MOLLUSCAN SUCCESS

- Origin of the Coelom
- Molluscan Characteristics
- Class Gastropoda
  - Torsion, Shell Coiling, Locomotion, Feeding and Digestion, Other Maintenance Functions, Reproduction and Development, Gastropod Diversity
- Class Bivalvia
  - Shell and Associated Structures, Gas Exchange, Filter Feeding, and Digestion,Other Maintenance Functions, Reproduction and Development, Bivalve Diversity
- Class Cephalopoda
  - Shell Locomotion, Feeding and Digestion, Other Maintenance Functions, Reproduction and Development
- Class Polyplacophora
- Class Scaphopoda
- Class Monoplacophora
- Class Caudofoveata
- Class Aplacophora

FILTER FEEDING

- ✓ The gills trap food particles brought into the mantle cavity.
- ✓ The food-trapping mechanism is unclear, but once food particles are trapped, cilia move them to the gills' ventral margin.
- ✓ Cilia along the ventral margin of the gills then move food toward the mouth.
- ✓ Cilia covering leaflike labial palps on either side of the mouth also sort filtered food particles.
- ✓ Cilia carry small particles into the mouth and move larger particles to the edges of the palps and gills.
- ✓ This rejected material, called pseudofeces, falls, or is thrown, onto the mantle, and a ciliary tract on the mantle transports the pseudofeces posteriorly.
- ✓ Water rushing out when valves are forcefully closed washes pseudofeces from the mantle cavity.

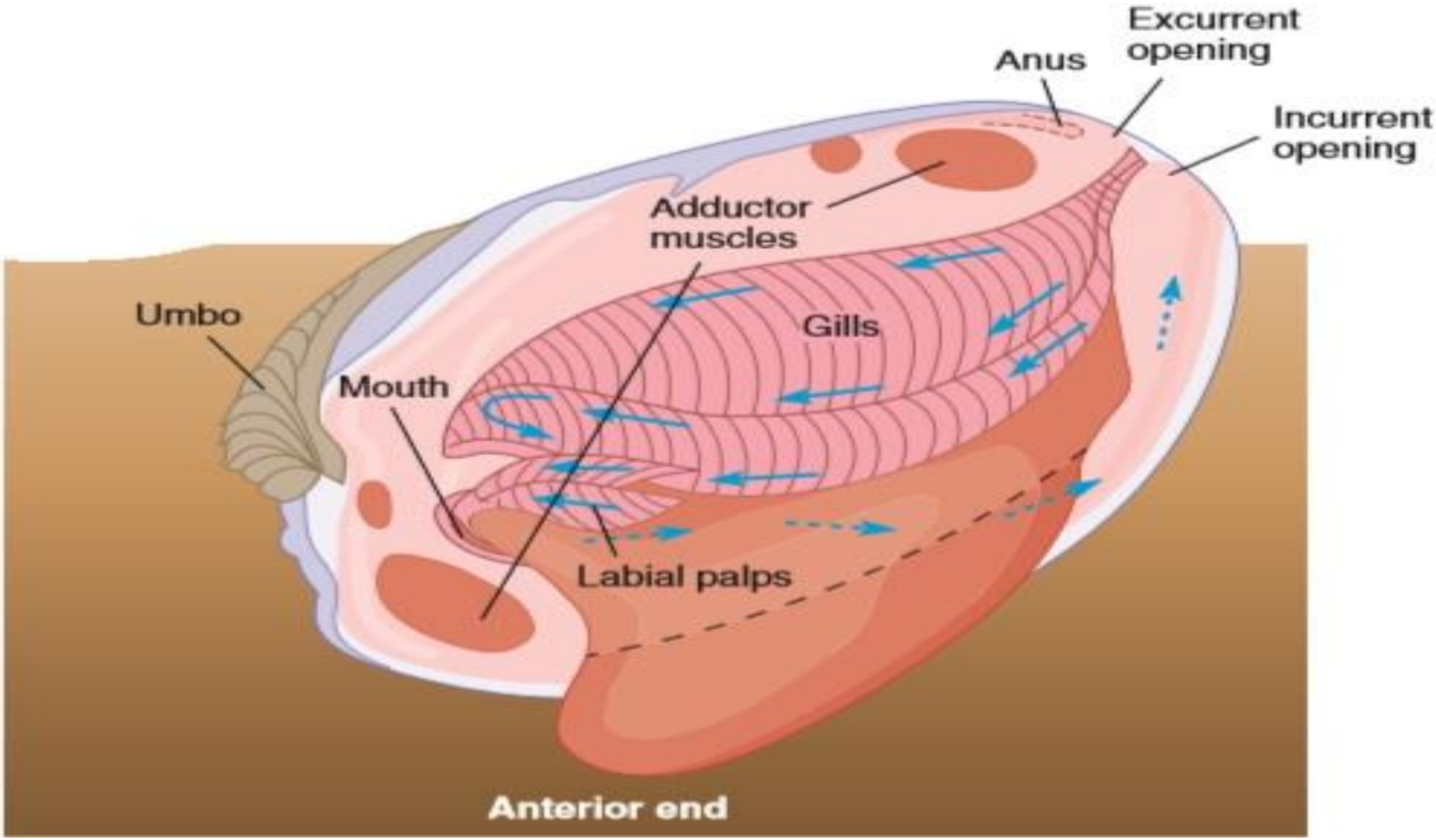


Fig: Bivalve Feeding. Solid blue arrows show the path of food particles after the gills filter them. Dashed blue arrows show the path of particles that the gills and the labial palps reject.

DIGESTION

Food entering the esophagus entangles in a mucoid food string, which extends to the stomach and is rotated by cilia lining the digestive tract.

↓

A consolidated mucoid mass, the crystalline style, projects into the stomach from a diverticulum, called the style sac.

↓

Enzymes for carbohydrate and fat digestion are incorporated into the crystalline style.

↓

Cilia of the style sac rotate the style against a chitinized gastric shield.

↓

The mucoid food string winds around the crystalline style as it rotates, which pulls the food string farther into the stomach from the esophagus.

↓

Cont...

DIGESTION

Further sorting separates fine particles from undigestible coarse materials.

Partially digested food from the stomach enters a digestive gland for intracellular digestion.

Cilia carry undigested wastes in the digestive gland back to the stomach and then to the intestine.

The intestine empties through the anus near the excurrent opening, and excurrent water carries feces away.

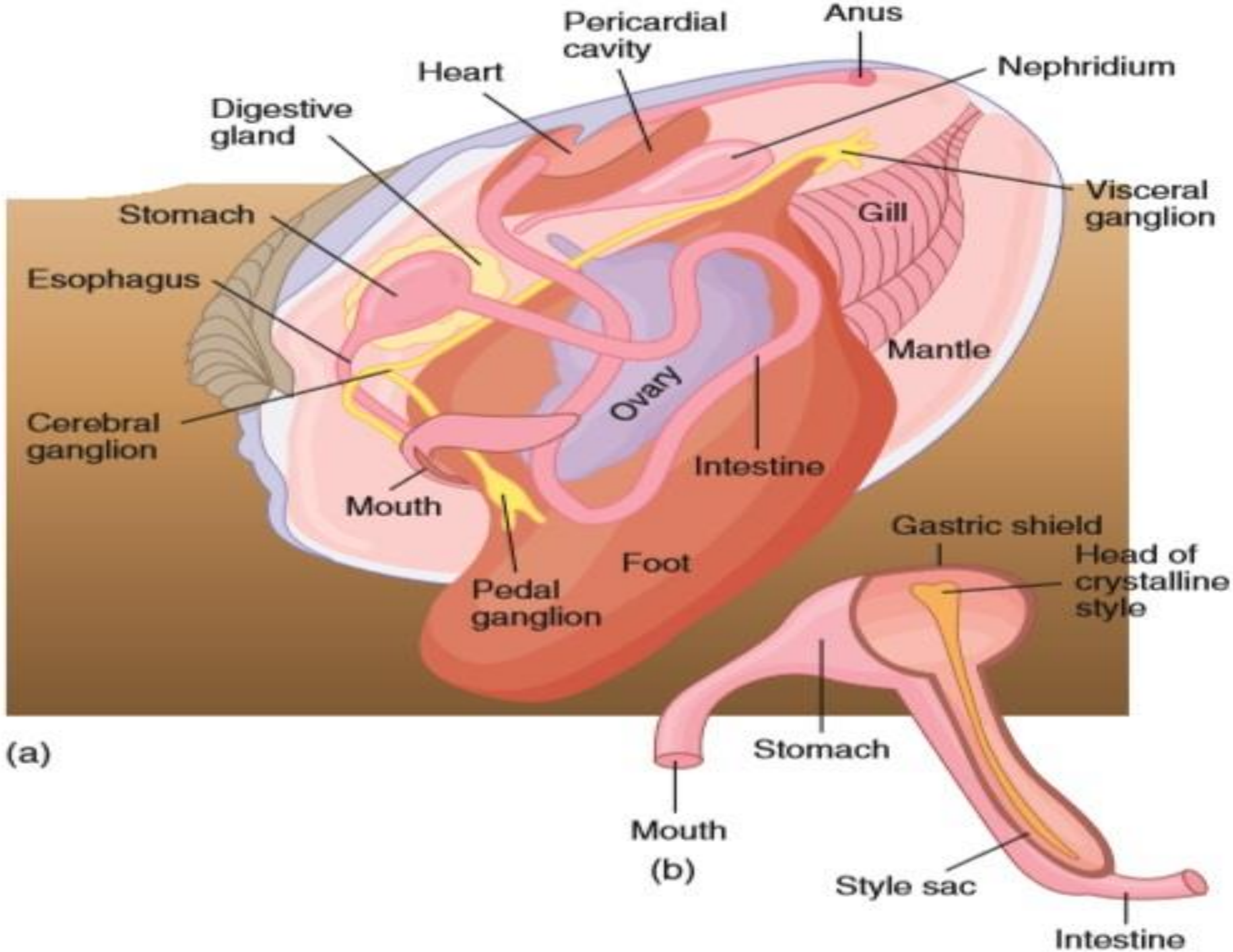


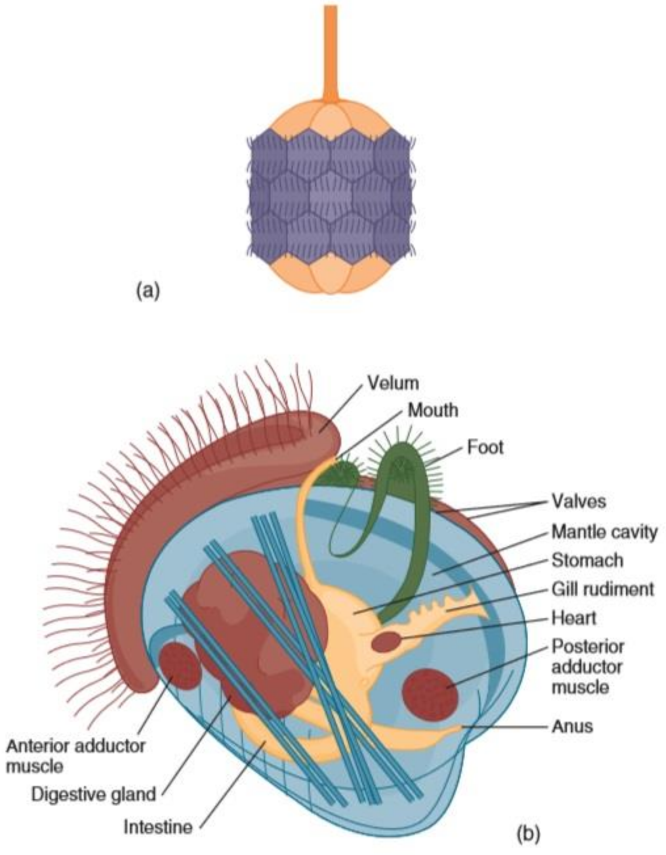
Fig: Bivalve Structure. (a) Internal structure of a bivalve. (b) Bivalve stomach, showing the crystalline style and associated structures.

OTHER MAINTENANCE FUNCTIONS

- In bivalves, blood flows from the heart to tissue sinuses, nephridia, gills, and back to the heart.
- The mantle is an additional site for oxygenation.
- Two nephridia are below the pericardial cavity (the coelom).
- Duct system connects to the coelom at one end and opens at nephridiopores in the anterior region of the suprabranchial chamber.
- Nervous system consists of three pairs of interconnected ganglia associated with the esophagus, the foot, and the posterior adductor muscle.
- The margin of the mantle is the principal sense organ.
- In some species (e.g., scallops), photoreceptors are in the form of complex eyes with a lens and a cornea.
- Other receptors include statocysts near the pedal ganglion.
- An osphradium in the mantle, beneath the posterior adductor muscle.

REPRODUCTION AND DEVELOPMENT

- Most bivalves are dioecious.
- Gonads are in the visceral mass, where they surround the looped intestine.
- Ducts of these gonads open directly to the mantle cavity or by the nephridiopore to the mantle cavity.
- Most bivalves exhibit external fertilization.
- Gametes exit through the suprabranchial chamber of the mantle cavity and the exhalant opening.
- Development proceeds through trochophore and veliger stages.



Larval Stages of Bivalves. (a) Trochophore larva (0.4 mm) of *Yoldia limatula*. (b) Veliger (0.5 mm) of an oyster.

REPRODUCTION AND DEVELOPMENT

- Most freshwater bivalves brood their young.
- Fertilization occurs in the mantle cavity by sperm brought in with inhalant water.
- Some brood their young in maternal gills through reduced trochophore and veliger stages. Young clams are shed from the gills.
- Others brood their young to a modified veliger stage called a glochidium, which is parasitic on fishes.
- These larvae possess two tiny valves, and some species have toothlike hooks.
- The mantles of some freshwater bivalves have elaborate modifications that present a fishlike lure to entice predatory fish.

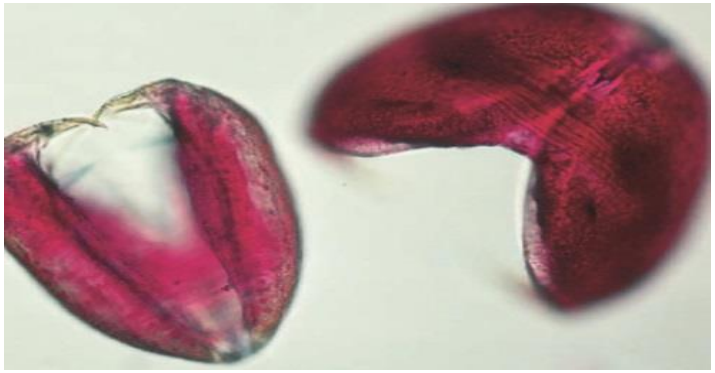


Fig: Larval Stages of Bivalves. Glochidium (1.0 mm) of a freshwater clam. Note the tooth used to attach to fish gills.

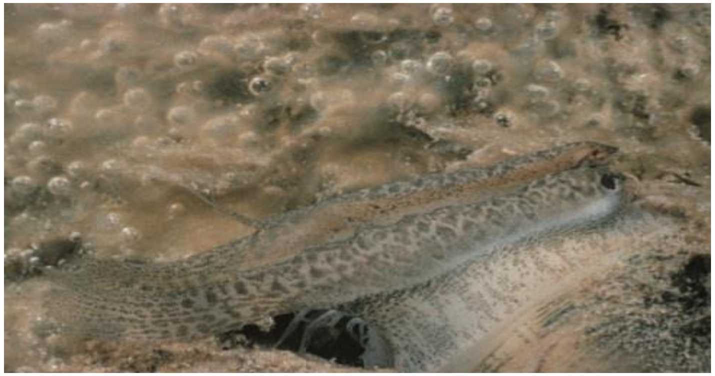


Fig: Class Bivalvia. This photograph shows a modification of the mantle of a freshwater bivalve (*Lampsilis reeviana*) into a lure.

BIVALVE DIVERSITY

- ✓ Bivalves live in nearly all aquatic habitats.
- ✓ They may completely or partially bury themselves in sand or mud, attach to solid substrates, or bore into submerged wood, coral, or limestone.
- ✓ The mantle margins of burrowing bivalves are frequently fused to form distinct openings in the mantle cavity (siphons).
- ✓ Some surface-dwelling bivalves attach to the substrate either by proteinaceous strands called byssal threads.
- ✓ Boring bivalves live beneath the surface of limestone, clay, coral, wood, and other substrates.
- ✓ Acidic secretions from the mantle margin that dissolve limestone sometimes accompany physical abrasion.
- ✓ As the bivalve grows, it is often imprisoned in its rocky burrow because the most recently bored portions of the burrow are larger in diameter than portions bored earlier.

CLASS CEPHALOPODA

- ✓ Includes the octopuses, squid, cuttlefish, and nautili.
- ✓ They are the most complex molluscs and, in many ways, the most complex invertebrates.
- ✓ The anterior portion of their foot has been modified into a circle of tentacles or arms
- ✓ The foot is also incorporated into a funnel associated with the mantle cavity and used for jetlike locomotion.
- ✓ The cephalopod head is in line with the visceral mass.
- ✓ Cephalopods have a highly muscular mantle.
- ✓ The mantle acts as a pump to bring large quantities of water into the mantle cavity.

SHELL

- The only living cephalopod that possesses an external shell is the ***nautilus***.
- **Septa** subdivide its coiled shell.
- As the nautilus grows, it moves forward, secreting new shell around itself and leaving an empty septum behind.
- Only the last chamber is occupied.
- A cord of tissue called a **siphuncle** perforates the septa, absorbing fluids by osmosis and replacing them with metabolic gases.
- The amount of gas in the chambers is regulated to alter the **buoyancy** of the animal.

Fig: Class Cephalopoda. Chambered nautilus (*Nautilus*).

SHELL

- **Cuttlefish shell**, called cuttlebone, is used to make powder for polishing and is fed to pet birds to supplement their diet with calcium.
- The **shell of a squid** is reduced to an internal, chitinous structure called the **pen**.
- In addition, squid also have **cartilaginous plates** in the mantle wall, neck, and head that support the mantle and protect the brain.
- The shell is **absent** in octopuses.

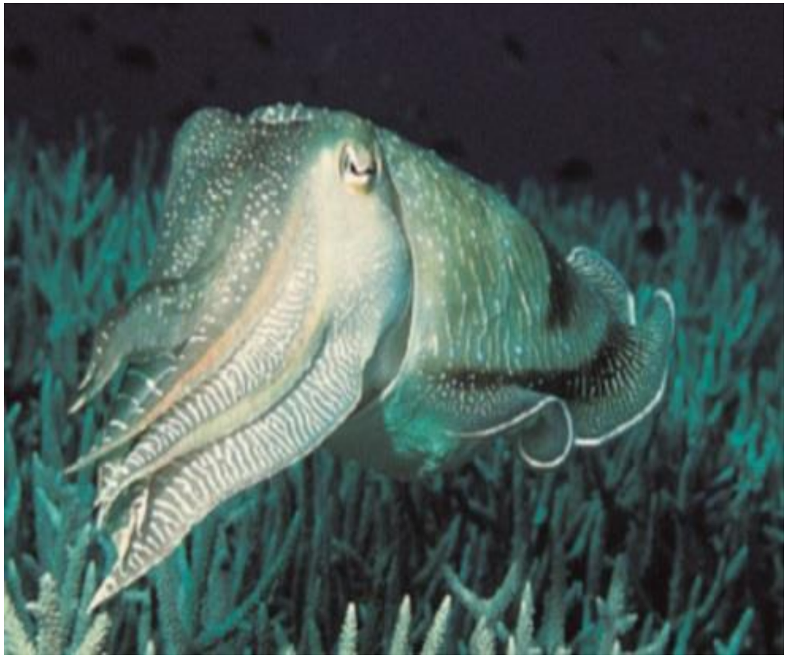


Fig: Class Cephalopoda. A cuttlefish (*Sepia*).

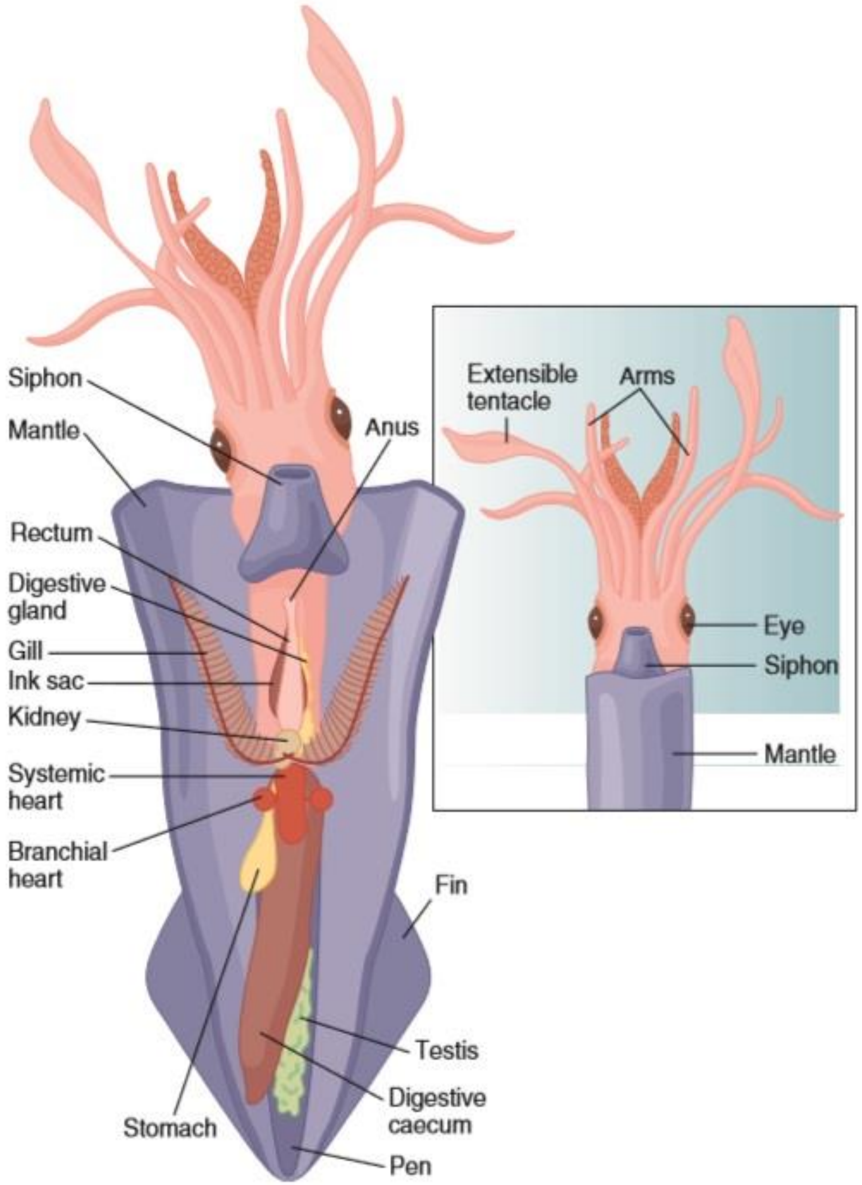


Fig: Internal Structure of the Squid, *Loligo*. The shell of most cephalopods is reduced or absent, and the foot is modified into a funnel and a circle of tentacles and/or arms that encircle the head. The inset shows the undissected anatomy of the squid.

LOCOMOTION

Jet-propulsion system:

- The mantle of cephalopods contains radial and circular muscles.
- When circular muscles contract, they decrease the volume of the mantle cavity and close collarlike valves to prevent water from moving out of the mantle cavity between the head and the mantle wall.
- Water is thus forced out of a narrow funnel. Muscles attached to the funnel control the direction of the animal's movement.
- Radial mantle muscles bring water into the mantle cavity by increasing the cavity's volume.
- Posterior fins act as stabilizers in squid and also aid in propulsion and steering in cuttlefish.

FEEDING AND DIGESTION

- Cephalopods locate their prey by sight and capture prey with tentacles that have adhesive cups.
- All cephalopods have jaws and a radula.
- The digestive tract of cephalopods is muscular, and peristalsis replaces ciliary action in moving food.
- Most digestion occurs in a stomach and a large cecum.
- Digestion is primarily extracellular, with large digestive glands supplying enzymes.
- An intestine ends at the anus, near the funnel, and exhalant water carries wastes out of the mantle cavity.

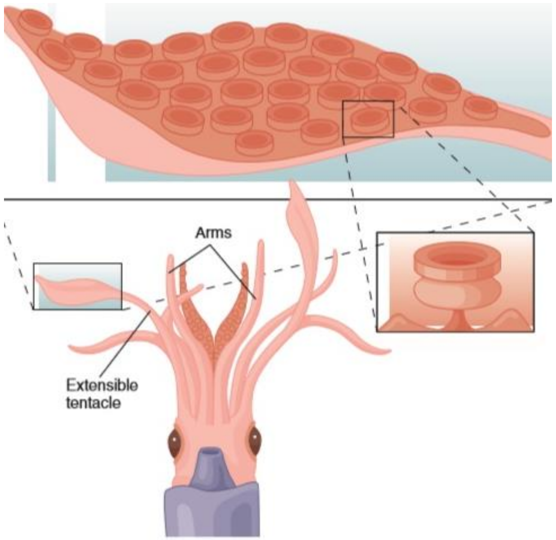


Fig: Cephalopod Tentacle. Cephalopods use suction cups for prey capture and as holdfast structures.

Cuttlefish and *nautili*	Feed on small invertebrates on the ocean floor
Octopuses	Feed on snails, fish, and crustaceans
Squid	Feed on fishes and shrimp

OTHER MAINTENANCE FUNCTIONS

- ✓ ***Cephalopods exhibit greater excretory efficiency because of the closed circulatory system. A close association of blood vessels with nephridia allows wastes to filter and secrete directly from the blood into the excretory system.***
- ✓ ***The cephalopod nervous system is unparalleled in any other invertebrate. Cephalopod brains are large, and their evolution is directly related to cephalopod predatory habits and dexterity***

Cephalopod Eye

- ✓ **The eyes of octopuses, cuttlefish, and squid is an excellent example of convergent evolution.**
- ✓ **In contrast to the vertebrate eye, nerve cells leave the eye from the outside of the eyeball, so that no blind spot exists.**
- ✓ **Cephalopods can form images, distinguish shapes, and discriminate some colors.**
- ✓ **The nautiloid eye is less complex. It lacks a lens.**

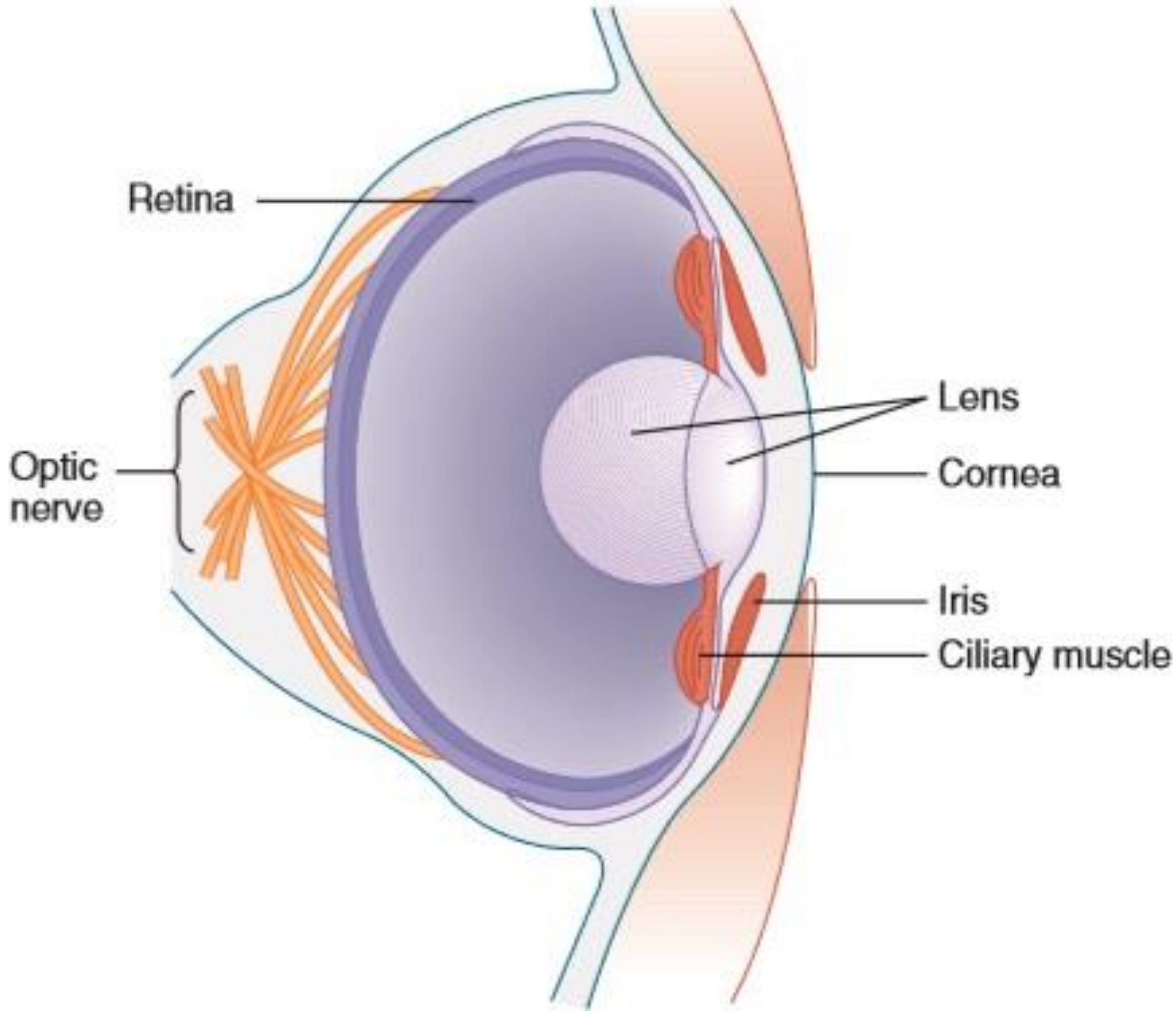


Fig: Cephalopod Eye. The eye is immovable in a supportive and protective socket of cartilages. It contains a rigid, spherical lens. An iris in front of the lens forms a slitlike pupil that can open and close in response to varying light conditions. Note that the optic nerve comes off the back of the retina.

OTHER MAINTENANCE FUNCTIONS

- Cephalopod statocysts respond to gravity and acceleration, and are in cartilages next to the brain.
- Osphradia are present only in Nautilus.
- Tactile receptors and additional chemoreceptors are widely distributed over the body.
- Cephalopods have pigment cells called chromatophores.
- When tiny muscles attached to these pigment cells contract, the chromatophores quickly expand and change the color of the animal.
- Color changes, in combination with ink discharge, function in alarm responses.
- Color changes are also involved with courtship displays.
- All cephalopods possess an ink gland that opens just behind the anus.

REPRODUCTION AND DEVELOPMENT

- ✓ Cephalopods are **dioecious** with gonads in the dorsal portion of the visceral mass.
- ✓ The male reproductive tract consists of testes and structures for encasing sperm in packets called **spermatophores.**
- ✓ The female reproductive tract produces large, yolky eggs and is modified with glands that secrete gel-like cases around eggs.
- ✓ These cases frequently harden on exposure to seawater.
- ✓ One tentacle of male cephalopods, called the **hectocotylus**, is modified for spermatophore transfer.
- ✓ Eggs are fertilized as they leave the oviduct, and are deposited singly or in **stringlike masses.**
- ✓ Cephalopods develop in the confines of the egg membranes, and the hatchlings are **miniature adults**. Young are never cared for after hatching.

CLASS POLYPLACOPHORA

- ✓ Contains the **chitons.**
- ✓ Chitons are common inhabitants of hard substrates in **shallow marine water**.
- ✓ Have a **reduced head**, **a flattened foot**, and **a shell** that divides into **eight** articulating dorsal valves.
- ✓ A **muscular mantle** extends beyond the margins of the shell and foot covers the broad foot.
- ✓ The **mantle cavity** is restricted to the space between the margin of the mantle and the foot.
- ✓ When chitons are disturbed, the edges of the mantle tightly grip the substrate, and foot muscles contract to raise the middle of the foot, creating a powerful **vacuum** that holds the chiton in place.

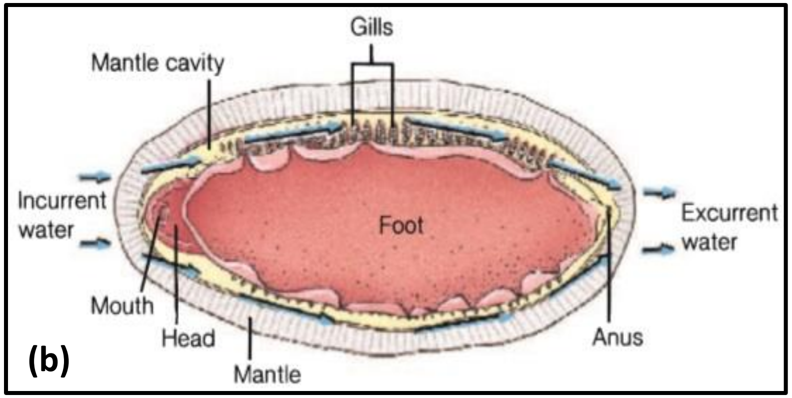


Fig: Class Polyplacophora. (a) Dorsal view of a chiton (*Tonicella lineata*). Note the shell consisting of eight valves and the mantle extending beyond the margins of the shell. (b) Ventral view of a chiton. The mantle cavity is the region between the mantle and the foot. Arrows show the path of water moving across gills in the mantle cavity.

CLASS POLYPLACOPHORA

- A linear series of gills is in the mantle cavity on each side of the foot.
- The digestive, excretory, and reproductive tracts open near the exhalant area of the mantle cavity.
- Most chitons feed on attached algae.
- A chemoreceptor, the subradular organ, extends from the mouth to detect food, which the radula rasps from the substrate.
- Mucus traps food, which then enters the esophagus by ciliary action.
- Extracellular digestion and absorption occur in the stomach, and wastes move on to the intestine.

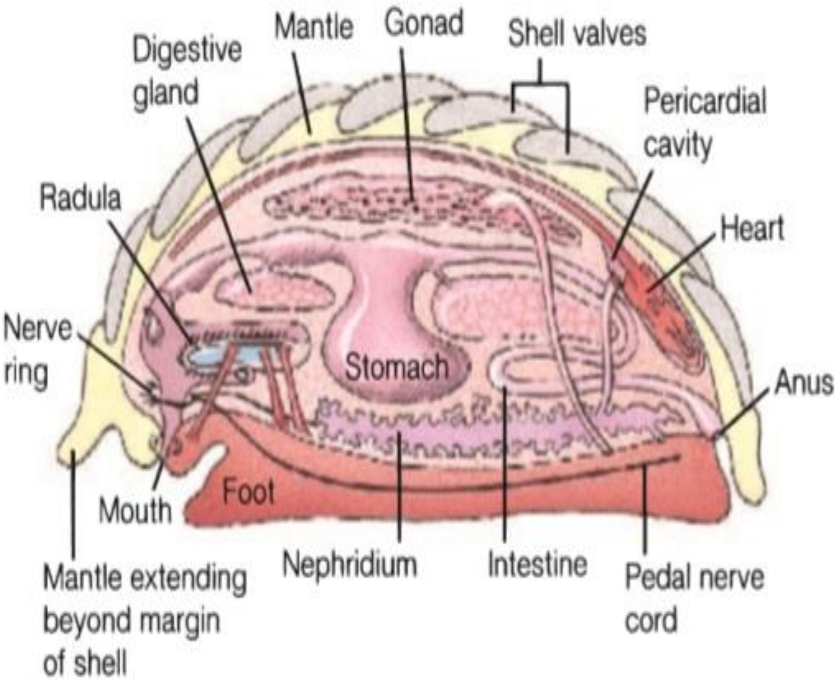


Fig: Internal structure of a chiton.

CLASS POLYPLACOPHORA

- ✓ The nervous system is ladderlike.
- ✓ Four anteroposterior nerve cords and numerous transverse nerves.
- ✓ A nerve ring encircles the esophagus.
- ✓ Sensory structures include osphradia.
- ✓ Tactile receptors on the mantle margin.
- ✓ Chemoreceptors near the mouth.
- ✓ Statocysts in the foot.
- ✓ Sexes are separate in chitons.
- ✓ External fertilization and development result in a swimming trochophore.
- ✓ Trochophore settles and metamorphoses into an adult without passing through a veliger stage

CLASS SCAPHOPODA

- Tooth shells or tusk shells.
- The over three hundred species.
- All burrowing marine animals that inhabit moderate depths.
- Conical shell that is open at both ends.
- The head and foot project from the wider end of the shell.
- Live mostly buried in the substrate with head and foot oriented down and with the apex of the shell projecting into the water above.

Class Scaphopoda. This conical shell is open at both ends. In its living state, the animal is mostly buried, with the apex of the shell projecting into the water.

CLASS SCAPHOPODA

- Incurrent and excurrent water enters and leaves the mantle cavity through the opening at the apex of the shell.
- Functional gills are absent, and
- Gas exchange occurs across mantle folds.
- Scaphopods have a radula and tentacles.
- Feed on foraminiferans.
- Sexes are separate.
- Trochophore and veliger larvae are produced.

CLASS MONOPLACOPHORA

- have an **undivided, arched shell**.
- A **broad, flat foot**; and
- Serially repeated pairs of **gills** and **foot-retractor muscles**.
- They are **dioecious**.
- This group of molluscs was known only from fossils **until 1952**, when a limpetlike monoplacophoran, named ***Neopilina***, was dredged up from a depth of **3,520 m** off the **Pacific coast** of Costa Rica.

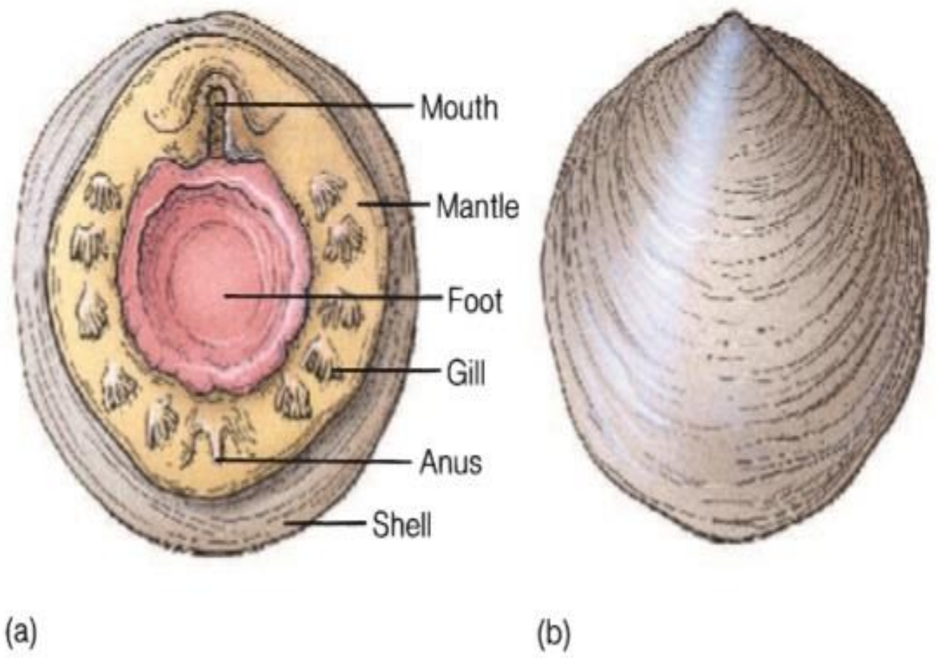


Fig: Class Monoplacophora. (a) Ventral and (b) dorsal views of Neopilina

CLASS CAUDOFOVEATA

- Members of the class Caudofoveata are **wormlike molluscs**.
- Range in size from **2 mm to 14 cm** and
- Live in **vertical burrows** on the **deep sea floor**.
- They have **scale like spicules** on the body wall and
- Lack the following typical molluscan characteristics: shell, crystalline style, statocysts, foot, and nephridia.
- Zoologists have described approximately **70 species**
- Little is known of their ecology.

CLASS APLACOPHORA

- Members of the class Aplacophora are called **solenogasters.**
- The approximately **250 species** of these **cylindrical molluscs.**
- **Lack a shell** and **crawl** on their ventral surface.
- Their nervous system is **ladderlike** and reminiscent of the flatworm body form, causing some to suggest that this group may be closely related to the ancestral molluscan stock.
- One small group of aplacophorans contains **burrowing species** that feed on microorganisms and detritus, and possess a radula and nephridia.
- Most aplacophorans lack nephridia and a radula, are **surface dwellers** on corals and other substrates, and are **carnivores**, frequently feeding on **cnidarian polyps.**