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

ORIGIN OF THE COELOM

1) Schizocoel hypothesis

- ✓ The schizocoel hypothesis is patterned after the method of mesoderm development and coelom formation in many protostomes.
- ✓ Mesoderm fills the area between ectoderm and endoderm.
- ✓ The coelom arises from a splitting of this mesoderm.
- ✓ If the coelom formed in this way during evolution, mesodermally derived tissues would have preceded the coelom, implying that a triploblastic, acoelomate (flatworm) body form could be the forerunner of the coelomate body form.

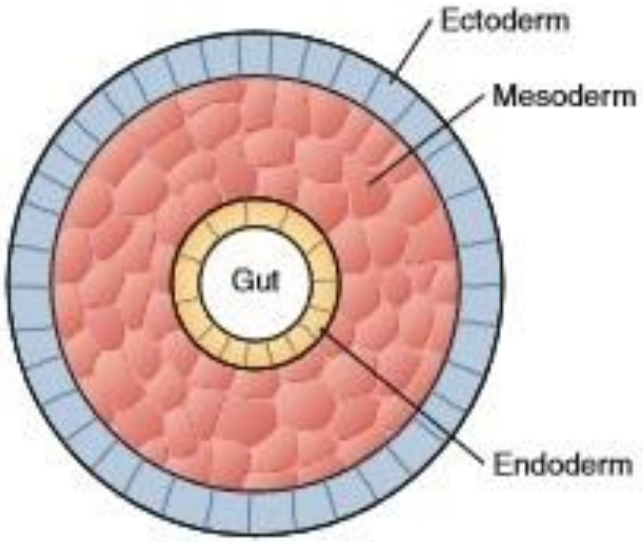

Fig: Triploblastic Body Plan. Triploblastic animals have tissues derived from ectoderm, mesoderm, and endoderm. Triploblastic acoelomate pattern.

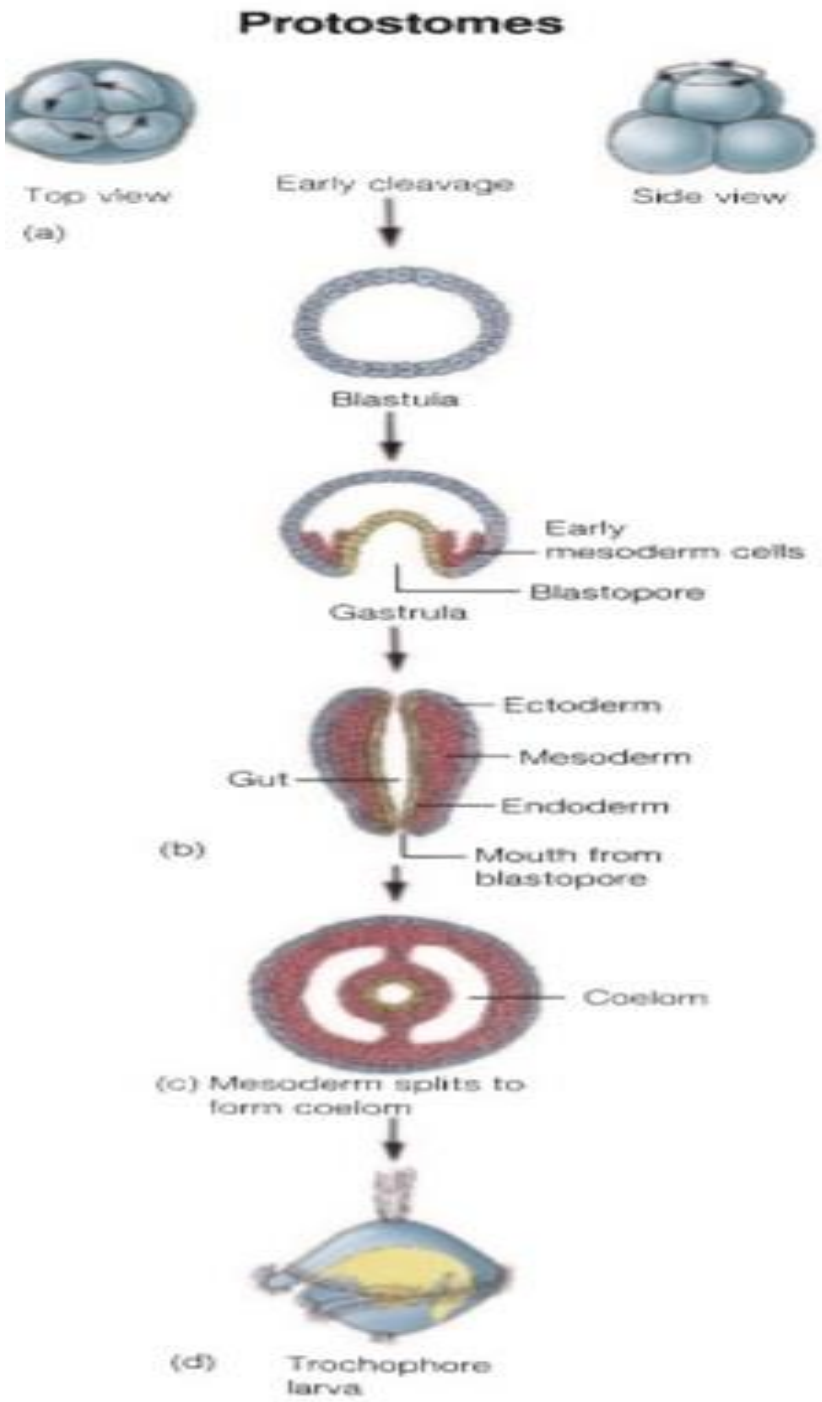

Fig: Developmental Characteristics of Protostomes. Protostomes are characterized by (a) spiral and determinate cleavage, (b) a mouth that forms from an embryonic blastopore, (c) schizocoelous coelom formation, and (d) a trochophore larva.

2) Enterocoel hypothesis

- ✓ The enterocoel hypothesis suggests that the coelom may have arisen as outpocketings of a primitive gut tract.
- ✓ This hypothesis is patterned after the method of coelom formation in deuterostomes. The implication of this hypothesis is that mesoderm and the coelom formed from the gut of a diploblastic animal.
- ✓ If this is true, the triploblastic, acoelomate body form would have been secondarily derived by mesoderm filling the body cavity of a coelomate animal.
- ✓ Unfortunately, zoologists may never know which, if either, of these hypotheses is accurate.
- ✓ Some zoologists believe that the coelom may have arisen more than once in different evolutionary lineages, in which case, more than one explanation could be correct.

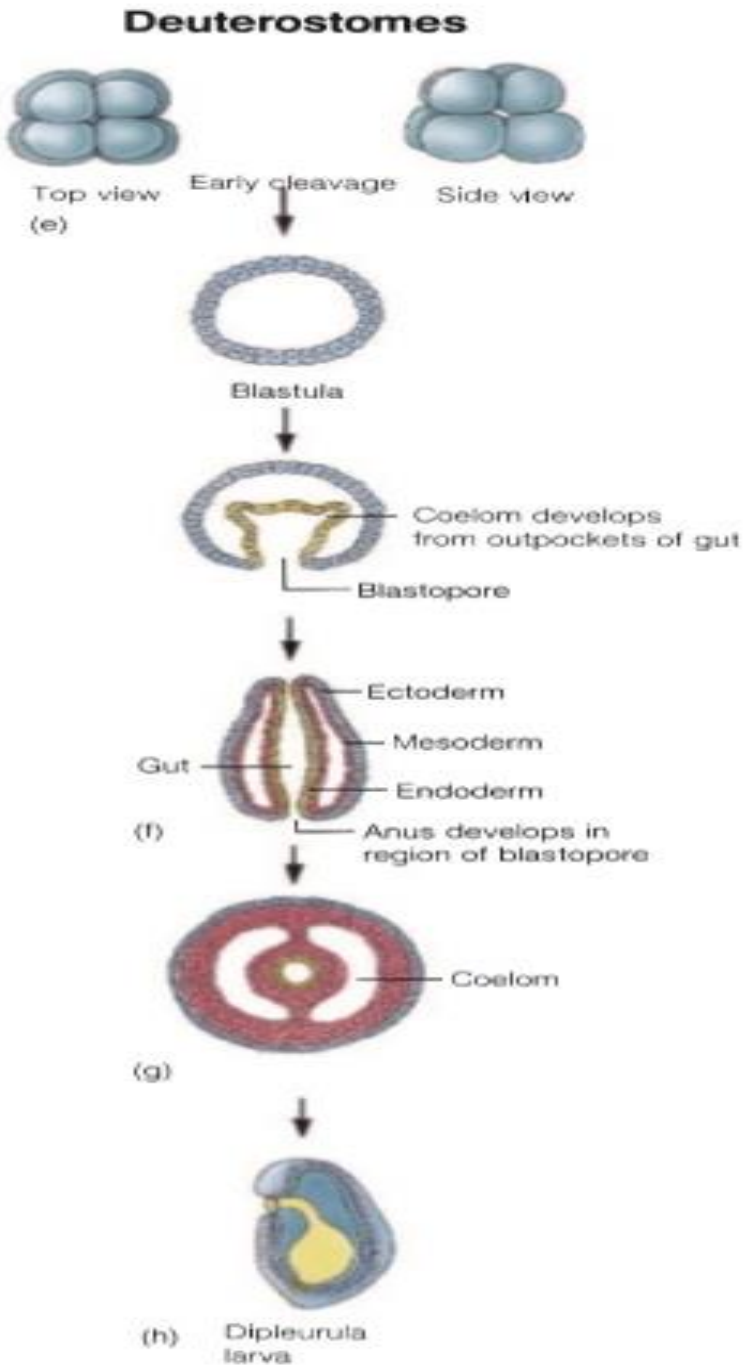

Fig: Developmental Characteristics of Deuterostomes. Deuterostomes are characterized by (e) radial and indeterminate cleavage, (f) an anus that forms in the region of the embryonic blastopore, and (g) enterocoelous coelom formation. A dipleurula larva is present in some echinoderms; however, this larval stage (h) is often absent in other deuterostomes.

Molluscan Characteristics

Characteristics of the phylum Mollusca include:

1) Body of two parts: head-foot and visceral mass.
2) Mantle that secretes a calcareous shell and covers the visceral mass.
3) Mantle cavity functions in excretion, gas exchange, elimination of digestive wastes, and release of reproductive products.
4) Bilateral symmetry.
5) Protostome characteristics, including trochophore larvae, spiral cleavage, and schizocoelous coelom formation.
6) Coelom reduced to cavities surrounding the heart, nephridia, and gonads.
7) Open circulatory system in all but one class (Cephalopoda).
8) Radula usually present and used in scraping food

CLASSIFICATION OF THE MOLLUSCA

Phylum Mollusca (mol-lus′kah)
The coelomate animal phylum whose members possess a head-foot, visceral mass, mantle, and mantle cavity. Most molluscs also possess a radula and a calcareous shell. Nearly 100,000 species.

Class Caudofoveata (kaw′do-fo″ve-a″ta)
Wormlike molluscs with a cylindrical, shell-less body and scale like, calcareous spicules; lack eyes, tentacles, statocysts, crystalline style, foot, and nephridia. Deep-water, marine burrowers. *Chaetoderma*. Approximately 70 species.

Class Aplacophora (a″pla-kof′o-rah)
Shell, mantle, and foot lacking; wormlike; head poorly developed; burrowing molluscs. Marine. *Neomenia*. Approximately 250 species.

Class Polyplacophora (pol″e-pla-kof′o-rah)
Elongate, dorsoventrally flattened; head reduced in size; shell consisting of eight dorsal plates. Marine, on rocky intertidal substrates. *Chiton*.

Class Monoplacophora (mon″o-pla-kof′o-rah)
Molluscs with a single arched shell; foot broad and flat; certain structures serially repeated. Marine. *Neopilina*.

Class Scaphopoda (ska-fop′o-dah)
Body enclosed in a tubular shell that is open at both ends; tentacles used for deposit feeding; no head. Marine. *Dentalium*. Over 300 species.

Class Bivalvia (bi″val′ve-ah)
Body enclosed in a shell consisting of two valves, hinged dorsally; no head or radula; wedge-shaped foot. Marine and freshwater. *Anodonta*, *Mytilus*, *Venus*. Approximately 30,000 species.

Class Gastropoda (gas-trop′o-dah)
Shell, when present, usually coiled; body symmetry distorted by torsion; some monoecious species. Marine, freshwater, terrestrial. *Nerita*, *Orthaliculus*, *Helix*. Over 35,000 species.

Class Cephalopoda (sef″ah-lah″po′-dah)
Foot modified into a circle of tentacles and a siphon; shell reduced or absent; head in line with the elongate visceral mass. Marine. *Octopus*, *Loligo*, *Sepia*, *Nautilus*.

This taxonomic listing reflects a phylogenetic sequence. The discussions that follow, however, begin with molluscs that are familiar to most students.

Body of a mollusc has three main regions

Headfoot

Head foot is elongate with an:

- ✓ Anterior head, containing the mouth and certain nervous and sensory structures.
- ✓ Elongate foot, used for attachment and locomotion

visceral mass

- ✓ contains the organs of digestion, circulation, reproduction, and excretion.
- ✓ positioned dorsal to the head-foot.

Mantle

- ✓ usually attaches to the visceral mass.
- ✓ enfolds most of the body.
- ✓ may secrete a shell that overlies the mantle.

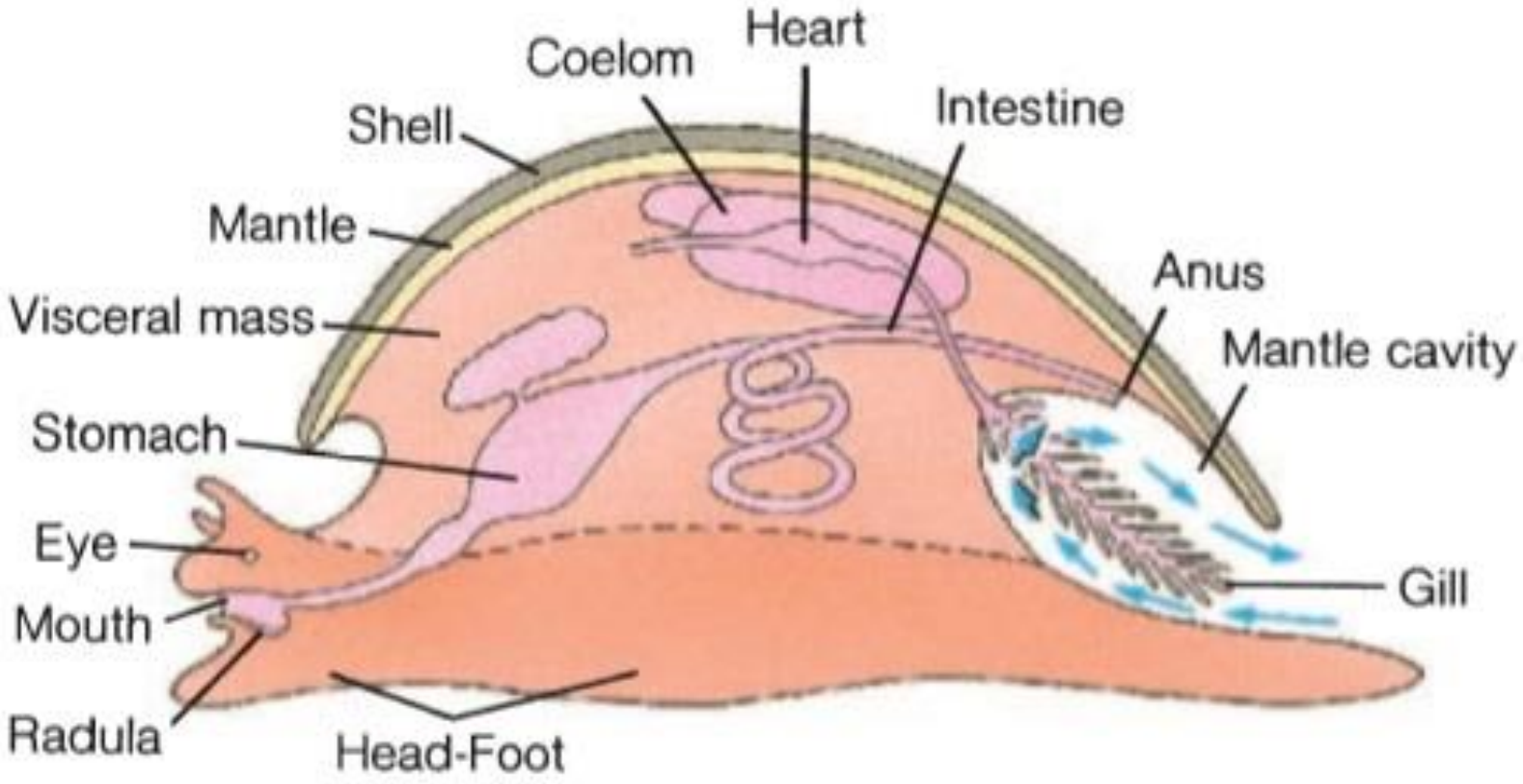

Fig: Molluscan Body Organization. All molluscs possess three features unique to the phylum. The head-foot is a muscular structure usually used for locomotion and sensory perception. The visceral mass contains organs of digestion, circulation, reproduction, and excretion. The mantle is a sheet of tissue that enfolds the rest of the body and secretes the shell. Blue arrows indicate the flow of water through the mantle cavity.

Shell of a mollusc is secreted in three layers.

Periostracum

- ✓ The outer layer of the shell.
- ✓ Mantle cells at the mantle's outer margin secrete this protein layer.

Prismatic layer

- ✓ The middle layer of the shell.
- ✓ Thickest of the three layers.
- ✓ Consists of calcium carbonate mixed with organic materials.
- ✓ Cells at the mantle's outer margin also secrete this layer.

Nacreous layer

- ✓ The inner layer of the shell.
- ✓ forms from thin sheets of calcium carbonate alternating with organic matter.
- ✓ Cells along the entire epithelial border of the mantle secrete the nacreous layer

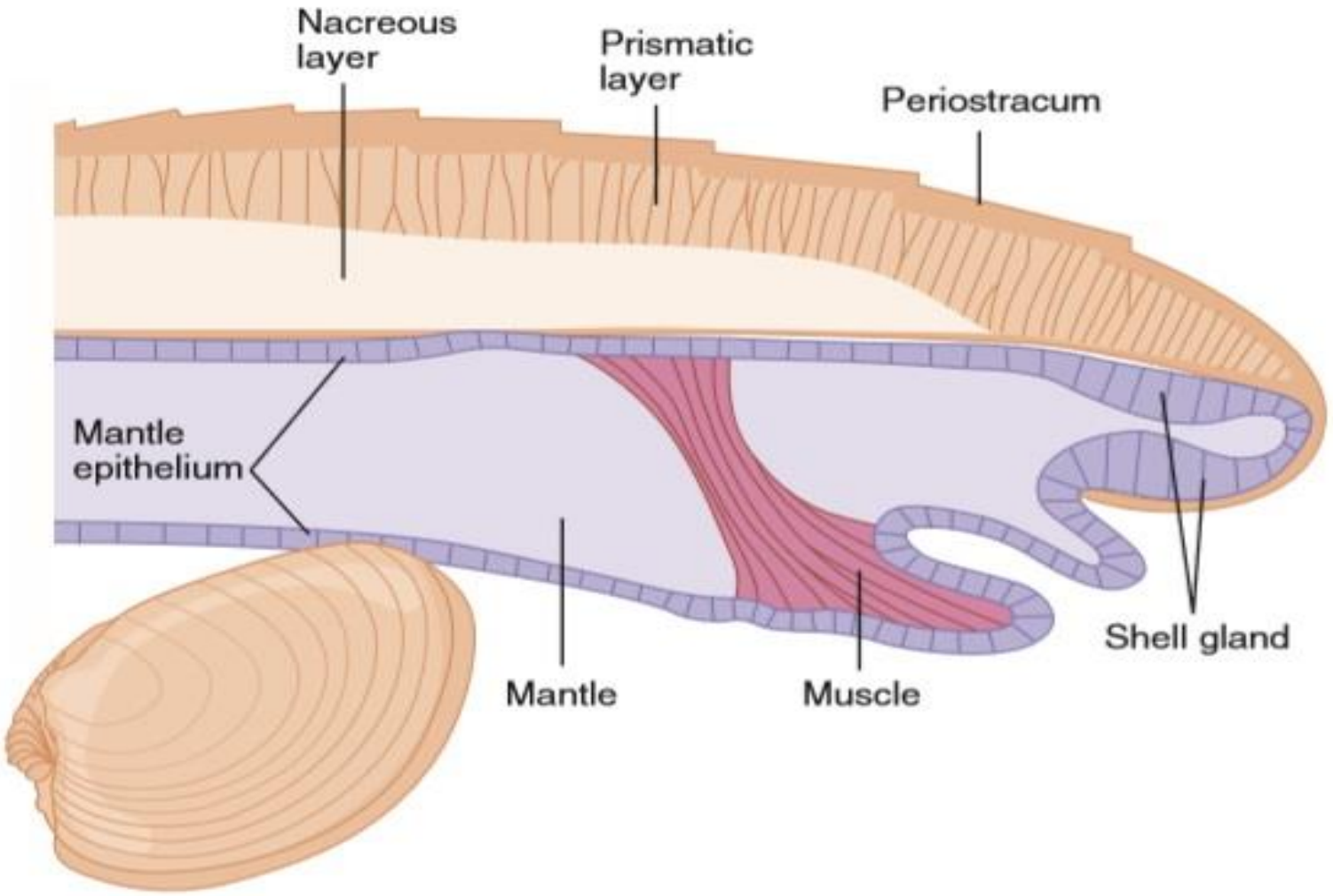

Fig: Molluscan Shell and Mantle. A transverse section of a bivalve shell and mantle shows the three layers of the shell and the portions of the mantle responsible for shell secretion.

Radula

- ✓ The mouth of most molluscs possesses a rasping structure called a radula.
- ✓ A chitinous belt and rows of posteriorly curved teeth.
- ✓ The radula overlies a fleshy, tonguelike structure supported by a cartilaginous odontophore.
- ✓ Muscles associated with the odontophore permit the radula to be protruded from the mouth.
- ✓ Muscles associated with the radula move the radula back and forth over the odontophore. Food is scraped from a substrate

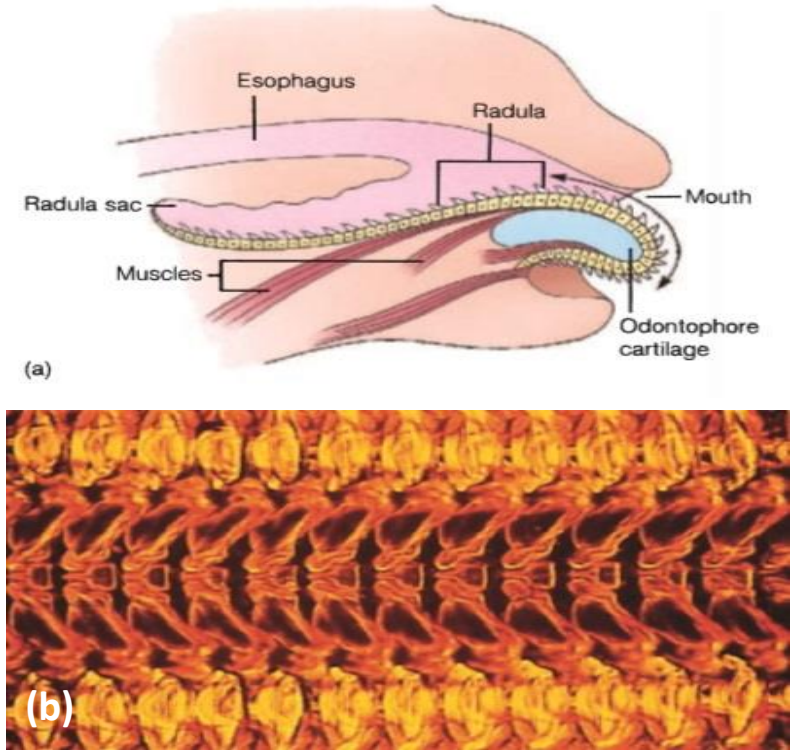

Fig: Radular Structure. (a) The radular apparatus lies over the cartilaginous odontophore. Muscles attached to the radula move the radula back and forth over the odontophore (see arrows). (b) Micrograph of radular teeth arrangement of the marine snail, *Nerita*. Tooth structure is an important taxonomic characteristic for zoologists who study molluscs.

CLASS GASTROPODA

- ✓ Includes the snails, limpets, and slugs.
- ✓ With over 35,000 living species.
- ✓ Largest and most varied molluscan class.
- ✓ Its members occupy a wide variety of marine, freshwater, and terrestrial habitats.
- ✓ Intermediate hosts for some medically important trematode parasites of humans.

TORSION

- ✓ Torsion is a 180°, counterclockwise twisting of the visceral mass, mantle, and mantle cavity.
- ✓ Torsion positions the gills, anus, and openings from the excretory and reproductive systems just behind the head and nerve cords.
- ✓ Twists the digestive tract into a U shape.

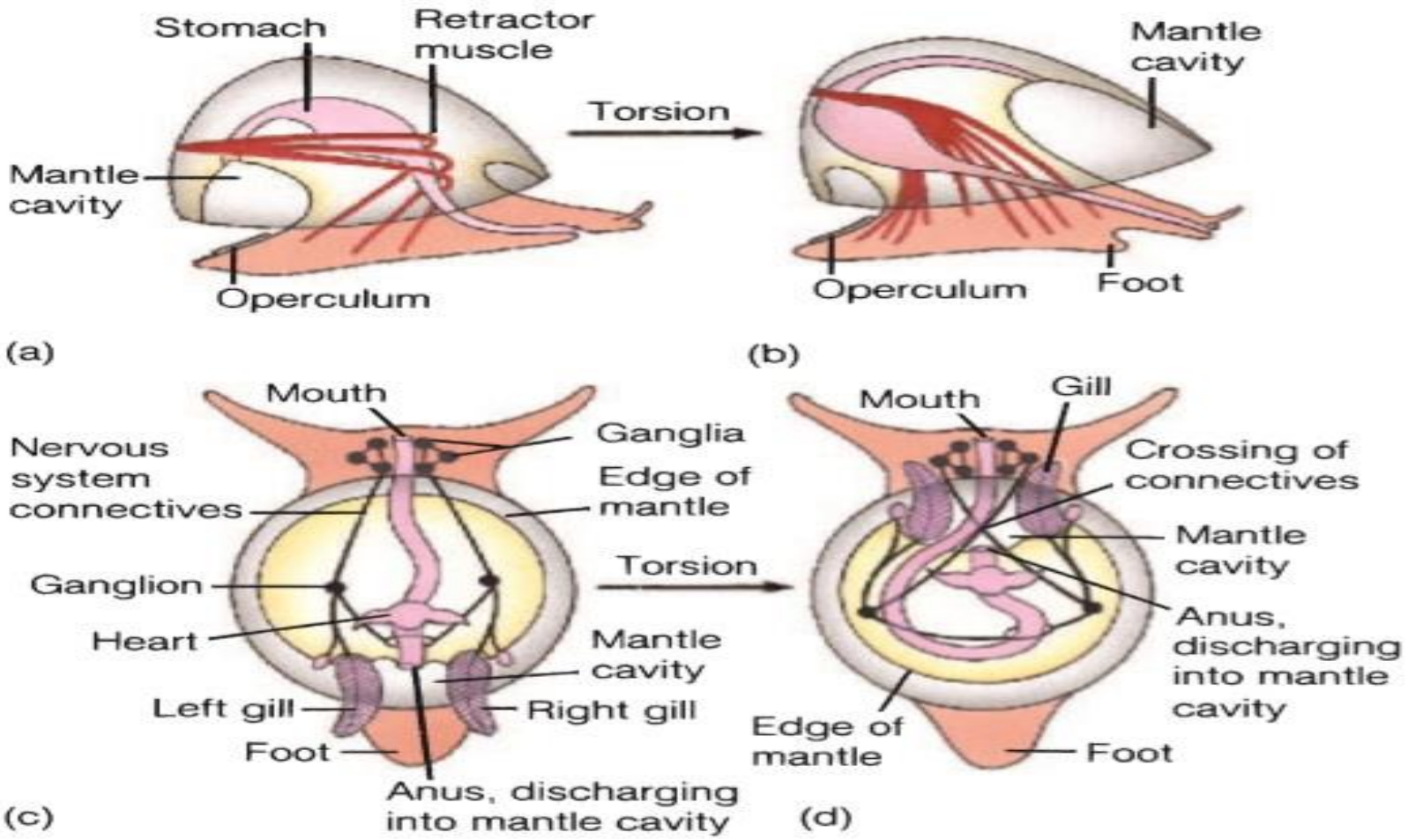

Fig: Torsion in Gastropods. (a) A pretorsion gastropod larva. Note the posterior opening of the mantle cavity and the untwisted digestive tract. (b) After torsion, the digestive tract is looped, and the mantle cavity opens near the head. The foot is drawn into the shell last, and the operculum closes the shell opening. (c) A hypothetical adult ancestor, showing the arrangement of internal organs prior to torsion. (d) Modern adult gastropods have an anterior opening of the mantle cavity and the looped digestive tract.

TORSION

Three advantages of torsion are plausible.

First Advantage

- ✓ With torsion, the head enters the shell first, exposing the head less to potential predators.
- ✓ In some snails, a proteinaceous covering, called an operculum enhances protection.

Second Advantage

- ✓ An anterior opening of the mantle cavity allows clean water from in front of the snail to enter the mantle cavity.

Third Advantage

- ✓ The twist in the mantle's sensory organs around to the head region makes the snail more sensitive to stimuli.

DETORSION

- Some embryo undergoes a full 180° torsion and then untwists approximately 90°.
- The mantle cavity thus opens on the right side of the body, behind the head.

SHELL COILING

- ✓ The earliest fossil gastropods had a shell that was coiled in one plane.
- ✓ Most modern snail shells are asymmetrically coiled into a more compact form.
- ✓ Successive coils or whorls slightly larger than, and ventral to, the preceding whorl.
- ✓ This pattern leaves less room on one side of the visceral mass for certain organs.

Fig: Gastropod Structure. (a) A land (pulmonate) gastropod (*Orthaliculus*)

LOCOMOTION

- ✓ Nearly all have a **flattened foot** that is often **ciliated**, covered with **gland cells**, and used to creep across the substrate.
- ✓ The smallest gastropods use **cilia** to propel themselves over a mucous trail.
- ✓ Larger gastropods use waves of **muscular contraction** that move over the foot.
- ✓ The foot of some gastropods is modified for **clinging**, or for **swimming**.

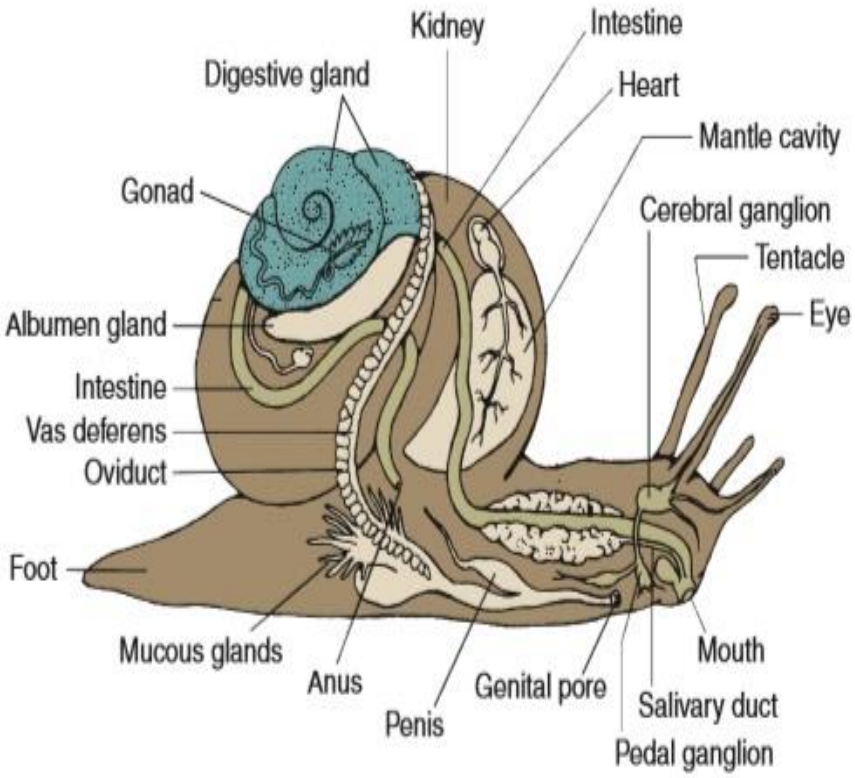

Fig: Gastropod Structure. Internal structure of a generalized gastropod.

FEEDING AND DIGESTION

- ✓ Most gastropods feed by scraping algae or other small, attached organisms from their substrate.
- ✓ Others are herbivores, scavengers, parasites, or predators.
- ✓ The anterior portion of the digestive tract may be modified into an extensible proboscis, which contains the radula.
- ✓ The digestive tract of gastropods, like that of most molluscs, is ciliated.
- ✓ Food is trapped in mucous strings and incorporated into a mucoid mass called the protostyle.
- ✓ A digestive gland in the visceral mass releases enzymes and acid into the stomach, and food trapped on the protostyle is freed and digested.
- ✓ Wastes form fecal pellets in the intestine.

OTHER MAINTENANCE FUNCTION

- ✓ Gas exchange always involves the mantle cavity.
- ✓ Primitive gastropods had two gills.
- ✓ Modern gastropods have lost one gill because of coiling.
- ✓ Some gastropods have a rolled extension of the mantle, called a siphon, that serves as an inhalant tube.
- ✓ Burrowing species extend the siphon to the surface of the substrate to bring in water.
- ✓ Gills are lost or reduced in land snails (pulmonates).
- ✓ Land snails have a richly vascular mantle for gas exchange between blood and air.
- ✓ Mantle contractions help circulate air and water through the mantle cavity.

Circulatory system

- ✓ Open circulatory system.
- ✓ Blood leaves the vessels and directly bathes cells in tissue spaces called sinuses.
- ✓ Heart consisting of a single, muscular ventricle and two auricles.
- ✓ Most have lost one member of the pair of auricles because of coiling.

hydraulic skeleton

- ✓ A hydraulic skeleton consists of blood confined to tissue spaces for support.
- ✓ A mollusc uses its hydraulic skeleton to extend body structures by contracting muscles distant from the extending structure.

Nervous system

- ✓ Six ganglia located in the head-foot and visceral mass.
- ✓ The evolution of the gastropod nervous system has resulted in the untwisting of nerves and the concentration of nervous tissues into fewer, larger ganglia, especially in the head.

Sensory structures

- ✓ Eyes may be at the base or at the end of tentacles.
- ✓ They may be simple pits of photoreceptor cells or consist of a lens and cornea.
- ✓ Statocysts are in the foot.
- ✓ Osphradia are chemoreceptors in the anterior wall of the mantle cavity.
- ✓ The osphradia of predatory gastropods help detect prey.

Excretion

- ✓ In modern species, the right nephridium has disappeared, probably because of shell coiling.
- ✓ The nephridium consists of a sac with highly folded walls and connects to the reduced coelom, the pericardial cavity.
- ✓ Excretory wastes are derived largely from fluids filtered and secreted into the coelom from the blood.
- ✓ Aquatic gastropod species excrete ammonia because they have access to water in which toxic ammonia is diluted.
- ✓ Terrestrial snails must convert ammonia to a less-toxic form—uric acid.

REPRODUCTION AND DEVELOPMENT

- ✓ Many marine snails are dioecious.
- ✓ Gonads lie in spirals of the visceral mass.
- ✓ Ducts discharge gametes into the sea for external fertilization.
- ✓ Many other snails are monoecious, and internal, crossfertilization is the rule.
- ✓ Copulation may result in mutual sperm transfer, or one snail may act as the male and the other as the female.
- ✓ Some monoecious snails are protandric.
- ✓ Internally fertilized eggs are deposited in gelatinous strings or masses.
- ✓ In marine gastropods, spiral cleavage results in a free-swimming trochophore larva that develops into another free-swimming larva called a veliger larva.
- ✓ Torsion occurs during the veliger stage, followed by settling and metamorphosis to the adult.

GASTROPOD DIVERSITY

Subclass Prosobranchia

- ✓ The largest group of gastropods.
- ✓ Its 20,000 species are mostly marine.
- ✓ Most members of this subclass are herbivores or deposit feeders.
- ✓ Some carnivorous species inject venom into their prey with a radula modified into a hollow, harpoonlike structure.
- ✓ Include most of the familiar marine snails and the abalone.
- ✓ This subclass also includes the heteropods.
- ✓ These animals are voracious predators, with very small shells or no shells.
- ✓ The foot is modified into an undulating "fin".

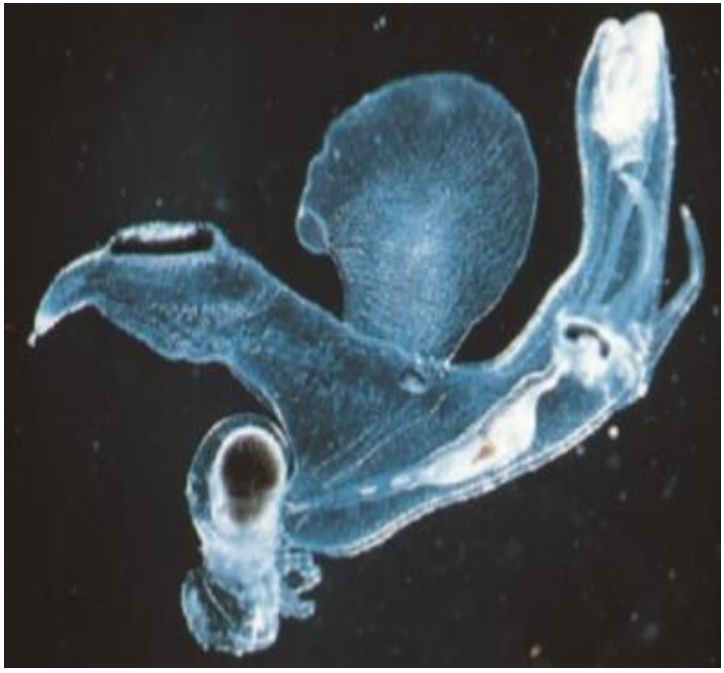

Fig: Variations in the Gastropod Body Form. Subclass Prosobranchia. This heteropod (*Carinaria*) is a predator that swims upside down in the open ocean. Its body is nearly transparent. The head is at the left, and the shell is below and to the right. Heteropoda is a superfamily of prosobranchs comprised of open-ocean, swimming snails with a finlike foot and reduced shell.

GASTROPOD DIVERSITY

Subclass Opisthobranchia

- ✓ Include sea hares, sea slugs, and their relatives.
- ✓ They are mostly marine and include fewer than two thousand species.
- ✓ The shell, mantle cavity, and gills are reduced or lost in these animals, but they are not defenseless.
- ✓ Many acquire undischarged nematocysts from their cnidarian prey, which they use to ward off predators.
- ✓ The pteropods have a foot modified into thin lobes for swimming.

Fig: Variations in the Gastropod Body Form. Subclass Opisthobranchia. Colorful nudibranchs have no shell or mantle cavity. The projections on the dorsal surface are used in gas exchange. In some nudibranchs, the dorsal projections are armed with nematocysts for protection. Nudibranchs prey on sessile animals, such as soft corals and sponges

GASTROPOD DIVERSITY

Subclass Pulmonata

- ✓ The subclass Pulmonata contains about 17,000.
- ✓ Predominantly freshwater or terrestrial species.
- ✓ These snails are mostly herbivores and have a long radula for scraping plant material.
- ✓ The mantle cavity of pulmonate gastropods is highly vascular and serves as a lung.
- ✓ Air or water moves in or out of the opening of the mantle cavity, the pneumostome.
- ✓ In addition to typical freshwater or terrestrial snails, the pulmonates include terrestrial slug.

Subclass Pulmonata. Terrestrial slugs like this one (*Ariolimax columbianus*) lack a shell. Note the opening to the lung (pneumostome).

CLASS BIVALVIA

- ✓ With close to 30,000 species.
- ✓ Class Bivalvia is the second largest molluscan class.
- ✓ Includes the clams, oysters, mussels, and scallops.
- ✓ A sheetlike mantle and a shell consisting of two valves cover these laterally compressed animals.
- ✓ Many bivalves are edible, and some form pearls.
- ✓ Because most bivalves are filter feeders, they are valuable in removing bacteria from polluted water.

SHELL AND ASSOCIATED STRUCTURES

- ✓ The two convex halves of the shell are called valves.
- ✓ A proteinaceous hinge.
- ✓ A series of tongue-and-groove modifications of the shell, called teeth.
- ✓ The oldest part of the shell is the umbo.
- ✓ Although bivalves appear to have two shells, embryologically, the shell forms as a single structure.
- ✓ An elastic hinge ligament.
- ✓ If a sand grain or a parasite lodges between the shell and the mantle, the mantle secretes nacre around the irritant, gradually forming a pearl.
- ✓ The Pacific oysters, *Pinctada margaritifera* and *Pinctada mertensi*, form the highest-quality pearls.

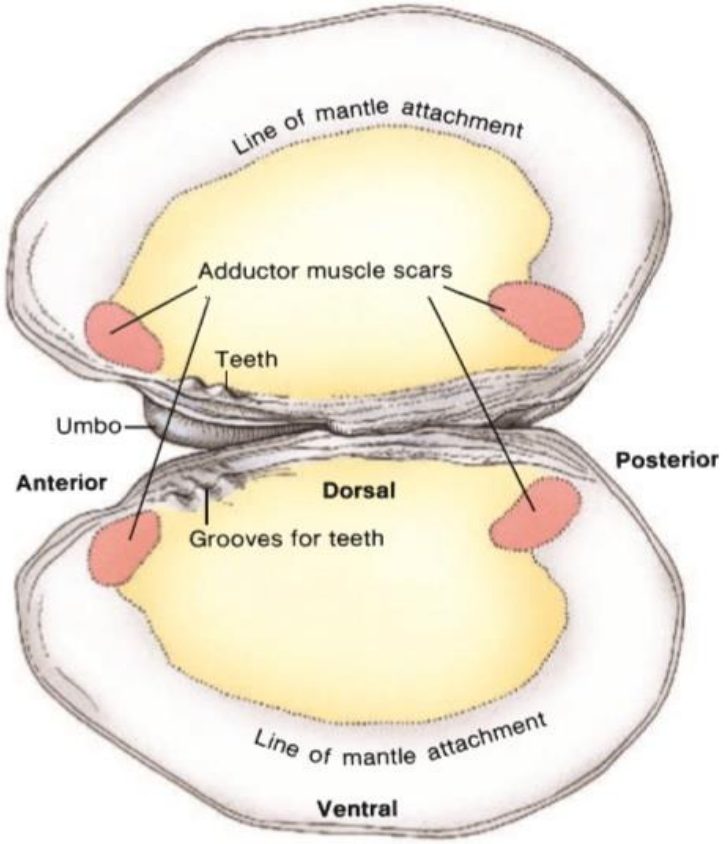

Fig: Inside View of a Bivalve Shell. The umbo is the oldest part of the bivalve shell. As the bivalve grows, the mantle lays down more shell in concentric lines of growth.

GAS EXCHANGE

- ✓ Gills form folded sheets (lamellae), with one end attached to the foot and the other end attached to the mantle.
- ✓ The mantle cavity ventral to the gills is the inhalant region.
- ✓ The cavity dorsal to the gills is the exhalant region.
- ✓ Cilia move water into the mantle cavity through an incurrent opening of the mantle.
- ✓ A bivalve buried in the substrate can extend its siphon to the surface and still feed and exchange gases.
- ✓ Water moves from the mantle cavity into small pores in the surface of the gills, and from there, into vertical channels in the gills, called water tubes.
- ✓ Water exits the bivalve through a part of the mantle cavity at the dorsal aspect of the gills, called the suprabranchial chamber, and through an excurrent opening in the mantle.

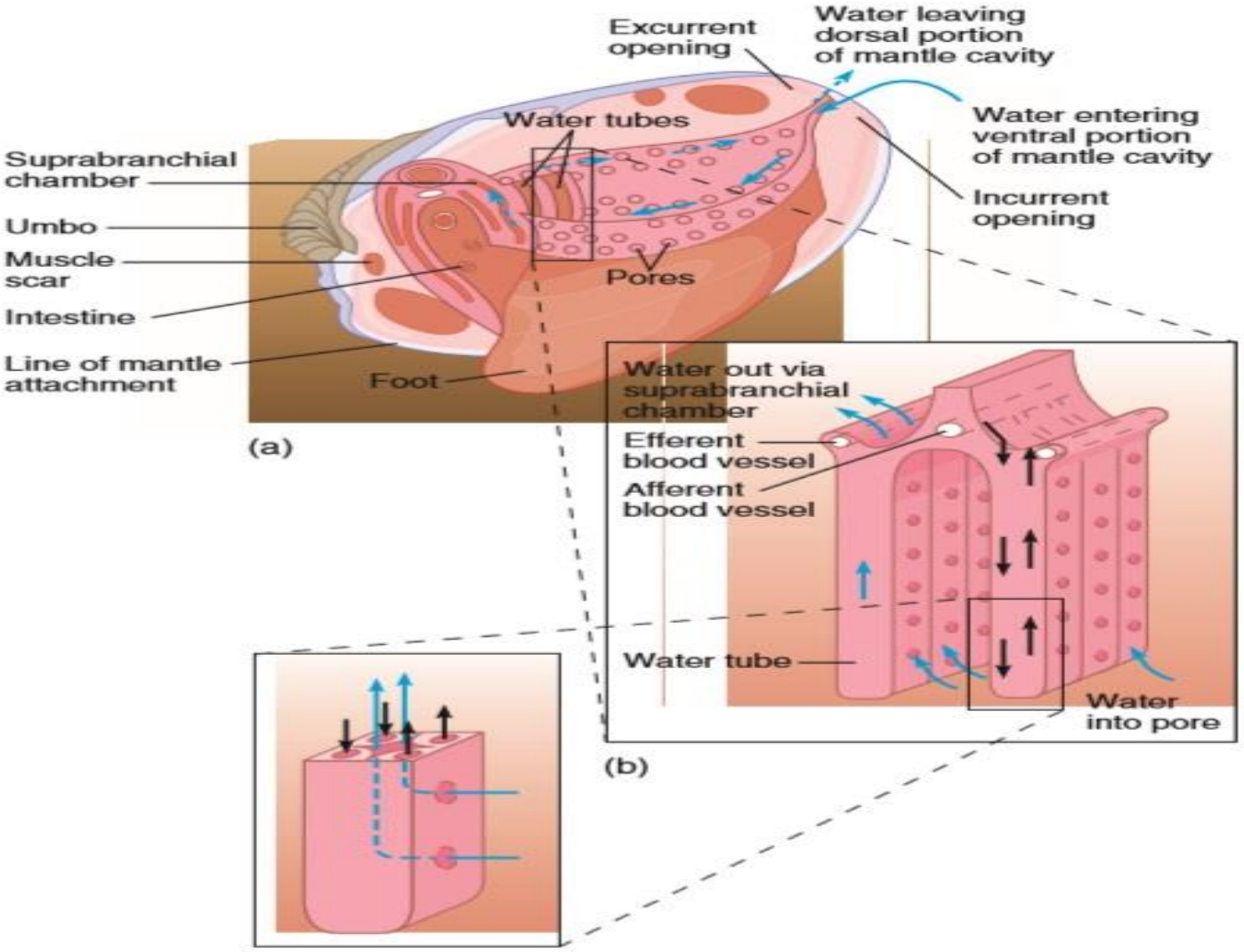

Fig: Lamellibranch Gill of a Bivalve. (a) Blue arrows indicate incurrent and excurrent water currents. Food is filtered as water enters water tubes through pores in the gills. (b) Cross section through a portion of a gill. Water passing through a water tube is in close proximity to blood. Water and blood exchange gases in the water tubes. Blue arrows show the path of water. Black arrows show the path of blood.