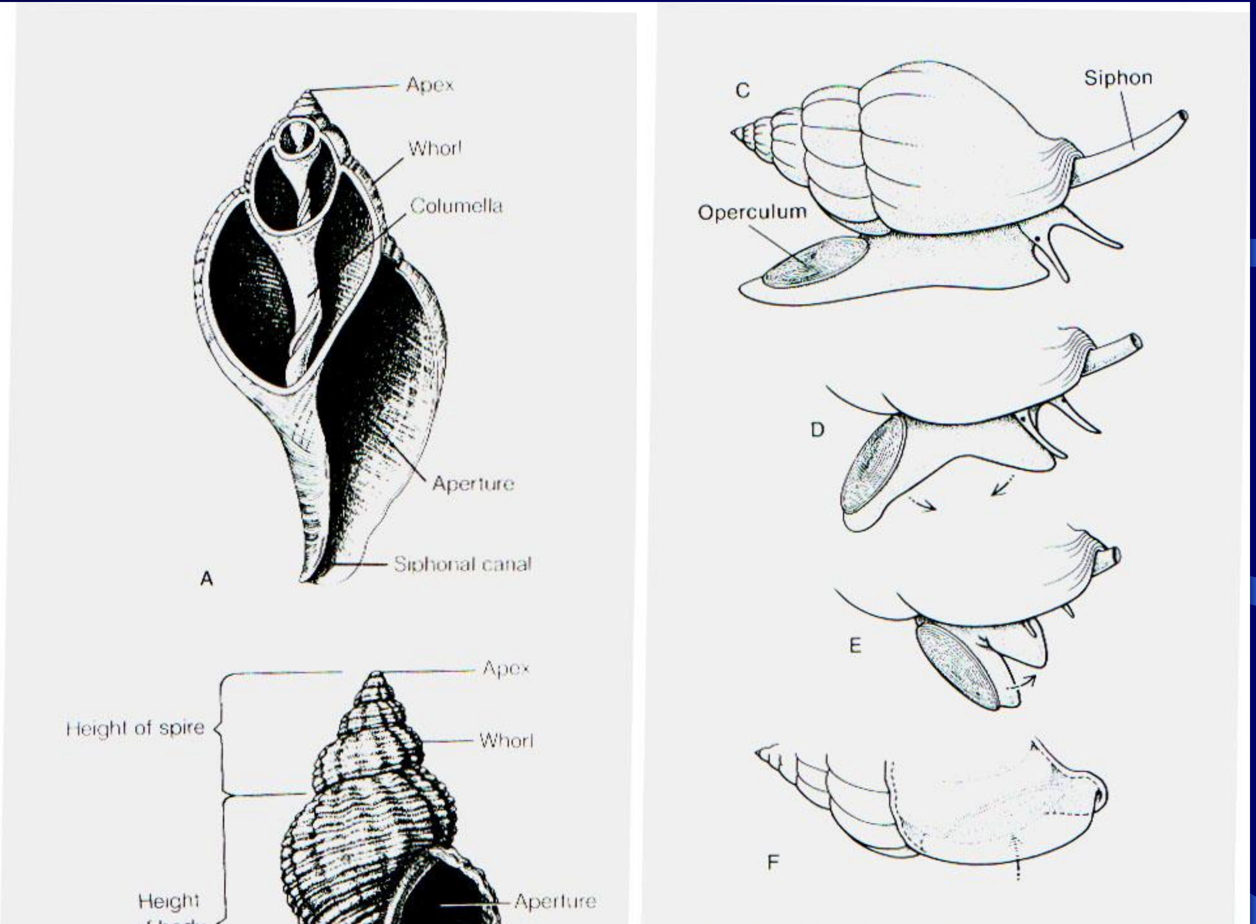
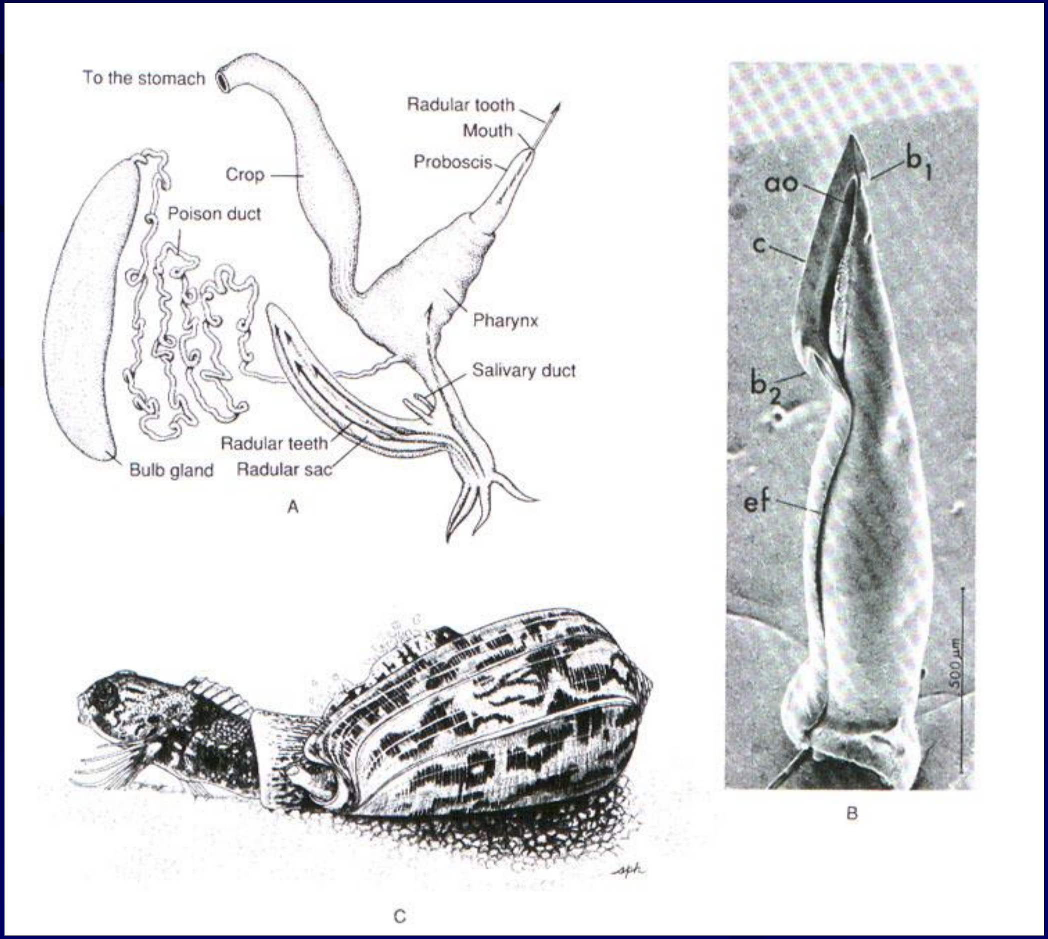


FIGURE 10–15 Gastropod shells. **A,** Longitudinal section through a shell. **B,** Shell of the oyster drill *Urosalpinx cinerea*, showing commonly designated features. **C,** Gastropod with an operculum. **D–F,** Withdrawal into the shell and closure by the operculum. *(B. After Turner.)*

Nutrition

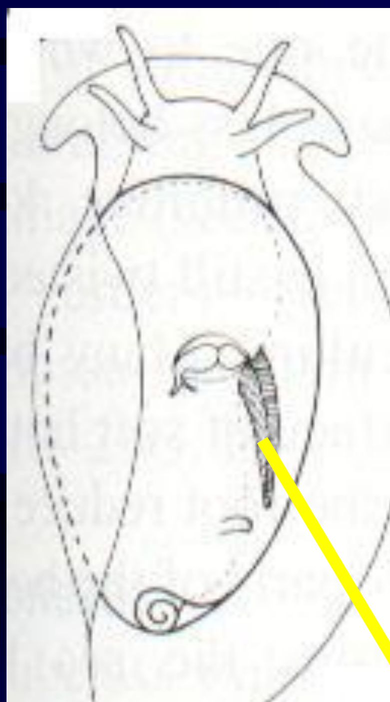
- Many gastropods are herbivores and use their radula scrap algae from surfaces of rocks
- Some gastropods are active predators and in these the radula is often highly modified, e.g., as a drill (oyster drills) or harpoon (venomous gastropods)

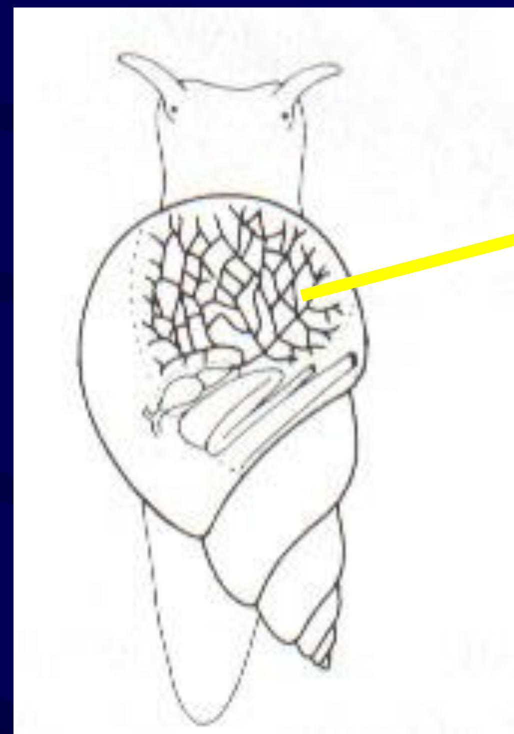


Cone snail

Respiration

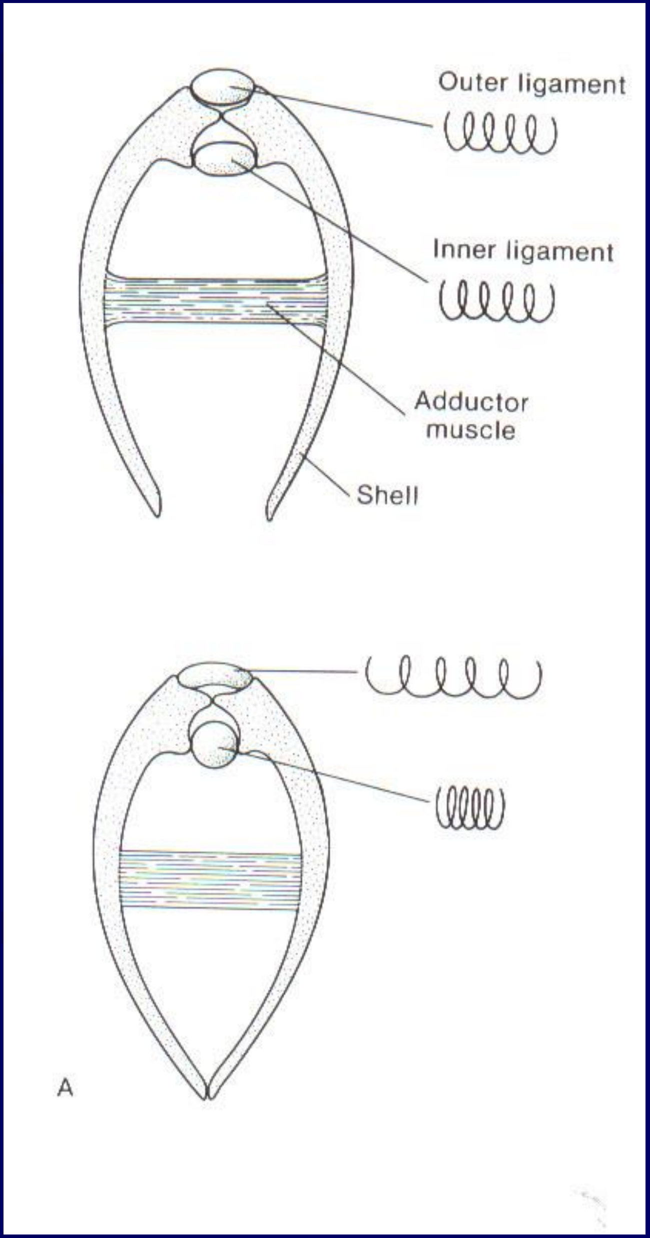
- Aquatic gastropods possess gills for respiration
- Terrestrial gastropods obtain oxygen via a well vascularized mantle



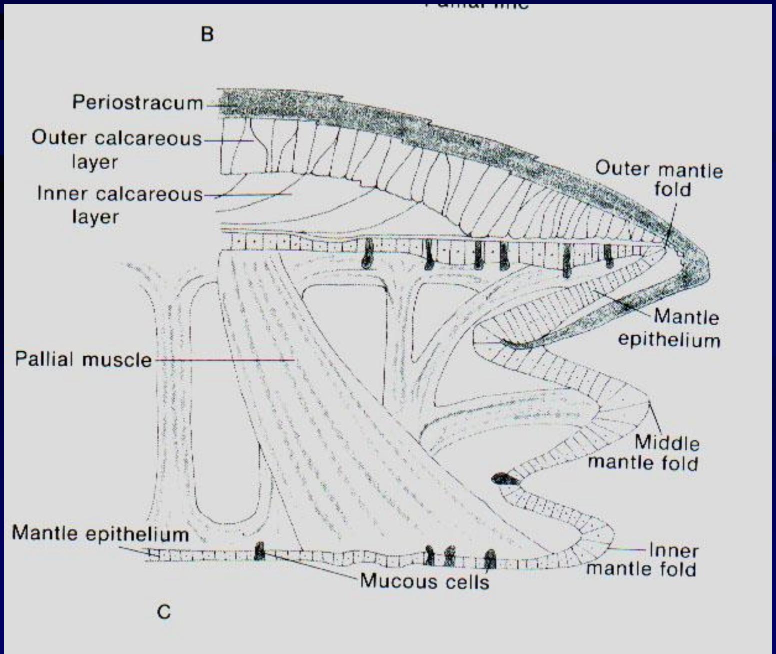


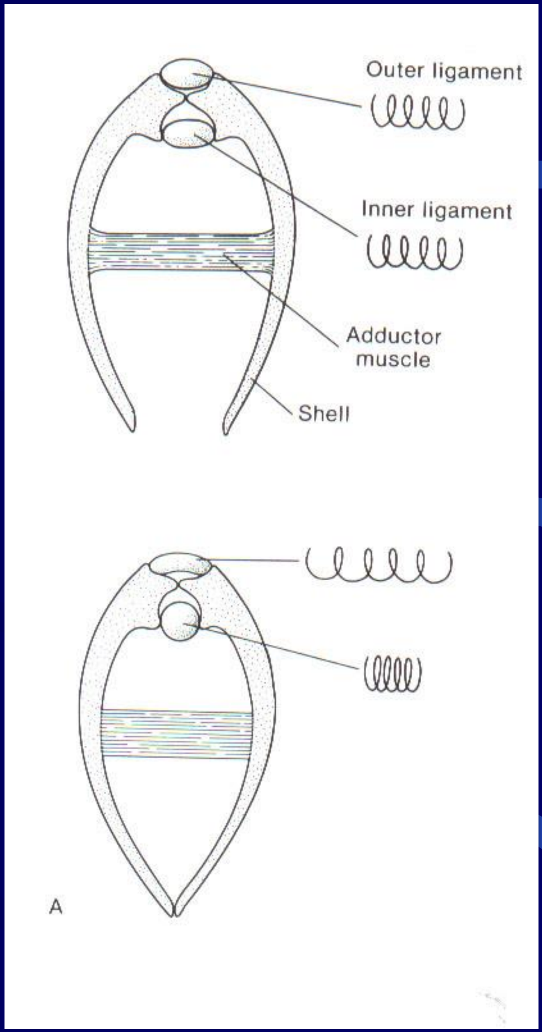
Class Bivalvia

• Shells divided into 2 equal halves or **valves**
• Mantle tissue is indented in the anterior-posterior margins, with 2 centers of calcification
• Shells joined at the dorsal midline by a non calcified protein ligaments called the **hinge**



• **Pallial muscles** insert on the underside of the shell and are attached to the free edge of the mantle; pull the mantle under the shell
• Muscles fused across the width (from left to right) at 1 anterior and posterior position and form **adductor muscles**; connect the 2 shell across their width; close the shell
• When relaxed, shell swings open due to elastic ligaments of the hinge

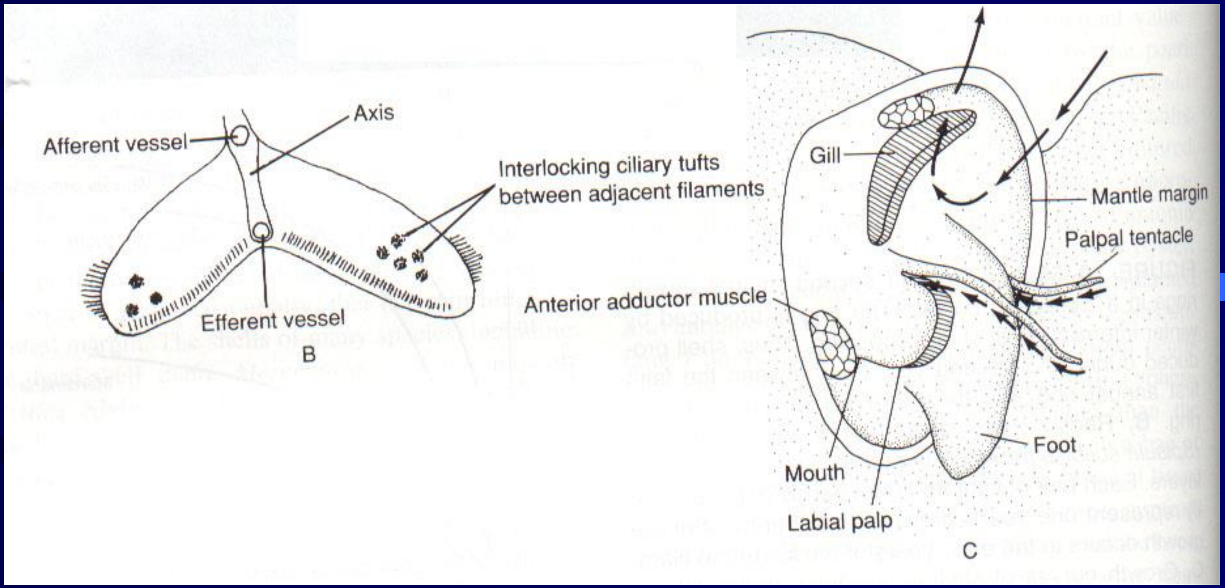




Protobranchs (Subclass Protobranchia)

• Possess a small foot

• Gills are *bipectinate;* cilia on the face of the gills - **lateral cilia** - generate water currents



• Protobranchs are *deposit feeders*

• A pair of elongate, ciliated **palp probosci** are extended from the animal into the substrate

• Each tentacle is associated with 2 **labial palps**

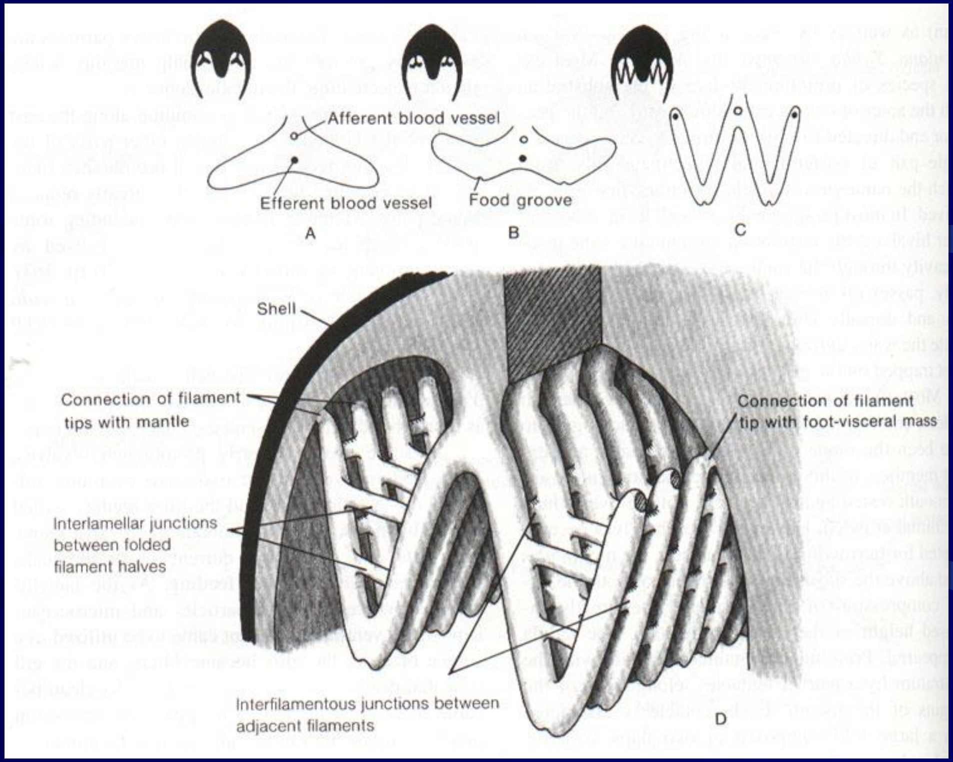
• During feeding the probosci are extended into the sediment and the cilia bring sediments with food toward the palps

• Before material enters into the mouth it is sorted by cilia on the palps

• Rejected material is **pseudofeces**

Lamellibranchs (Subclass Lamellibranchia)

• Gills play an important role in feeding: of the total volume of water that is processed by gills only 5% is required for gaseous exchange; 95% of the volume is used to supply the animal with food

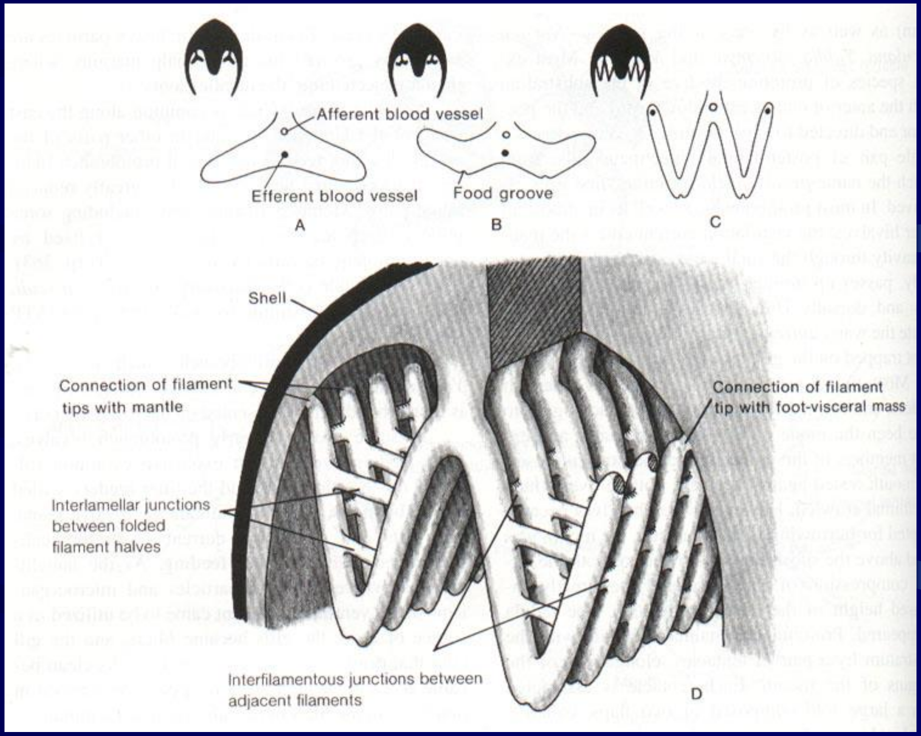


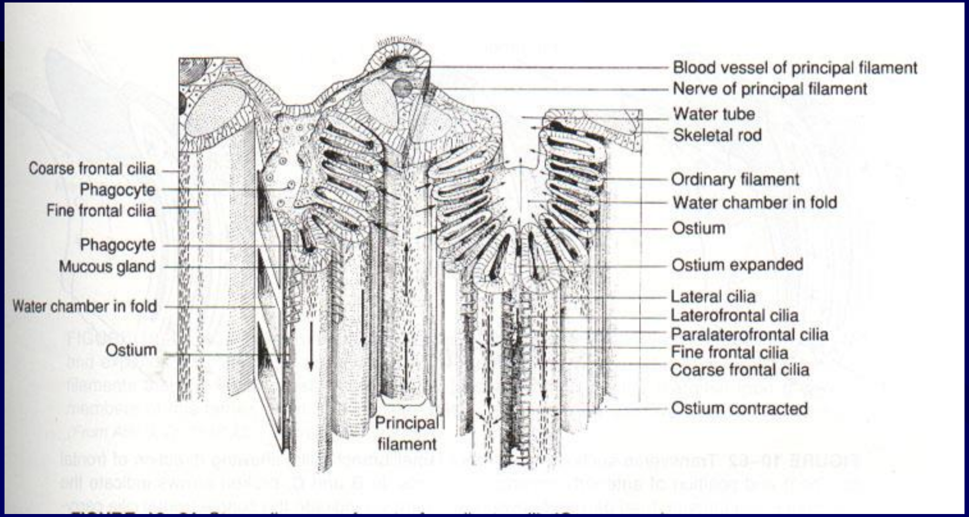
• There were 2 principal modification of in the lamellibranch gill:

1. Lengthening in the anterior-posterior perspective, forming a series of gill filaments
2. Flattening and folding of the gill filaments, greatly increasing surface area

More Regarding Gills and Filter Feeding

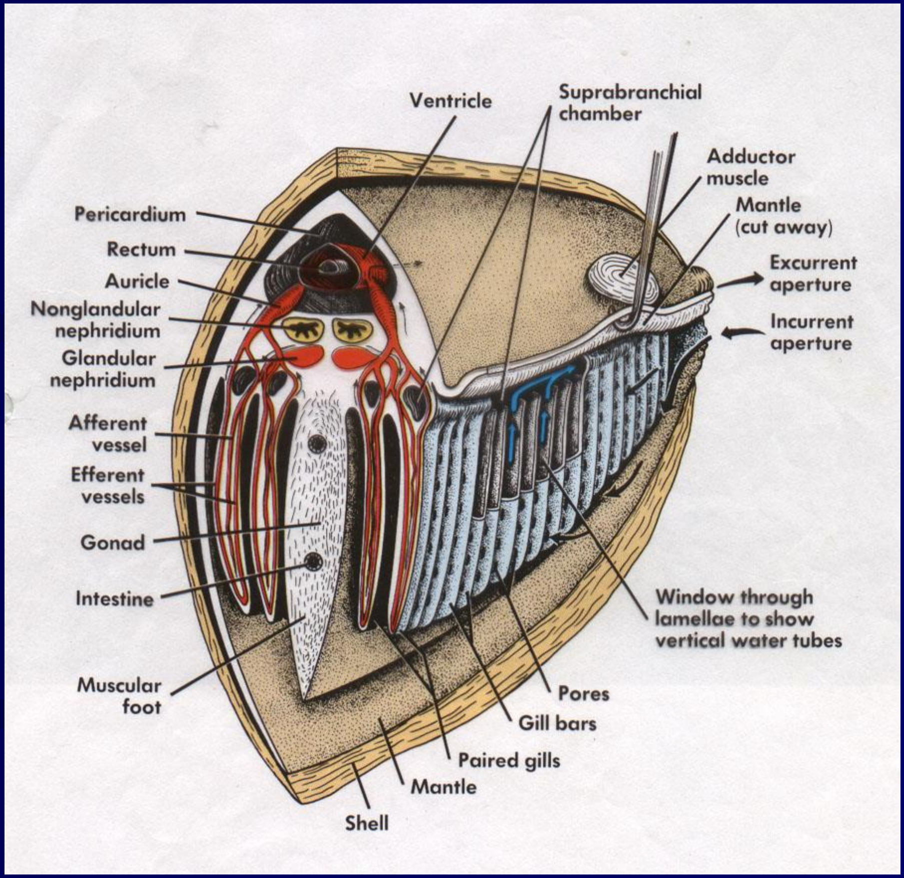
• The long folded filaments are supported by the development of cross connections between the two halves, by connections between adjacent filaments, and by connection of the tips of the filaments to the foot or mantle wall





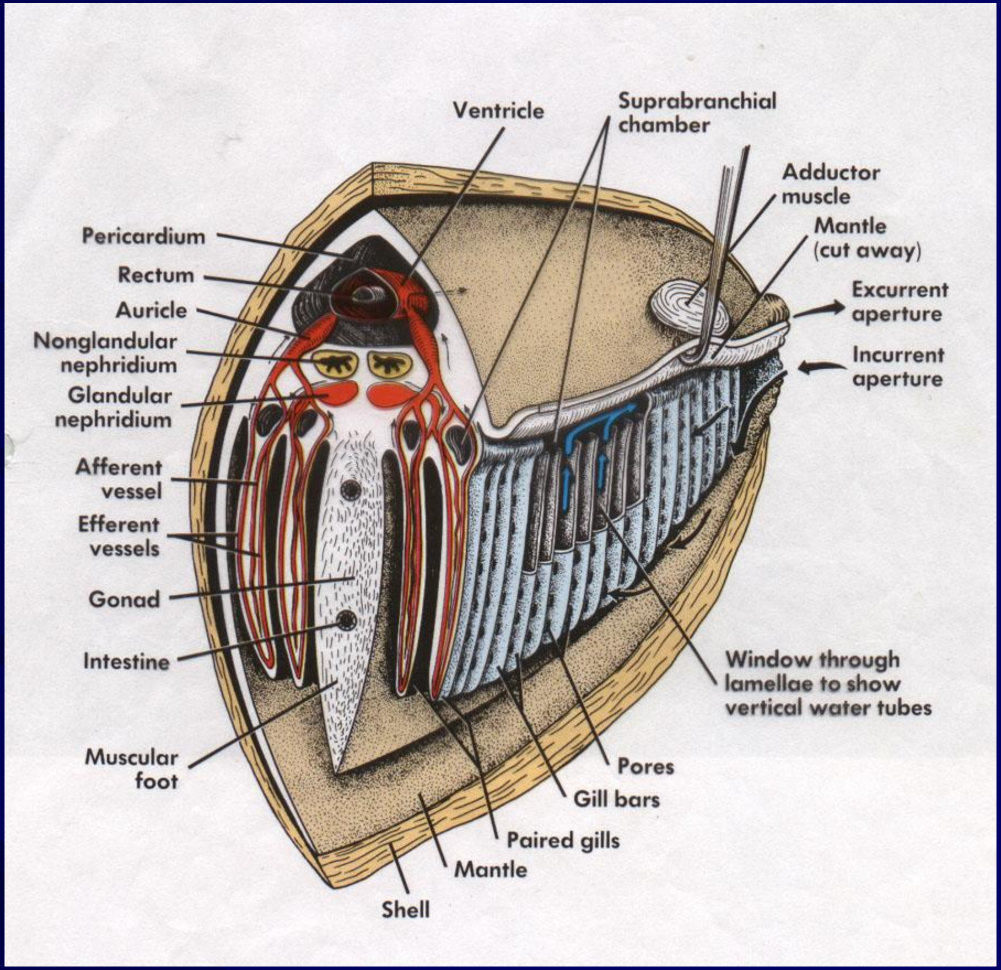
More Regarding Gills and Filter Feeding

- Lengthened filaments and their attachment to one another give the gills a sheet-like appearance
- Cilia in between the gill filaments generate the water current and other cilia are used to filter out food from the
- Where adjacent filaments are tightly connected, openings **(ostia)** remain for the passage of water between the filaments
- The interior space between the two folded halves of the filaments forms **water tubes,** which connect with the **suprabranchial cavity**



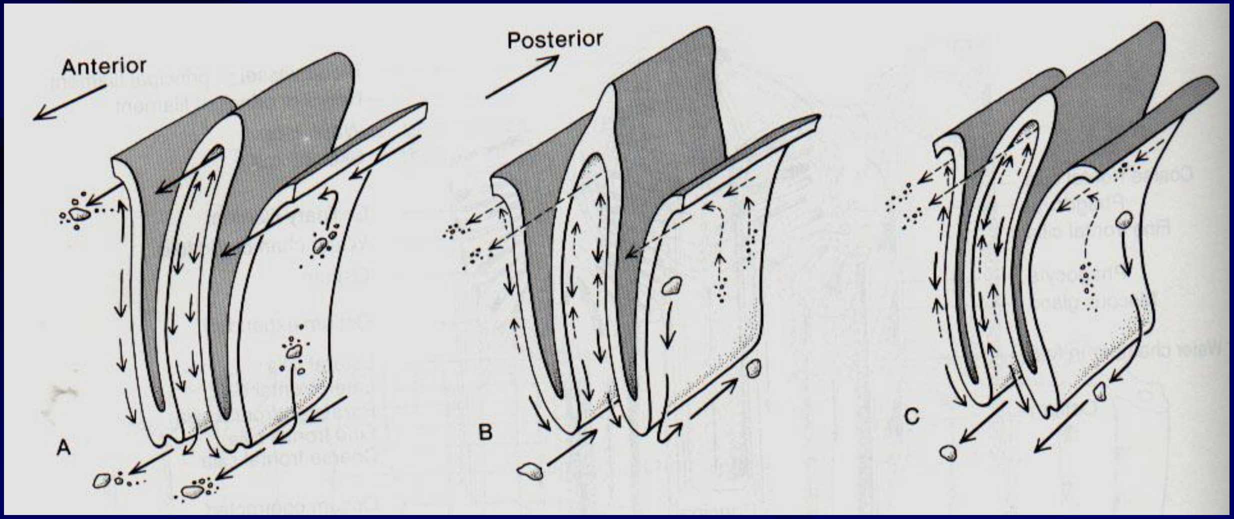
Movement of the Ventilating Currents

- In lamellibranchs, the ventilating currents enter posteriorly and ventrally
- Upon reaching the gills, there are cilia that bring it in through the ostia and into the water tubes
- Now water flows upward to the suprabranchial cavity, where it turns posteriorly and flows outward through the shell gape

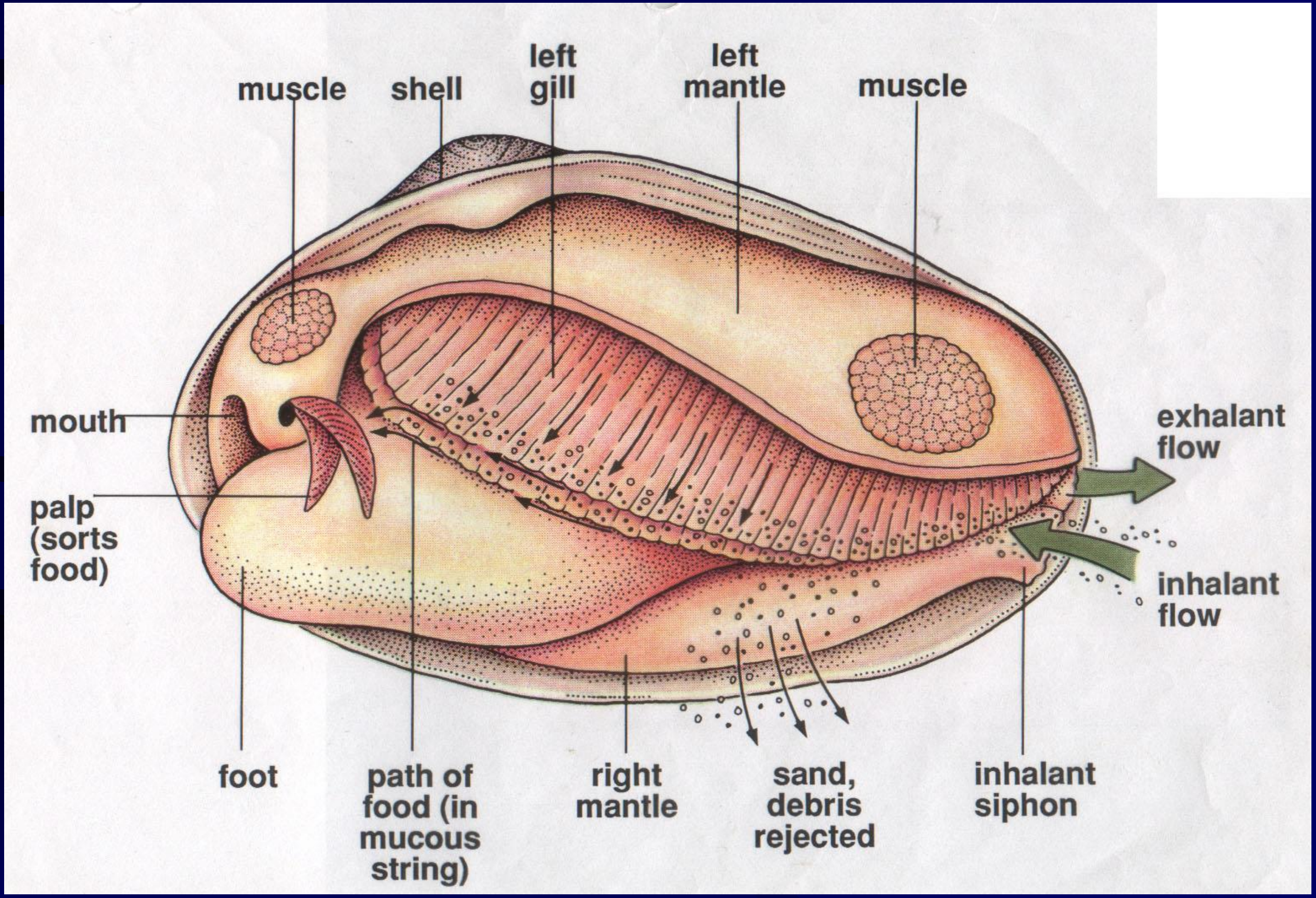


Movement of the Ventilating Currents

- Some kinds of cilia on the gills are used to trap food particles suspended in the water and move the trapped food over the surface of the gills toward **food grooves**
- Once here, food is directed anteriorly toward the mouth
- On route to the mouth cells in the gills secrete copious amounts of mucous, in which the food particles become entangled
- Prior to entering the mouth the mucous food thread is first sorted by the *labial palps*



Movement of the Ventilating Currents



Adaptive Radiation of Bivalves

Soft Bottom Burrowers

- Those that live deep in the sand or mud; burrowing is accomplished using the foot that is extended through a specific part of the shell - the **pedal gap**
- These molluscs have long tubular extensions of the mantle called **siphons,** with both inhalent and exhalent opening

Attached Surface Dwellers

- Those that live attached to hard surfaces
- Some (i.e. oysters) lie on their side and have one of the shell fused or cemented to the substrate; foot is absent
- The common mussels attach to the substrate by means of **byssal threads,** secreted by glands in the foot; foot is reduce in the organisms

Adaptive Radiation of Bivalves con't

Unattached Surface Dwellers

- Rest unattached on the substrate
- Capable of limited locomotion by rapid clapping of their valves using a powerful adductor muscle; forces a jet of water out of the mantle cavity

Hard Bottom Burrowers

- Several species of bivalves are capable of burrowing into hard surfaces such as rock, coral, wood
- Use the anterior margins of their shell to chip away at the rock; some secrete chemical to breakdown rock

Adaptive Radiation of Bivalves

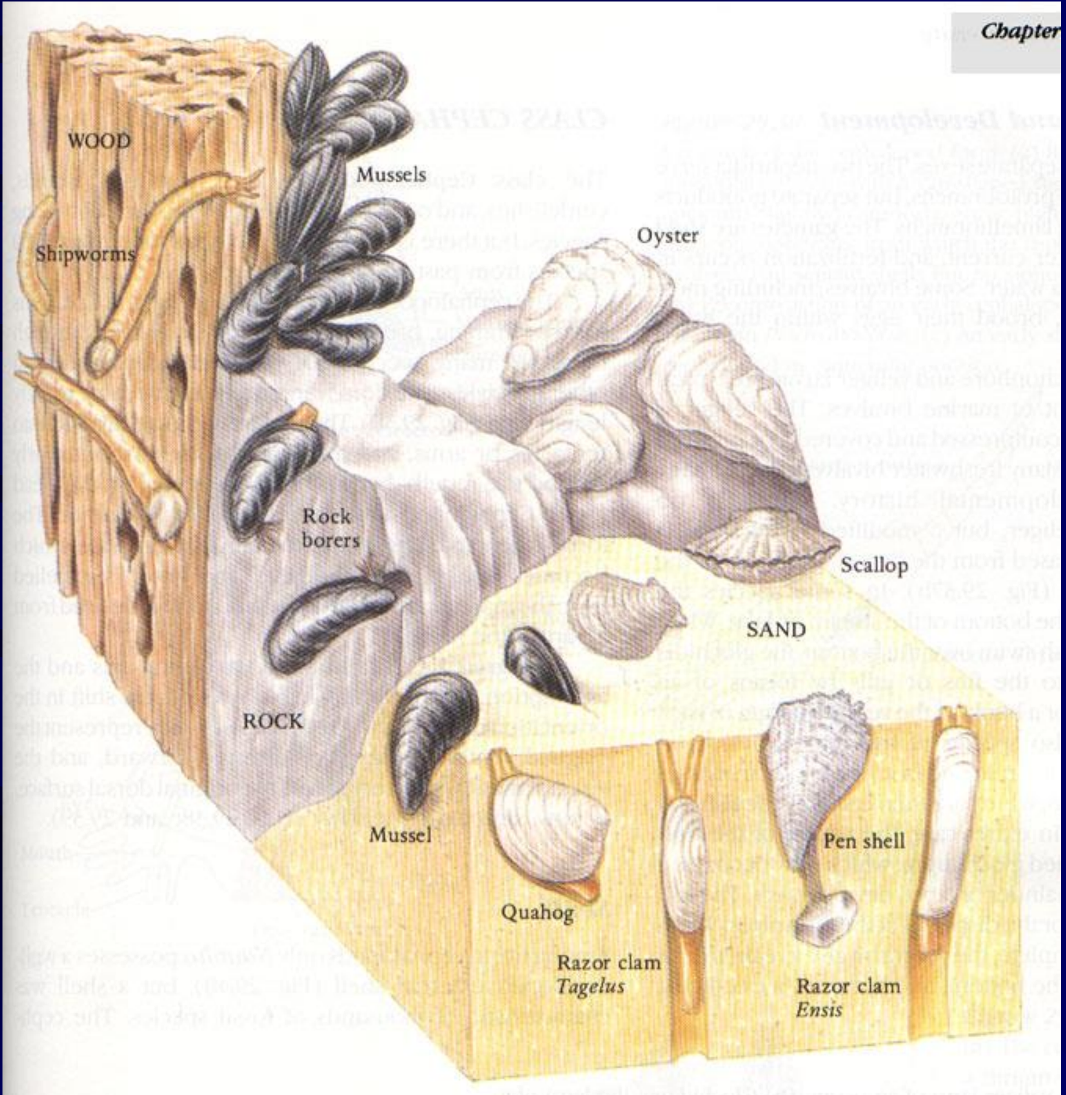
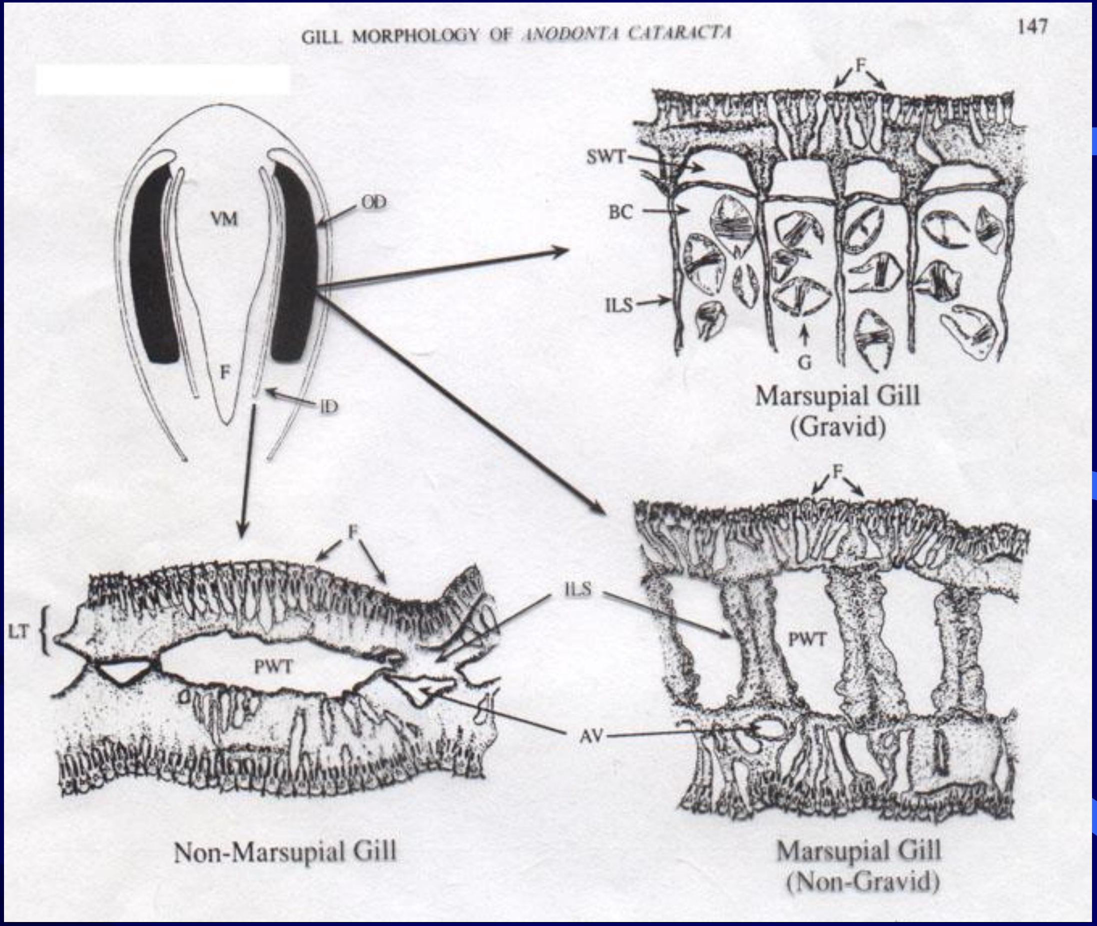


Figure 29.35
Bivalve life styles. All of these species would not found together in the same location as depicted here.

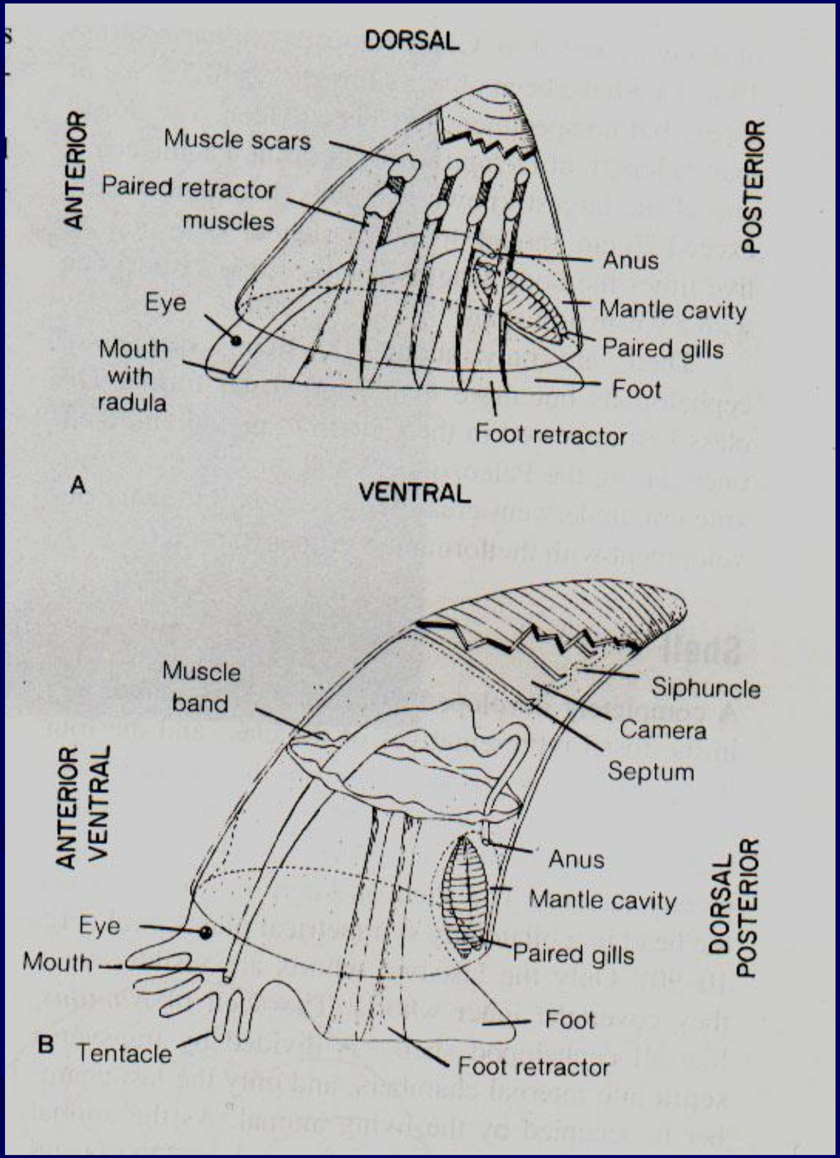
Reproduction

- Most are dioecious
- Marine forms usually produce free swimming trochophore and veliger larvae
- Many of the freshwater bivalves have a different life history pattern; produce larvae called **glochidia**
- Glochidia are housed in the outer gills; they use there outer gill as a brood camber - **marsupium**
- When the glochidia are released they parasitize the fins and gills of fishes



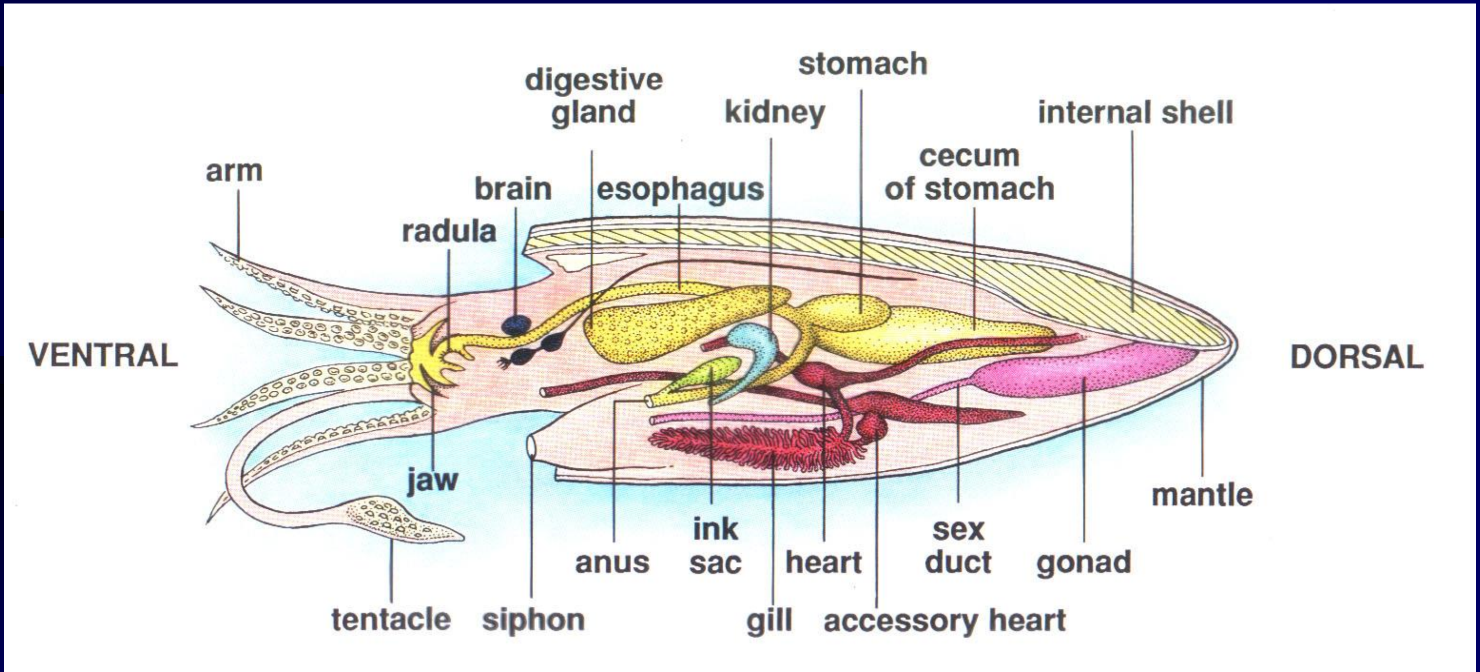
Class Cephalopoda

- Fast moving predators of the marine environment
- Cephalopods evolved following major readjustments in the HAM body plan:
- Dorso-ventral axis became elongated and the anterior-posterior axis became compressed
- Migration of the head to the ventral part of the body where it fused to the foot
- The foot is modified as a series of prehensile tentacles or arms
- A circle of 8 or 10 tentacles surround the head; studded with suckers and are used to capture prey.



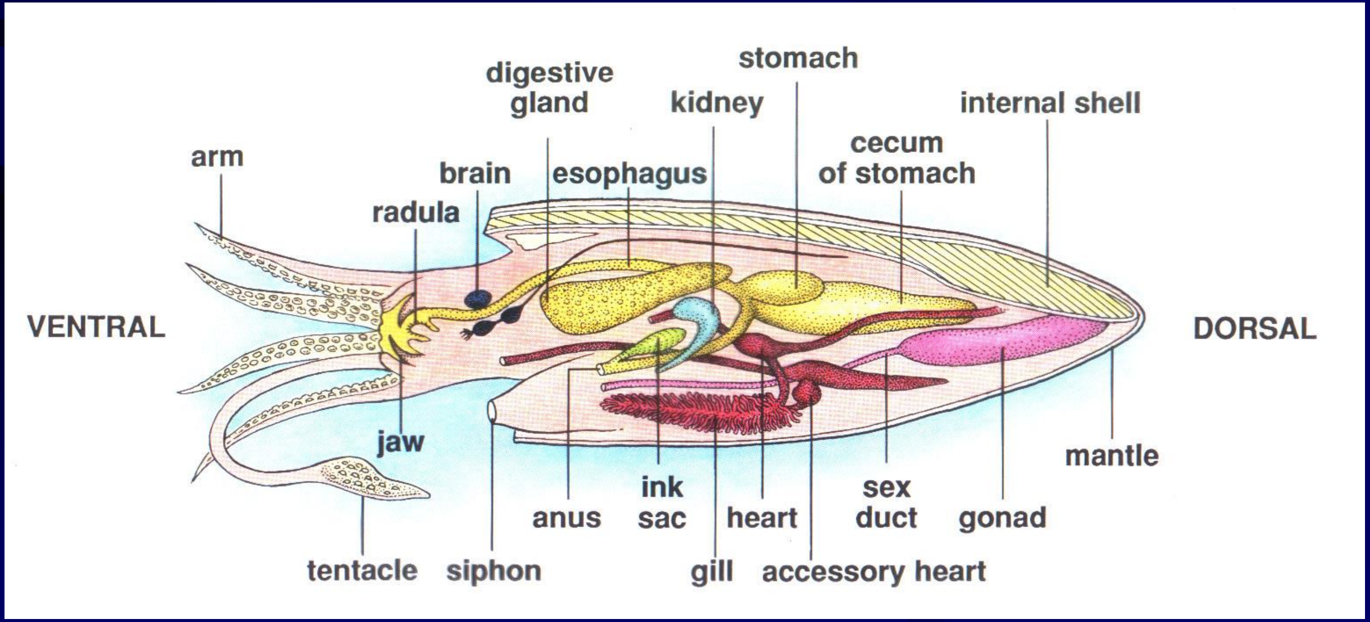
Feeding

- Cephalopods are carnivores
- Have a powerful parrot like beak that is used to tear prey apart.
- They also have a powerful radula
- In some of the octopuses the salivary glands are modified poison glands



Locomotion

- Cephalopods are excellent swimmers: streamlined body; tentacles and fins as stabilizers
- Swim by means of jet propulsion, using the highly modified muscular mantle and the **siphon**
  - By relaxing the mantle the mantle cavity is expanded and water can be drawn in
  - By contracting the mantle water can be forced out of the mantle cavity by means of the small siphonal opening



Shell

• Primitively the cephalopods possessed a shell; the fossil record indicates both coiled and non-coiled shells

• Extant members with coiled shells include Nautilus

• Some cephalopods (cuttlefishes) have an internal shell - cuddle bone

•The octopods have lost the shell entirely

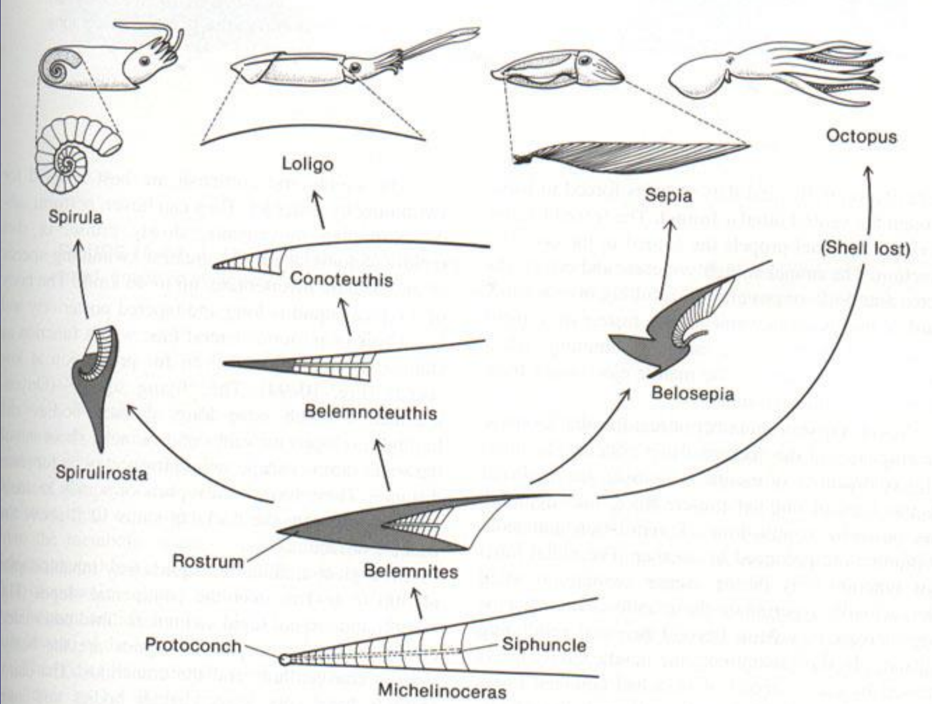
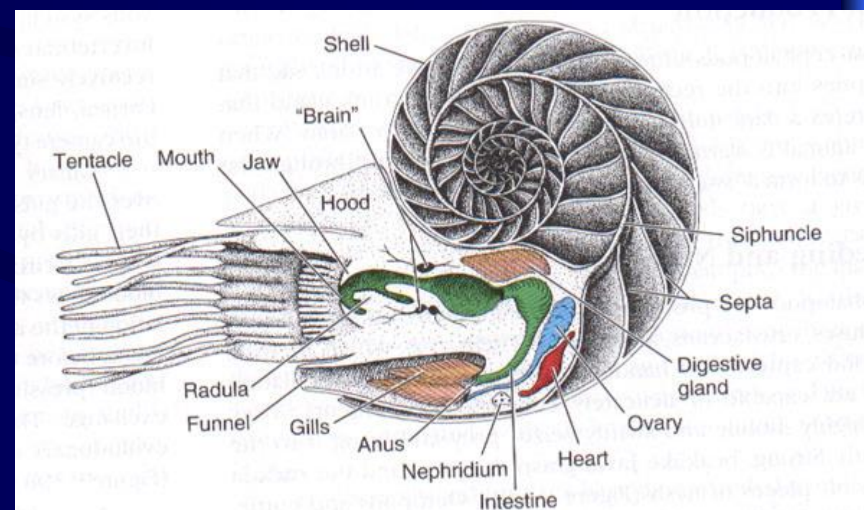


FIGURE 10–92 Evolution of shells of the Coleoidea. *(After Shrock and Twenhofel.)*



Other General Features

- For protection, they possess an **ink sacs**
- Cephalopods have well-developed sense organs, including a camera type eye
- Some have well-developed brains and show a remarkable capacity for learning.
- Cephalopods are the only molluscan class with a **closed circulatory system**

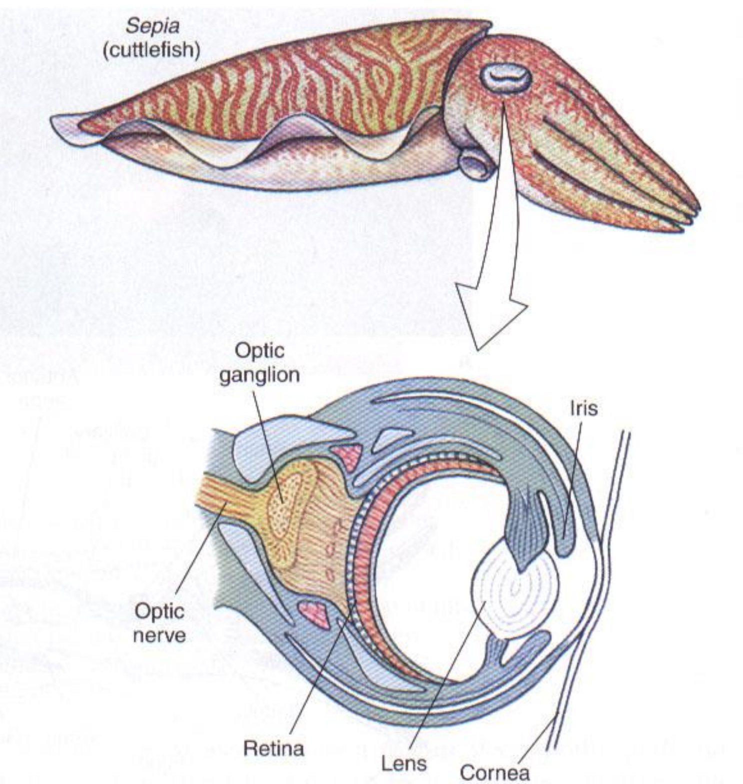
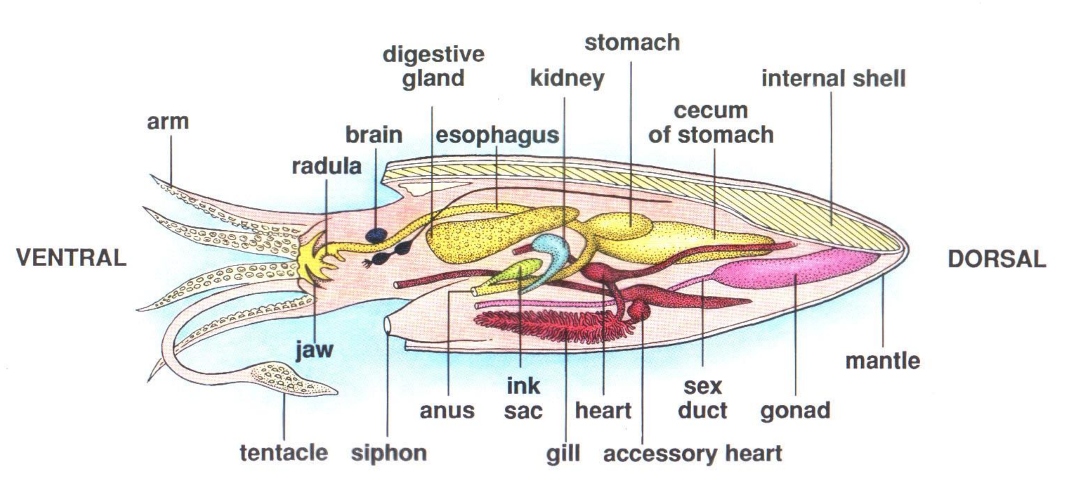


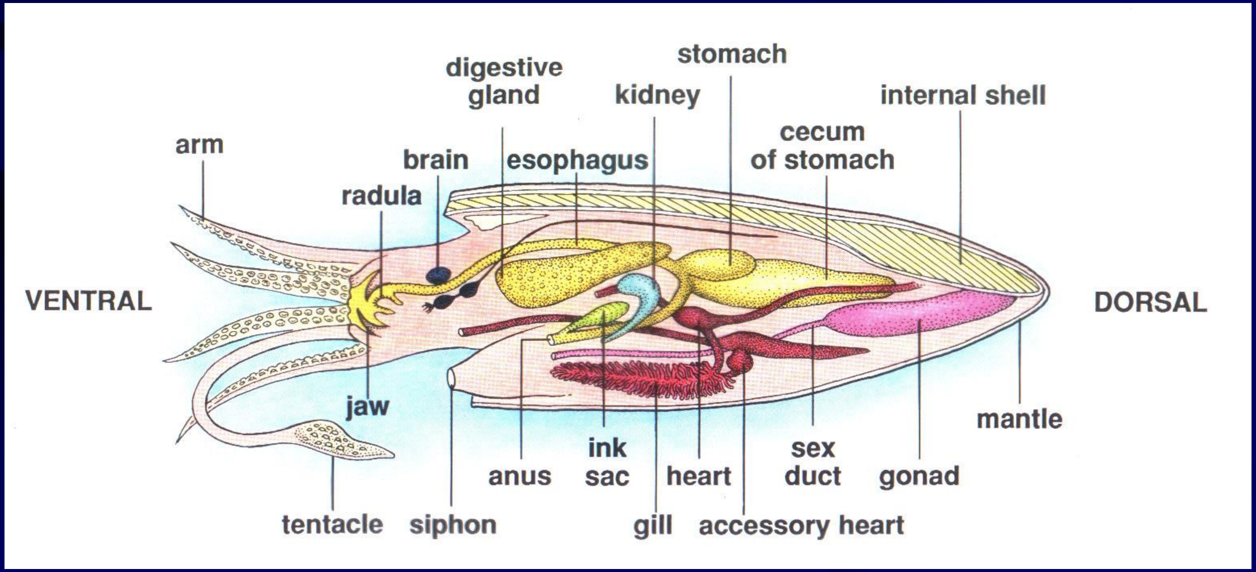
FIGURE 9-33

Eye of a cuttlefish (*Sepia*). The structure of cephalopod eyes shows a high degree of convergent evolution with the eyes of vertebrates.

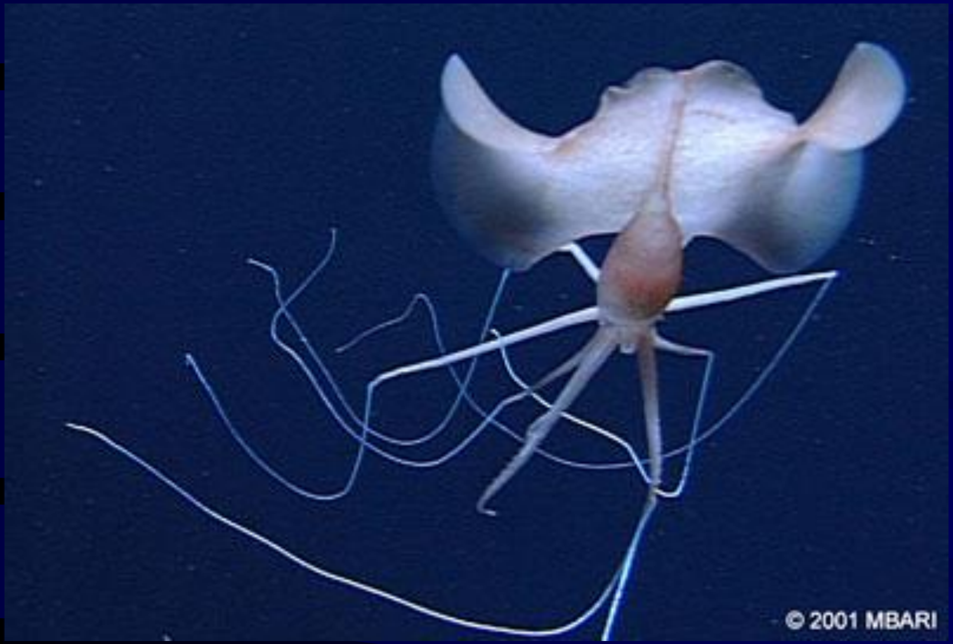


Reproduction

- Sexes are separate
- Sperm is transferred to females in packets - **spermatophores**
- Male uses a tentacle to reach into its mantle cavity and pick up some spermatophores
- It then inserts the tentacle into the mantle cavity of the female near or within the oviduct



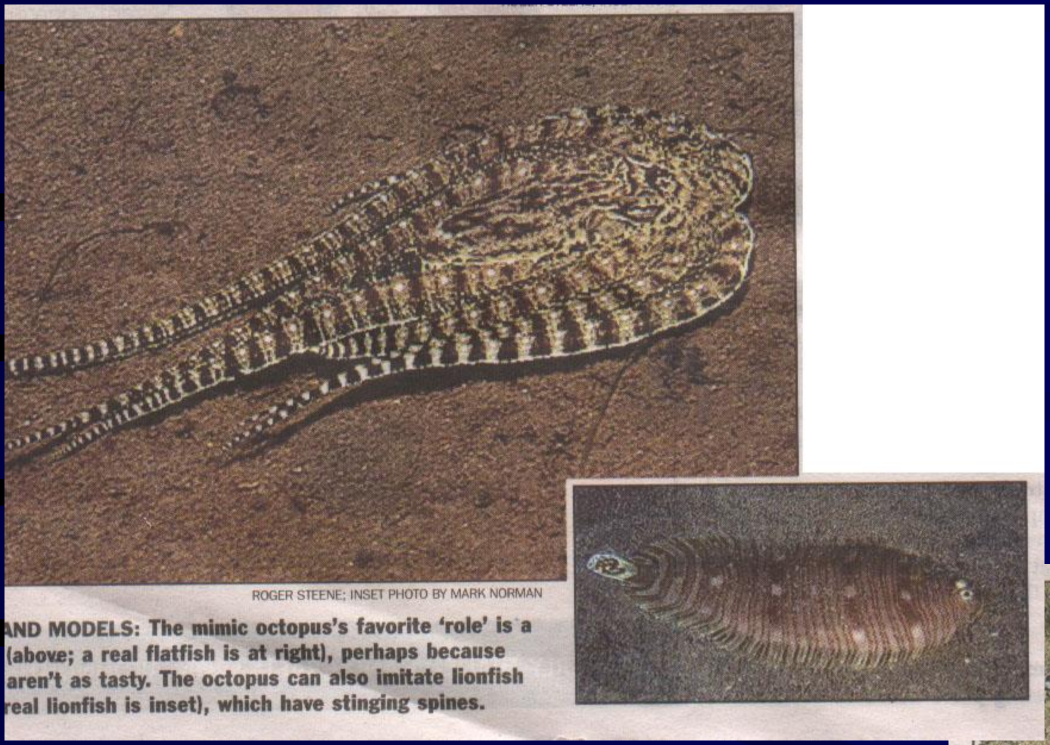
Examples of Cephalopods

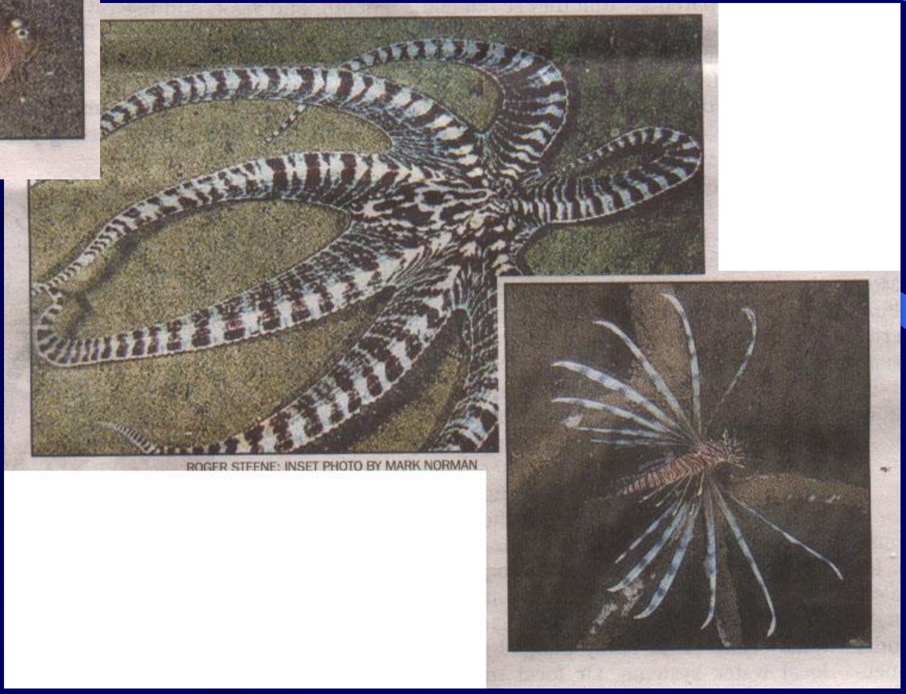


• Close-up view of an unknown species of bathypelagic squid encountered by ROV Tiburon at 3,380 meters depth off the coast of Oahu.
• This animal was estimated to be four to five meters in length.
• Different from other squids in that their eight arms and two tentacles are roughly equal in length and thickness.

• A giant squid (3.15-metre-long) has netted off the UK coast; first time in 15 years.
• The squid, believed to be female and three years old, did not survive being brought to the surface.

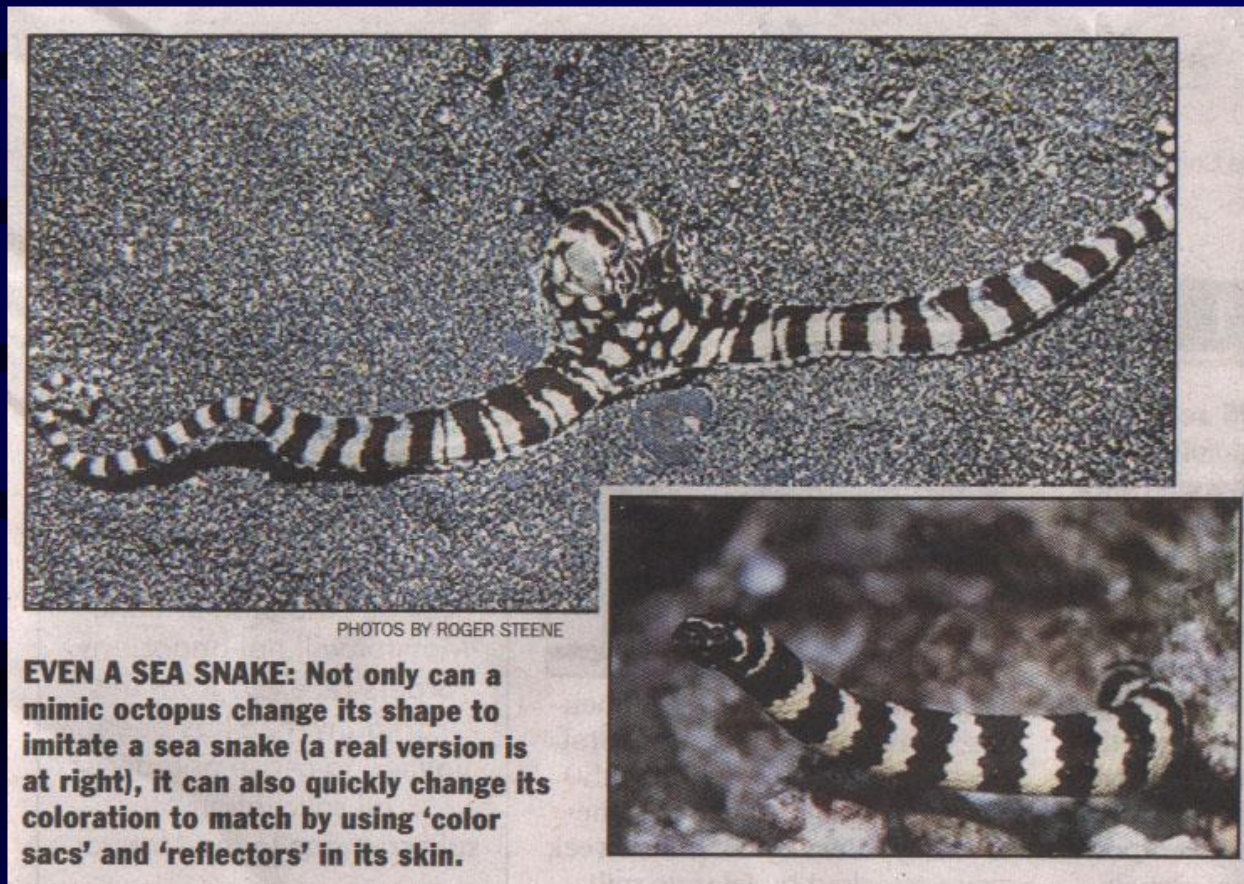
The Mimic Octopus





An Indonesian octopus mimicing a flatfish (above) and a lionfish (right)

The Mimic Octopus



PHOTOS BY ROGER STEENE

EVEN A SEA SNAKE: Not only can a mimic octopus change its shape to imitate a sea snake (a real version is at right), it can also quickly change its coloration to match by using 'color sacs' and 'reflectors' in its skin.