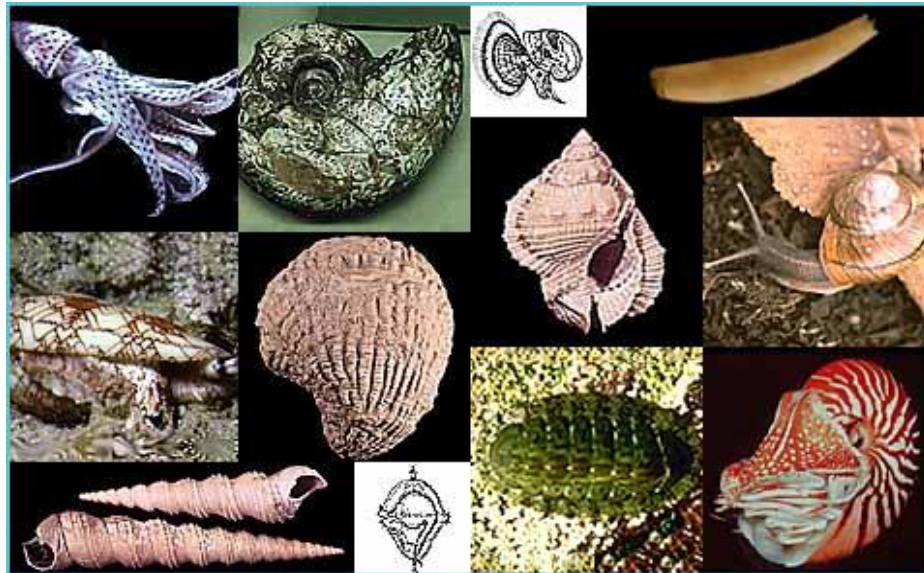


Invertebrate Zoology (Biol 242)

Chapter 12

Phylum Mollusca



Phylum Mollusca

▶ **Mollusca: L.: Soft**

▶ **Defining Characteristics:**

- ❑ *Dorsal epithelium forming a **mantle**, which secretes **calcareous spicules or a shell**.*
- ❑ *Cuticular band of teeth (**radula**) in the esophagus, used for feeding.*
- ❑ *Ventral body wall muscles develop into a locomotory or clinging **foot**.*

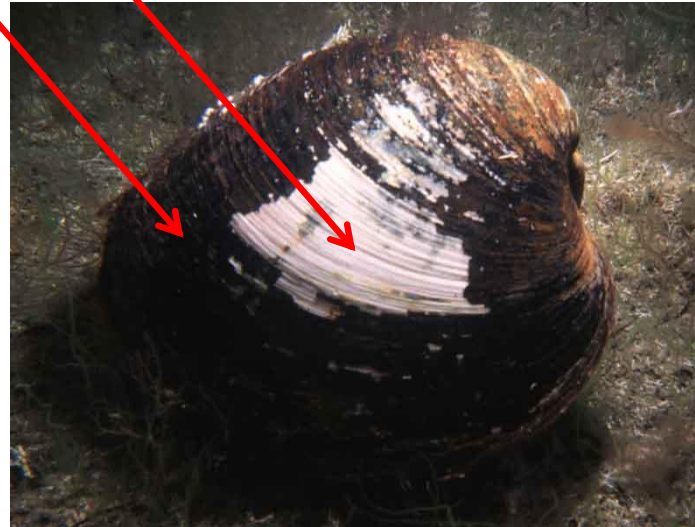
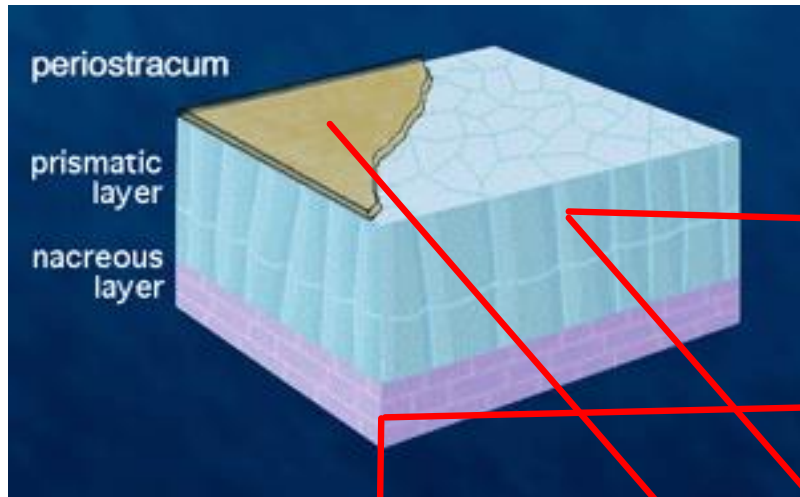
General Characteristics:

- ▶ **One of the largest** of all animal phyla including about 100,000 living species.
- ▶ It includes **many dissimilar species** like: **clams, snails, octopuses** etc. Therefore, it is very difficult to describe a typical molluscan body.
- ▶ However, many molluscs have **shells, mantle, foot, gills and radual.**



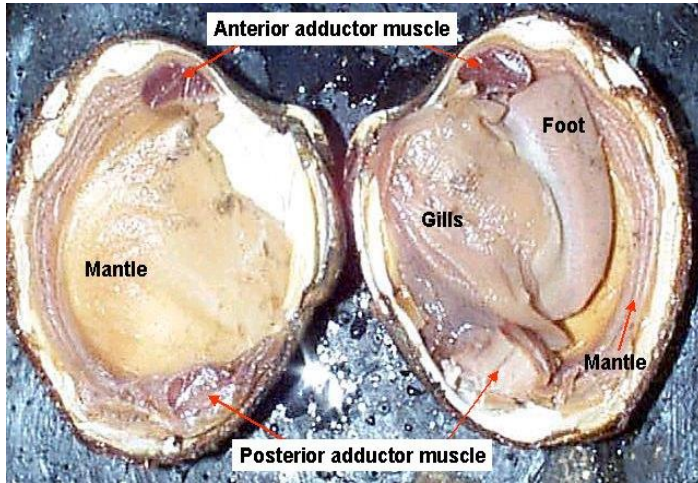
The Shell

- ▶ **Most**, but not all, molluscs **have shells** consisting **primarily of calcium carbonate** set in a **protein matrix**.
- ▶ The organic material may comprise 35%-70% of the dry weight of the shell.
- ▶ **Shell is composed of three layers:**
 - **Periostracum:** *Thin, outer organic layer.*
 - **Nacreous:** *Thin, innermost calcareous layer.*
 - **Prismatic:** *Thick, calcareous middle layer.*
- ▶ Shell material is secreted by specialized tissue known as the **mantle**.



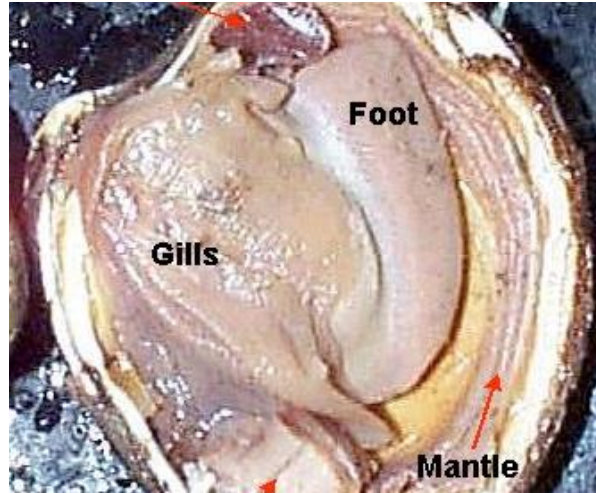
The Mantle

- ▶ The **mantle** is the dorsal body wall which covers the visceral mass and usually protrudes in the form of flaps well beyond the visceral mass itself.
- ▶ In addition to secreting and repairing the shell, the mantle could secrete **pearls** in oysters when sand particles become trapped between the mantle and the shell.



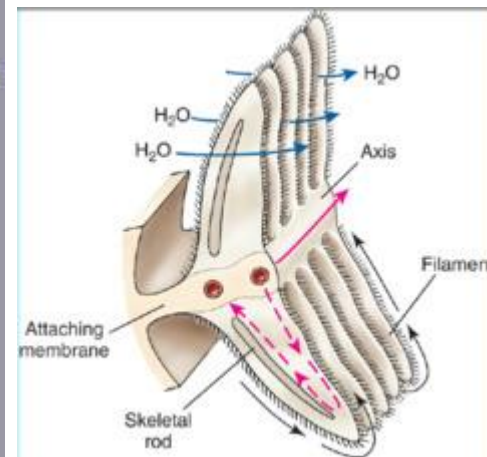
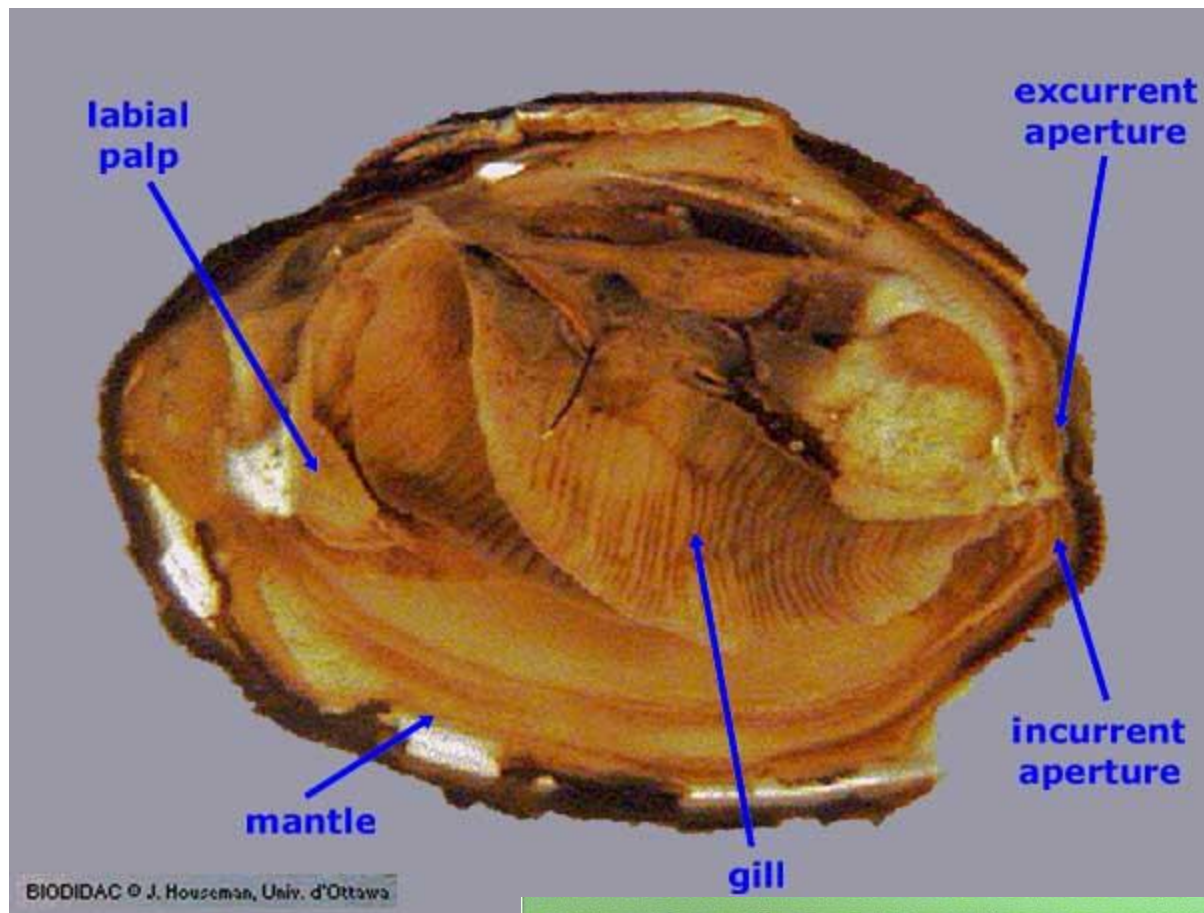
The Foot

- ▶ Most molluscs have a **foot**, which is modified for a variety of functions in different groups.



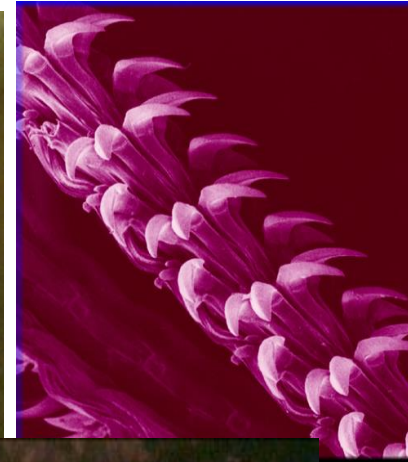
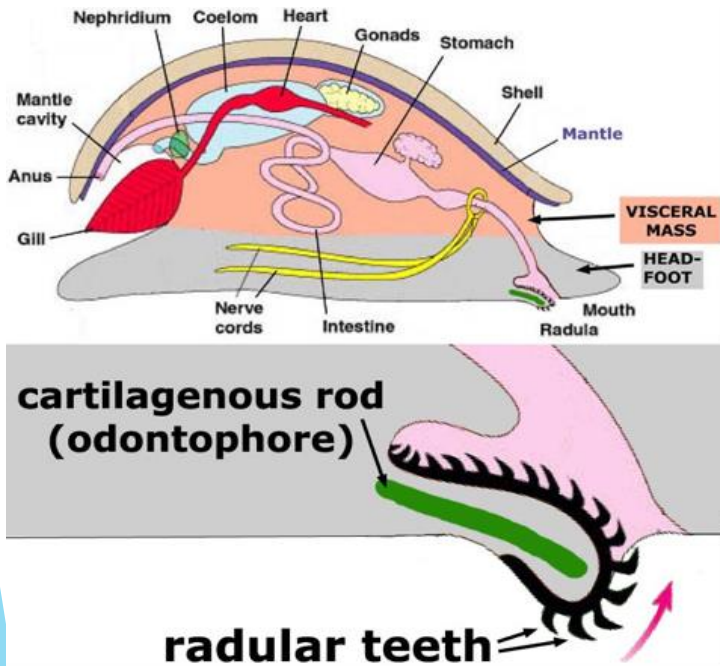
The Gills

- ▶ **Most molluscan gill are found inside** a characteristic cavity between the mantle and the viscera called the **mantle cavity**.
- ▶ Molluscan gills are called **ctenidia** (**comb-like**) are present.
- ▶ Ctenidia might have **other functions rather than respiration**. These include **collection and sorting of food**.
- ▶ **Chemoreceptor**, called **osphradium** (**osphra: G: smell**) is located adjacent to the ctenidium.

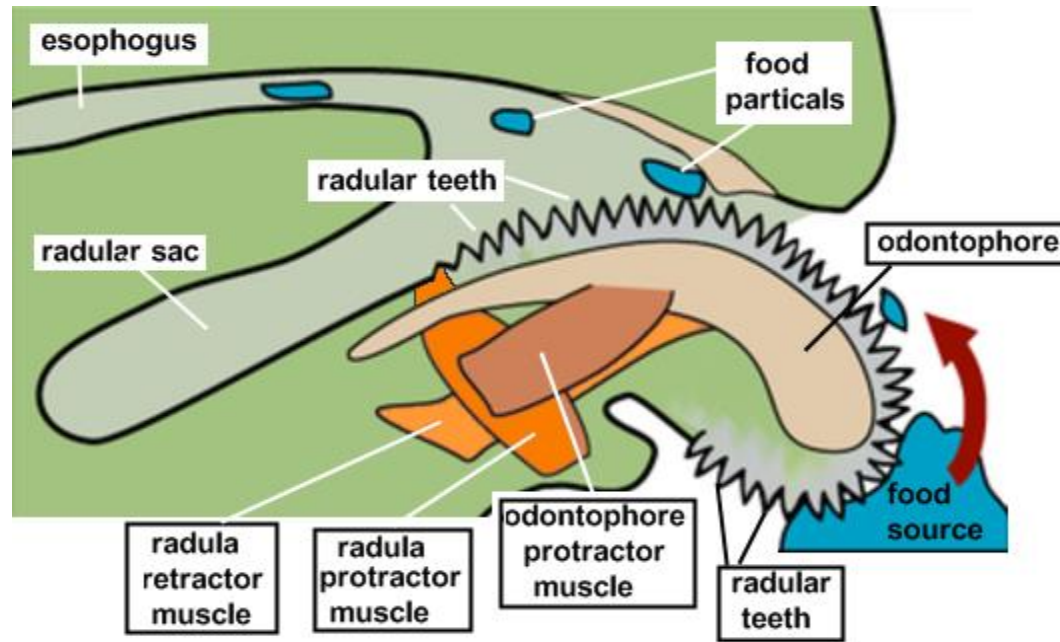
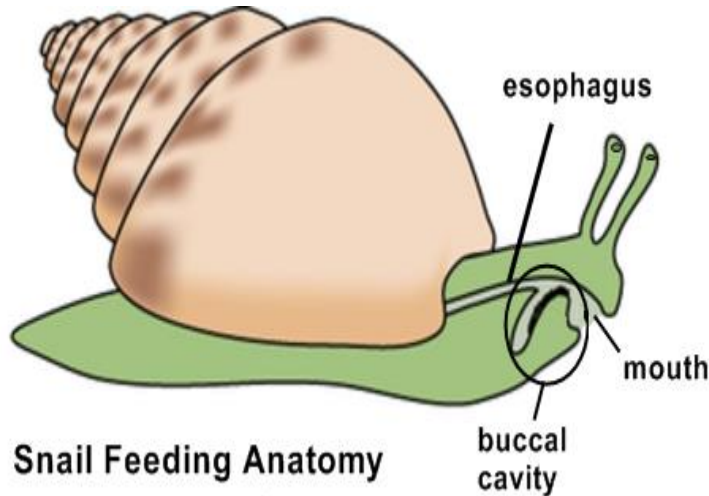


The radula

- ▶ Many molluscs possess a feeding structure known as the **radula**.
- ▶ It is provided with **2 rows** of sharp **chitinous teeth**.

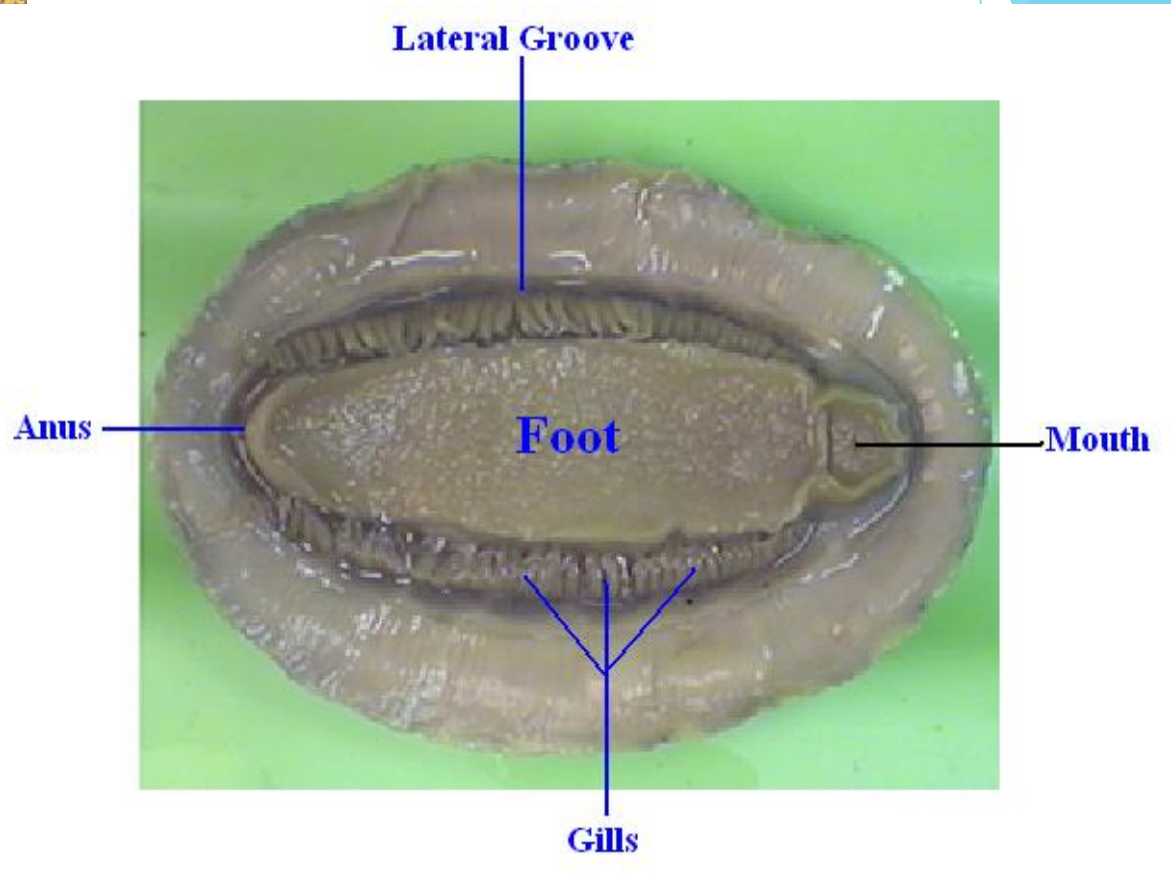


- ▶ It is produced from a **radular sac**.
- ▶ It is supported by a cartilage-like structure called the **odontophore** (G: *Tooth-bearer*).
- ▶ The odontophore-radular assembly, together with its complex musculature, is known as the **buccal mass** or the **odontophore complex**.

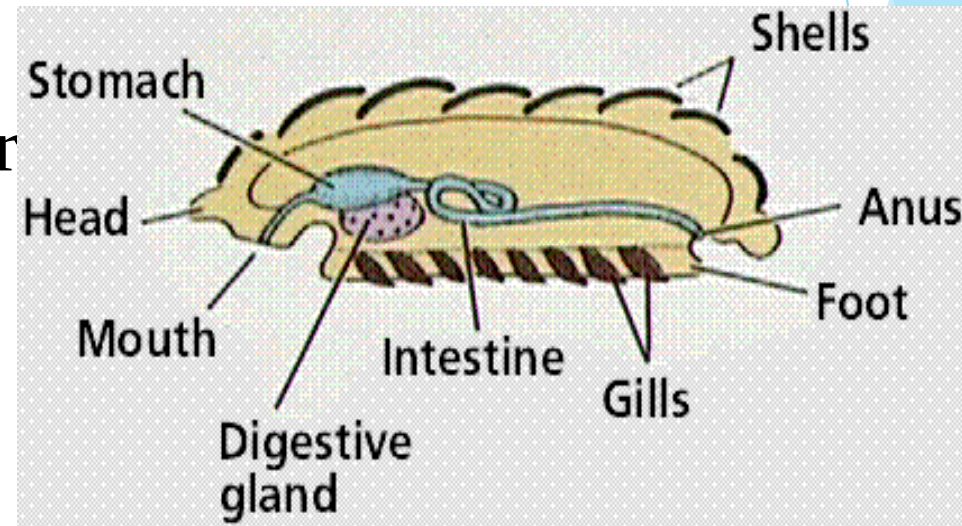


1) Class Polyplacophora

- ▶ **Polyplacophora**: G: **Many-plate-bearing**.
- ▶ **Defining Characteristic**: **shell takes the form of a series of 7-8 separate plates**.
- ▶ About 500 species called **Chitons**.
- ▶ **Size is 3-10 cm** long and lives close to the shore (intertidal zone).
- ▶ They are restricted to **rocky shores**.
- ▶ Chiton's thick **lateral mantle** is called the **girdle**.
- ▶ The **mantle cavity** of chitons takes the form of **2 lateral grooves**, one on each side of the body.



- ▶ About **80 bipectinate** (double-combed) **ctenidia** (gills) hang down from the roof of each lateral groove.
- ▶ The flow of water current over the gills is in opposite direction to the flow of blood. This is called **counter current exchange system**.
- ▶ The **foot** extends along the entire ventral surface and is completely covered by the shell.
- ▶ Locomotion is by waves of muscular contraction (**called pedal waves**).
- ▶ **Digestive system is linear**; mouth and anus are at opposite directions.



- They **feed usually on algae** by means of the **radula** (some are carnivorous).
- A pair of **pharyngeal glands** (called **sugar glands**) releases **amylase-containing secretions** into the stomach.
- Chitons have **fossil records** extending back some **500 million years**.

2) Class Aplacophora

- *Aplacophora: G: Not-shell-bearing.*
- *Defining Characteristic: Cylindrical, vermiform body with the foot forming a narrow keel.*
- These are vermiform molluscs (about 320 species).
- Found in all oceans, **mostly in deep waters.**
- Most species are very small (few mm long and rarely more than few cm).



- Body is **unsegmented** and bears **numerous calcareous spines** or scales embedded in an outer cuticle.



- ▶ Have **no true shell**.
- ▶ Have a **radula** and a small **posterior mantle cavity**.
- ▶ Have **no clear foot**.

3) Class Monoplacophora:

- *Monoplacophora: G: One shell bearing.*
- *Defining Characteristics:*
 - ▶ *3-6 pairs of ctenidia, 6-7 pairs of nephridia.*
 - ▶ *Multiple (usually 8) pairs of foot (pedal) retractor muscles.*

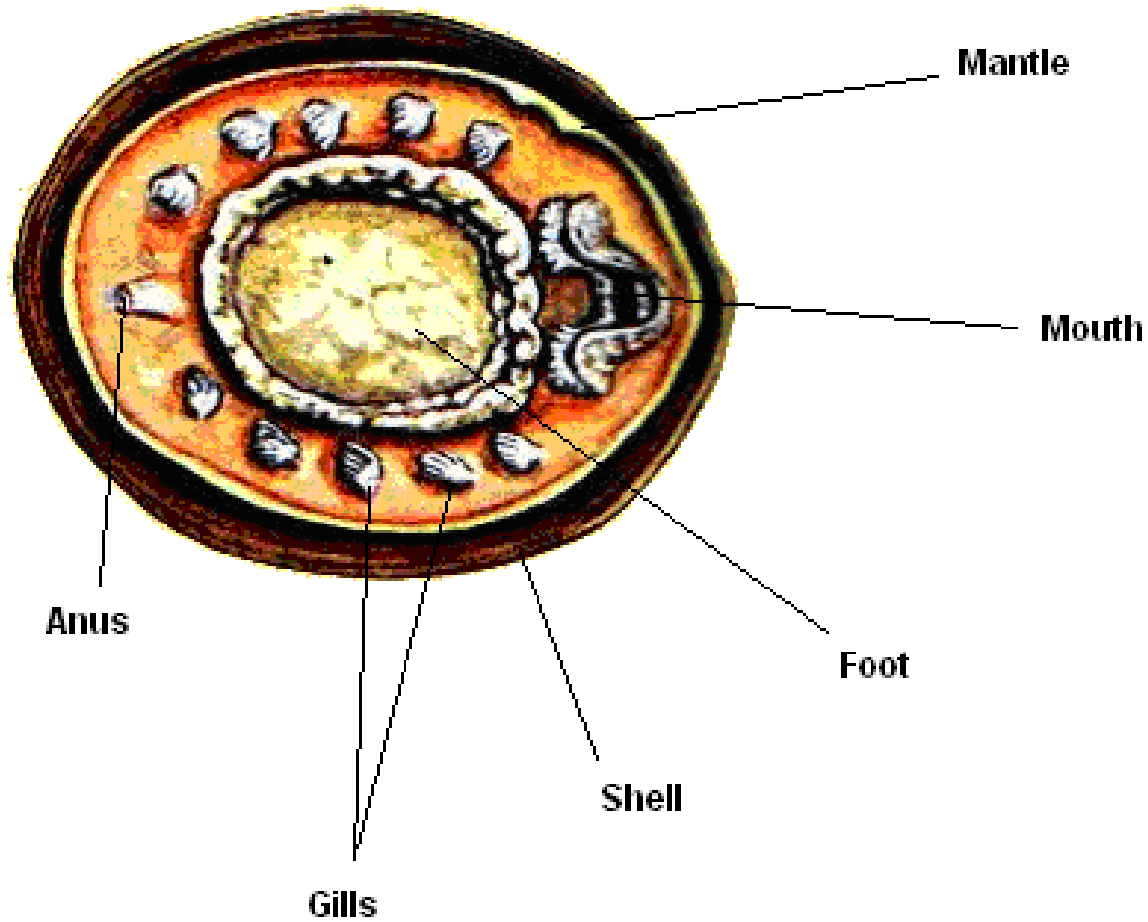


Photo by Robert Sprackland



- **19 living species**, **all are marine** and live in **deep water** (**>2000m**).
- A **single, unhinged, cap-shaped shell** is present.
- **Shell is flattened** rather than spiral.
- **Shell length** ranges between **1 mm- 37 mm**.
- The **foot is flattened** and covers much of the ventral surface.
- ▶ The **mantle cavity** takes the form of **2 lateral grooves**, within which 3, 5 or 6 pairs of gills are found

- Have **radula** and a **linear digestive system**.
- Mouth opens anterior and anus posterior.

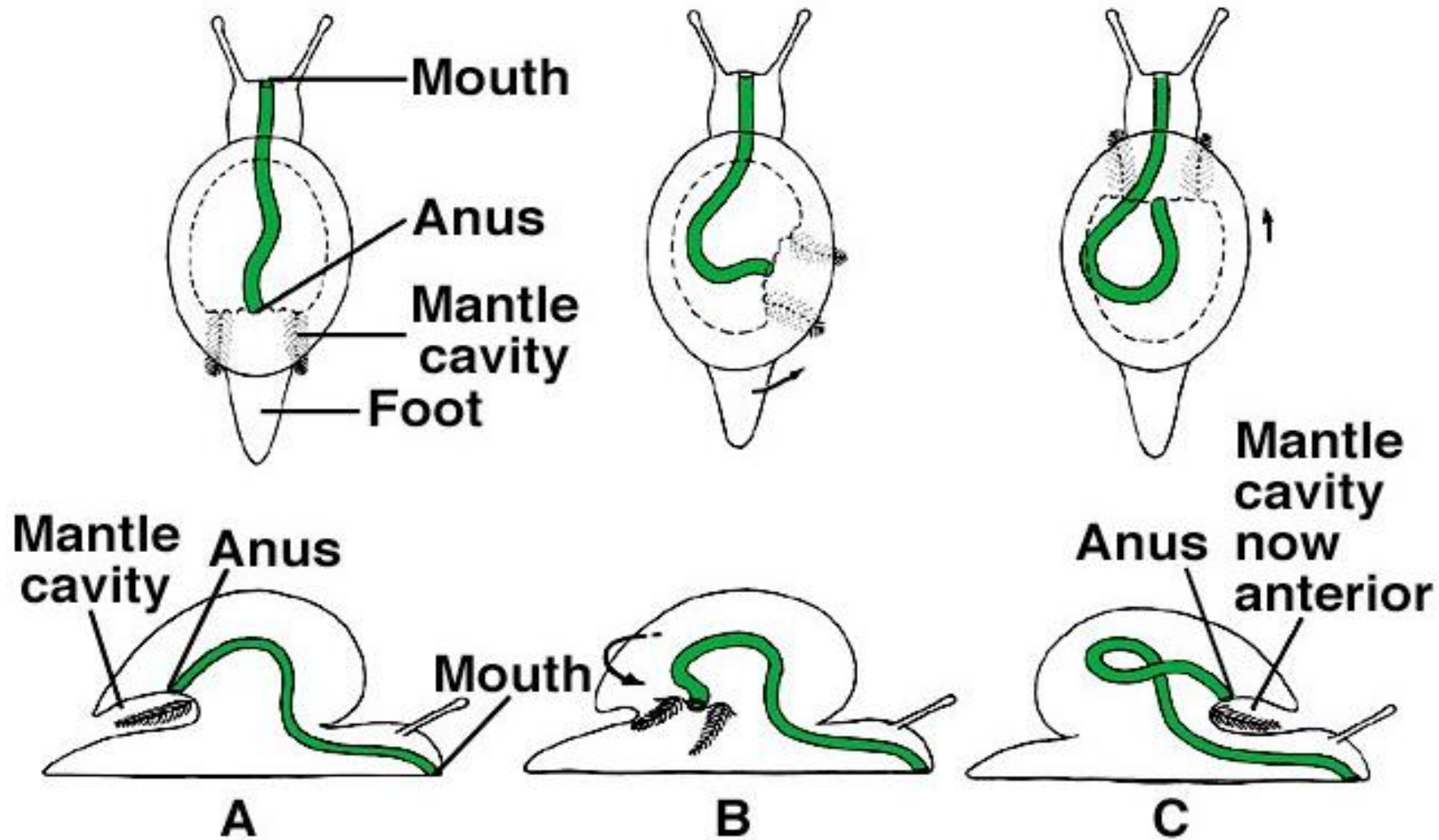


4) Class Gastropoda:

- *Gastropoda: G: stomach-foot.*
- *Defining Characteristics:*
 - *Visceral mass and nervous system become twisted 90-180° (**Torsion**) during embryonic development.*
 - *Proteinaceous shield on the foot (**operculum**).*



Torsion in gastropods





- The **largest class of molluscs** comprising 40,000 species of **snails and slugs**.



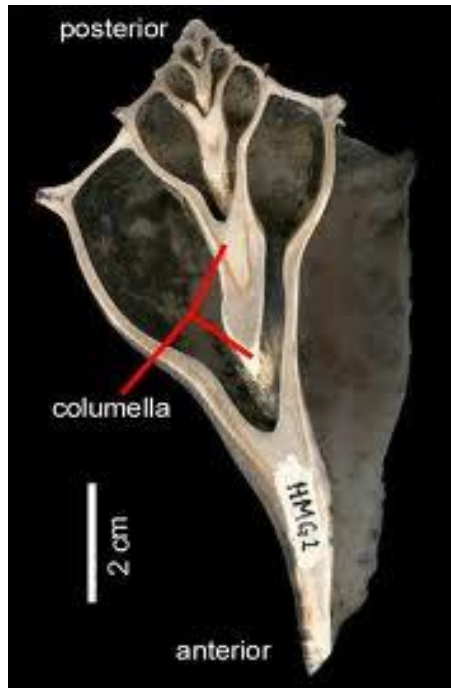
A snail



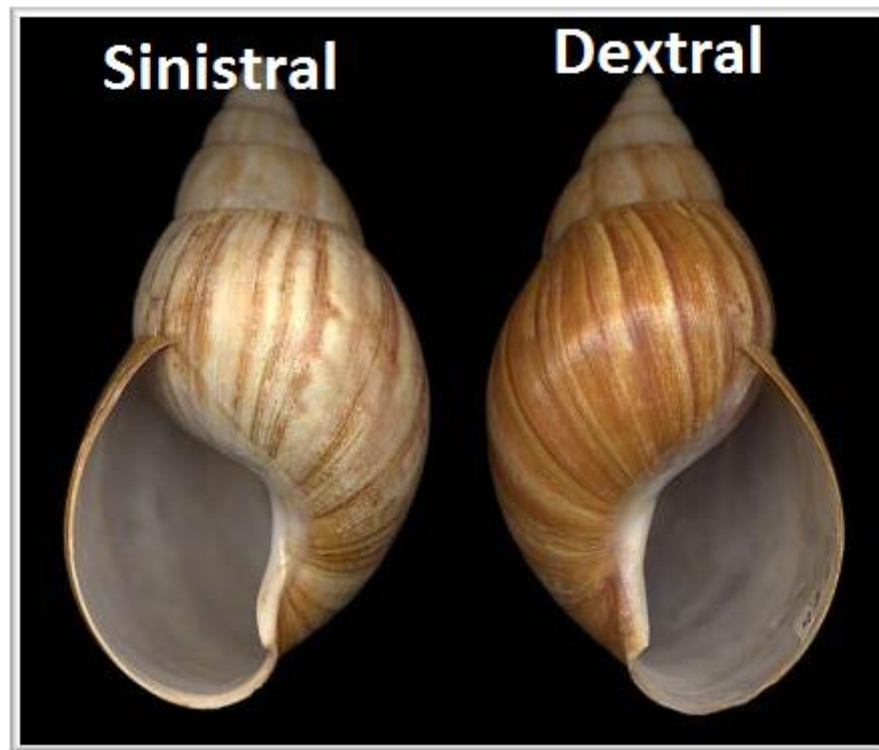
A slug

- Found in **freshwater, marine** and **terrestrial environments**.
- Their feeding habits are diverse: **suspension-feeders, carnivorous, herbivorous, deposit-feeders and ectoparasitic species**.
- The typical snail consists of a **visceral mass** (all internal organs) sitting atop a muscular **foot**.
- Shell size ranges between **1 mm- >60 cm**.
-

- The animal is attached to the inside of its shell by a **columellar muscle**.
- The shell has a central axis called **columella**.



- Shells of most gastropods coil to the **right** (**clockwise**) and called **dextral** (dextro: right hand side).
- Other shells which coil to the **left** are called **sinistral** (sinister: left hand side).



- After torsion, some gastropods exhibit **detorsion**.
- Other gastropods exhibit **limited torsion** (90° only).
- Significance of torsion is not clear.

➤ **Movement:**

- Most gastropods move by **pedal waves** of foot muscle contractions.
- **Small** gastropods move by the **action of cilia** on the ventral surface of the foot.



- **Class Gastropoda** includes **3 subclasses**:

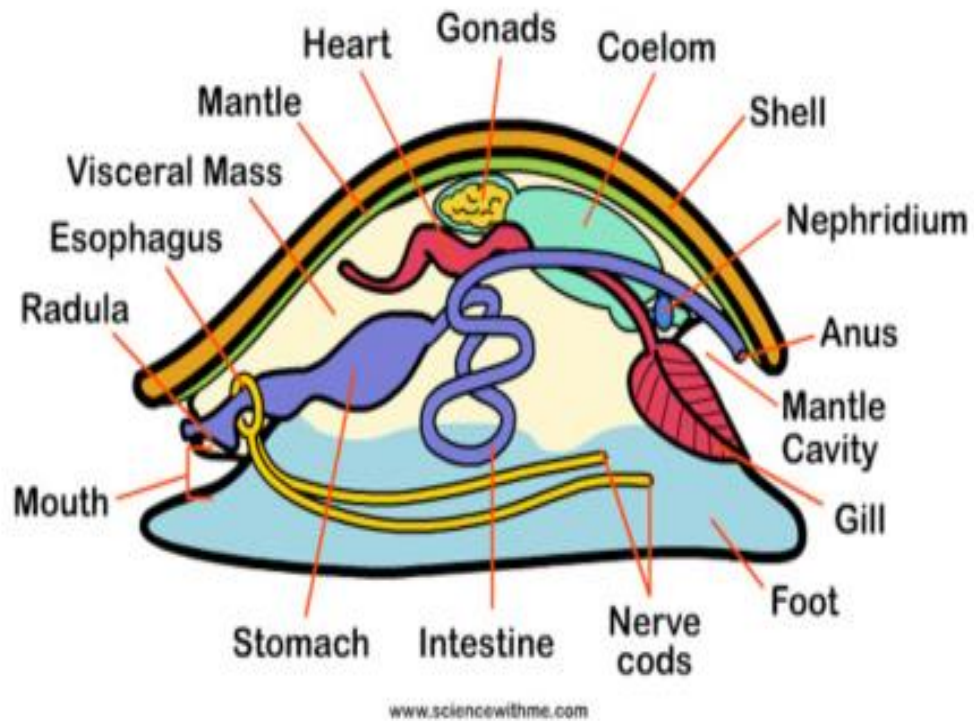
1) Subclass Prosobranchia:

Prosobranchia: G: anterior-gills.

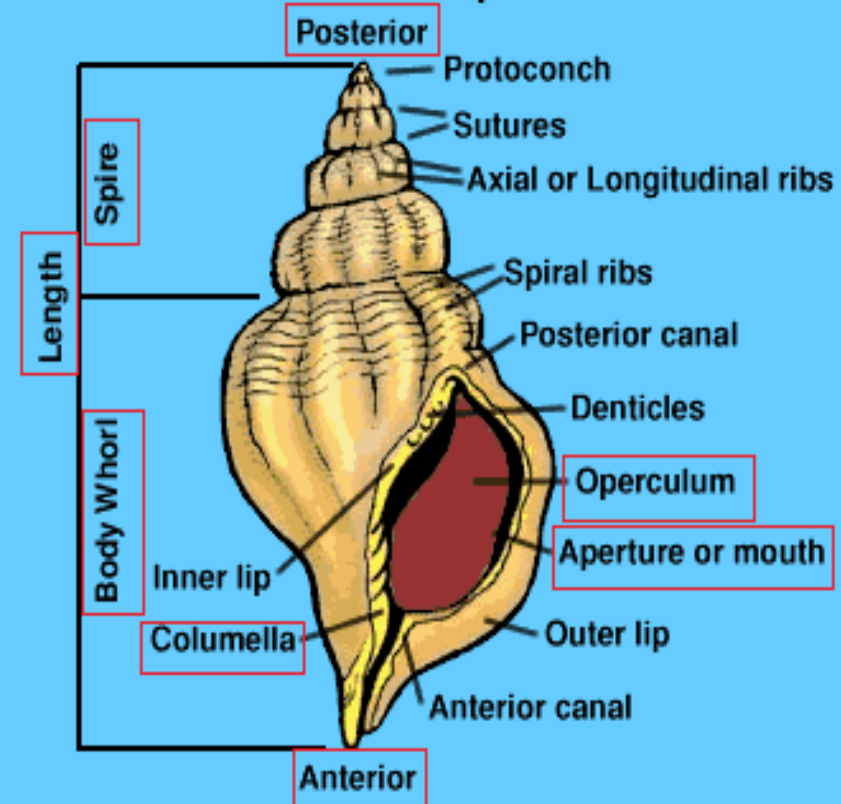
- *Defining Characteristic: Mantle cavity generally anterior, due to torsion.*
- The **largest** among the 3 subclasses (20,000 species).
- Includes **mostly marine** species (few freshwater or terrestrial).
- Feeding habits are diverse: **herbivores, deposit-feeders, omnivores, suspension-feeders or carnivorous.**

- Members of this subclass are considered the **most primitive gastropods** (thought to be ancestor for the other 2 subclasses).
- Most species have a well-developed **shell, mantle cavity, osphradium** and **radula**.
- The typical **prosobranch gill** is a **ctenidium** consisting of a series of flattened, triangular sheets (filaments) lying one adjacent to the next.

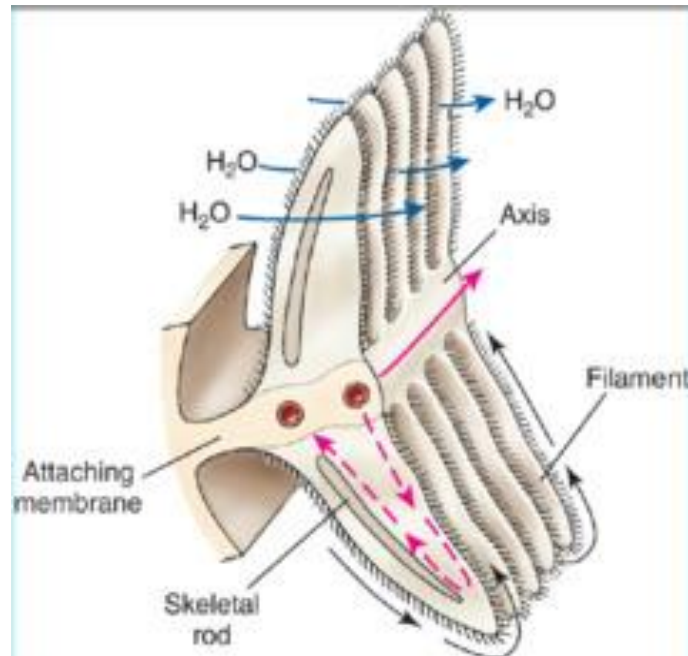
Generalized Molluscan Body Plan



Mollusc - Univalve Gastropod



- Water enters the mantle cavity through a cylindrical canal called the **siphon**.
- Gills are primitive (**bipectinate**)=gill filaments extend from both sides of the ctenidial axis.
- Members of other advanced gastropods have **monopectinate** gills.



2) Subclass Opisthobranchia:

- *Opisthobranchia: posterior gill*
- *Defining Characteristic: Mantle cavity lateral or posterior due to detorsion (or it could be lost).*
- Includes: **sea hares, sea slugs.**
- Contains **mainly marine** species (2000 spp).

► Examples:

Sea Slugs: nudibranchs



Sea Hares



- Most species have evolved other respiratory structures, like the colored **dorsal projections** called **cerata** in sea slugs (nudibranchs).



- Others have **feathery gills** arising from dorsal surface.



- ▶ Head bears, in addition to 1 pair of tentacles, a second pair of chemoreceptors called **rhinophores** (analogous to osphradium in prosobranchs).



■ Movement:

- Movement is generally by means of **cilia and pedal waves** of muscle contraction.
- Some, **like sea hares**, can **swim** by flapping lateral folds of the foot called **parapodia**.

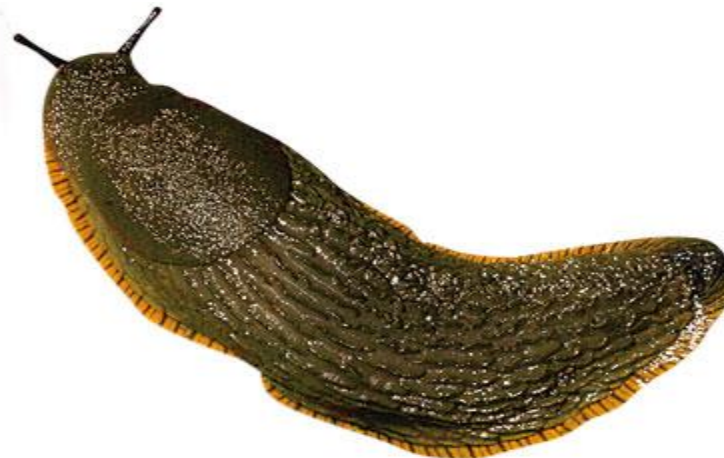


3) Subclass Pulmonata:

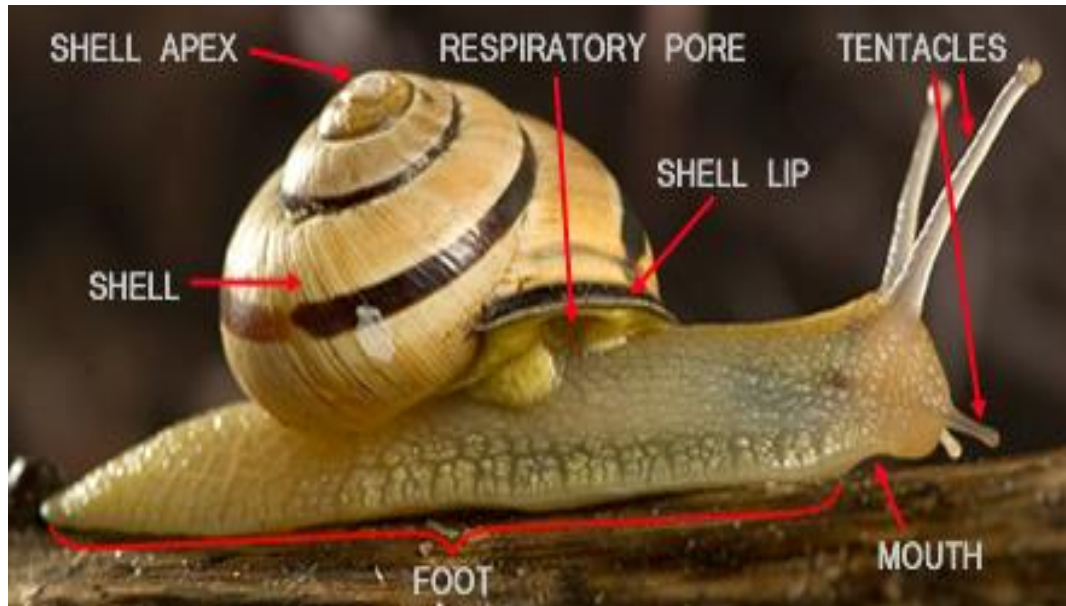
- *Pulmonata: L: Pulmo: Lung.*
- *Defining Characteristic: Mantle cavity highly vascularized and modified to form a lung.*
- About 17,000 species. Mostly **terrestrial or freshwater** (only few marine).
- Lung has a single opening called **pneumostome** (G: lung-opening), through which air and water flow.



- **Snails** have a **coiled shell** while **slugs** have their shell either **reduced, internalized or completely lost**.



- Most have a **long radula** (herbivores).
- Head commonly bears **2 pairs of tentacles**.
- Torsion is limited to about 90°.



5) Class Bivalvia (=Pelecypoda):

- *Bivalvia*: **L: two-valved**; *Pelecypoda*: **G: hatchet-foot**.
- *Defining Characteristics*:
 - *Two-valved shell*.
 - *Body flattened laterally*.
- Contains over 7000 species like: **clams, scallops, mussels and oysters**.
- Bivalves are **primarily marine (10-15% freshwater, no terrestrial)**.



Scallops



Clams





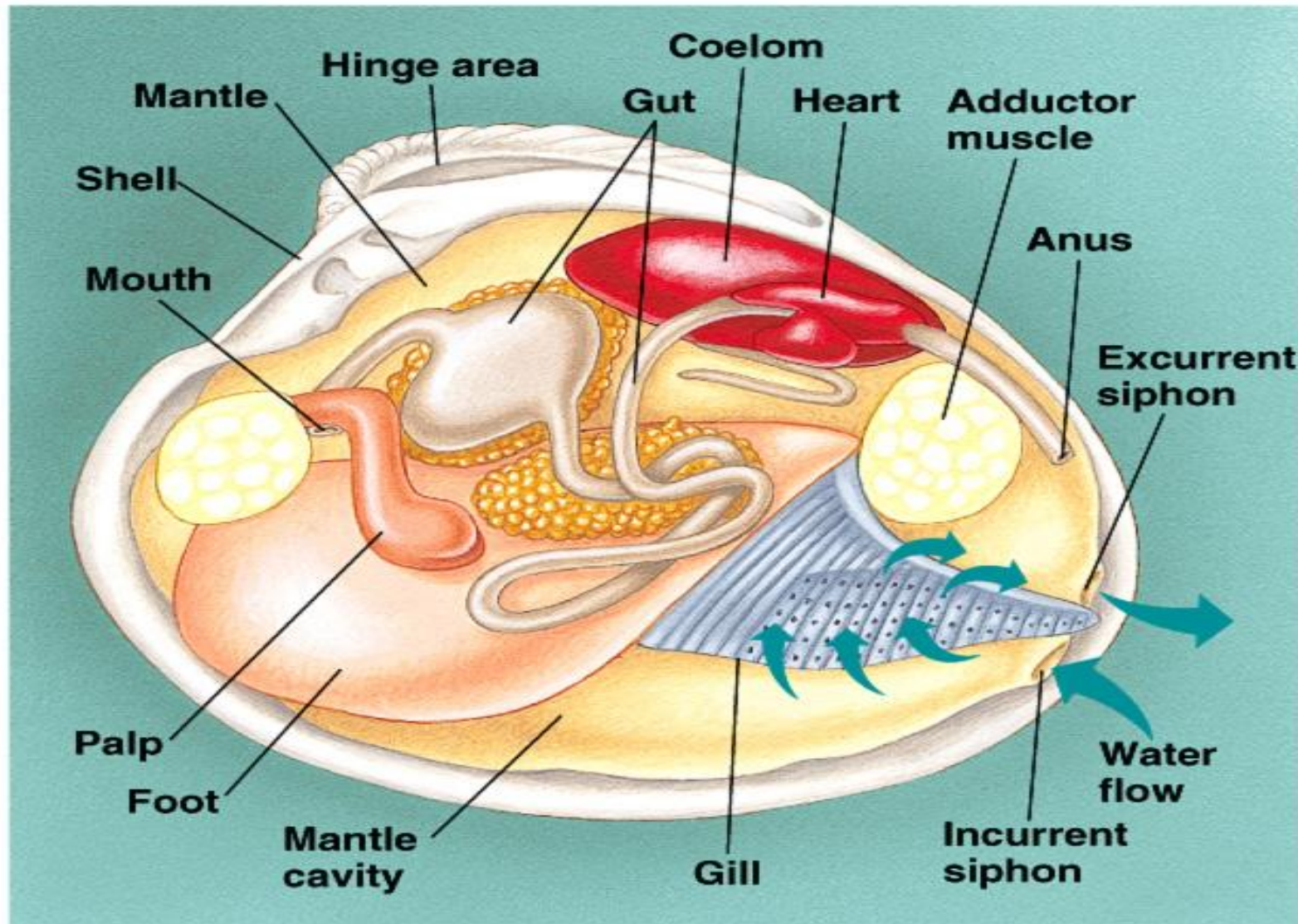
Oysters



Mussels

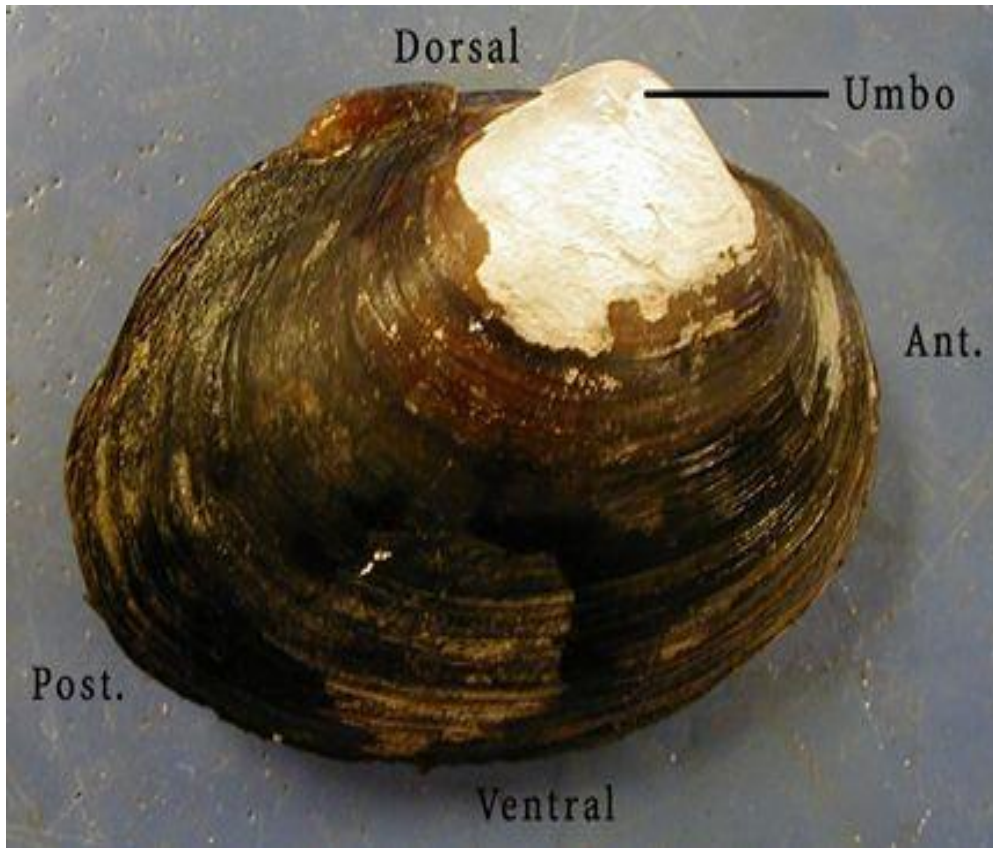
- Major characteristics include:
 - *A hinged shell: the 2 valves are jointed together by a hinge ligament.*
 - *Lateral compression of the body and foot.*
 - *Lack of cephalization (loss of head and associated organs).*
 - *A spacious mantle cavity.*
 - *Sedentary life style.*
 - *Absence of radula and odontophore complex.*

► Body structure:



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► Shell structure:



- Based on gill structure, bivalves can be subdivided into three subclasses as follows.

1) Subclass Protobranchia:

Protobranchia: G: First-gill.

- ❑ Gills small, functioning primarily as gas exchange surfaces (do not function in food collection).
- Have **one pair of bipectinate gills** inside the mantle cavity.
- All are **marine and live in soft substrates**.

- Feeding habit: **Deposit feeders**
- Food collection is achieved through mucus on **palp**
proboscides: long, thin, muscular extensions of the tissue surrounding the mouth.

2) Subclass *Lamellibranchia*:

- *Lamellibranchia*: G: plate gills
 - *Gills modified to collect suspended food particles, in addition to serving as gas exchange surfaces.*
 - *Secretion of Proteinaceous attachment material (byssal threads) by a specialized gland (the byssus gland) in the foot.*

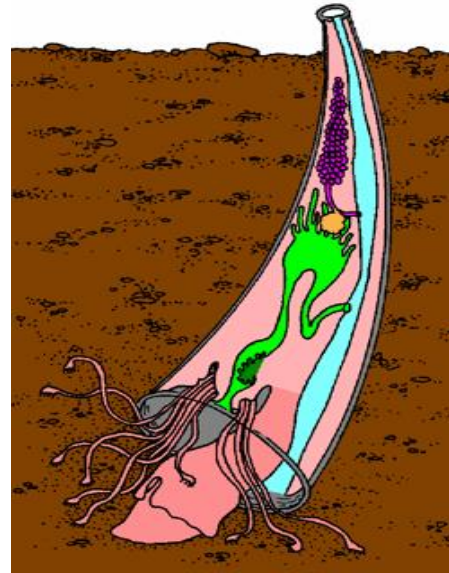
- The largest subclass.
 - Most species are **marine** (all freshwater species belong to this subclass).
 - These are important as **sea food** (**oysters and scallops**), and a **source of pearls**
- ▶ Feeding habit: **filter feeders**
 - ▶ Stomach is connected with a larger **digestive gland** (**digestive diverticula**), which serves as the major site of digestion and absorption.

3) Subclass Septibranchia:

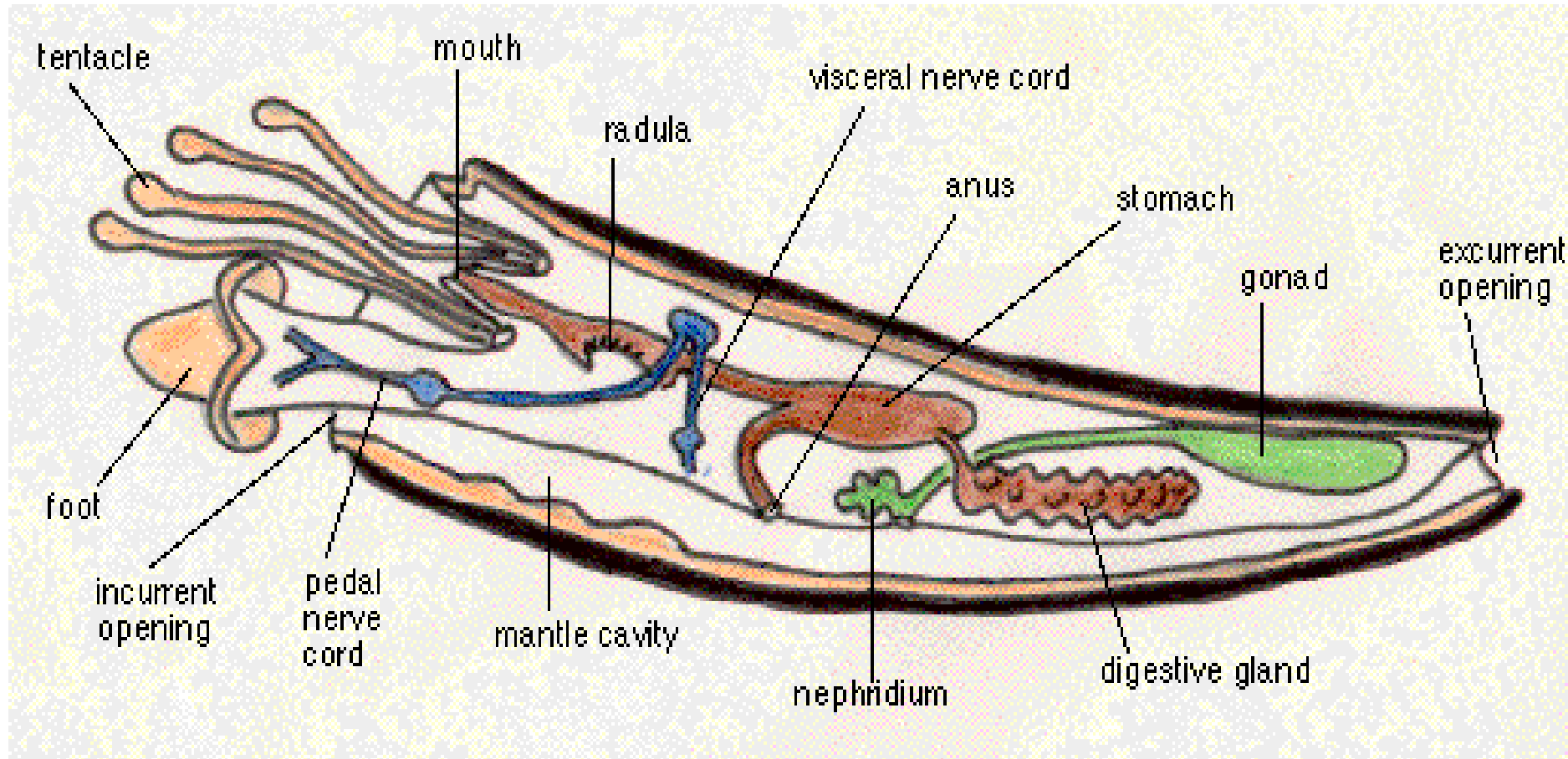
- *Septibranchia: G: fence gill.*
- *Defining Characteristic: Gills highly modified to form a muscular septum, which pumps water through the mantle cavity for respiration and feeding.*
- This is a **small group** (a few hundred species) of **carnivorous** bivalves that feed on small planktonic animals (Zooplankton) and on pieces of decomposing animal tissue.
- All are **marine** and **deep water** organisms.

6) Class Scaphopoda:

- *Scaphopoda: G: Spade foot*
- *Defining Characteristics:*
 - *Tusk-shaped, conical shell, open at both ends.*
 - *Development of anterior, thread-like, adhesive feeding tentacles.*



► Body structure:



- Includes 300-400 species that are **all marine**.
- They are **sedentary** and **deep sea** organisms.
- They have the typical molluscan features: **foot, mantle, mantle cavity, radula and shell**.
- The shell is never spiral, but rather grows linearly as a **hollow, curved tube (tusk shell)**.



7) Class Cephalopoda:

➤ *Cephalopoda: head foot*

➤ *Defining Characteristics:*

- *Closed circulatory system.*
- *Foot modified to form flexible arms and siphon.*
- *Ganglia fused to form a large brain encased in a cartilaginous cranium.*



Octopus



Squid



Nautilus

- Includes: **squids, octopuses and *Nautilus***. (600 species).
- Exclusively **marine**, fast-moving and carnivorous organisms.
- The largest cephalopod weighs about 1000kg and reaches a length of 18 m, while the smallest is less than 2 cm long.
- All have **ctenidia, radula, mantle cavity and foot**.
- Head and associated organs are well-developed.

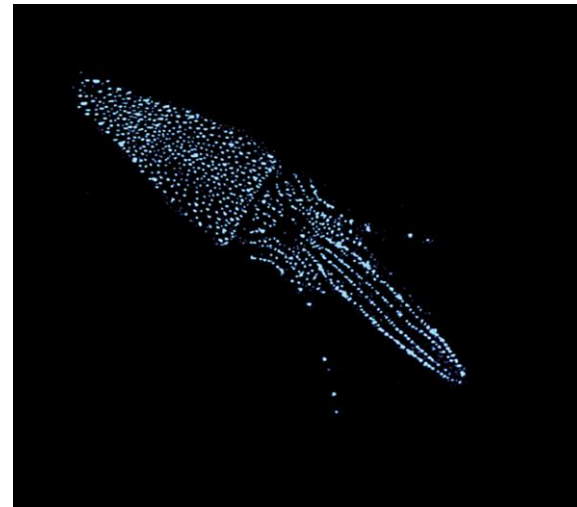
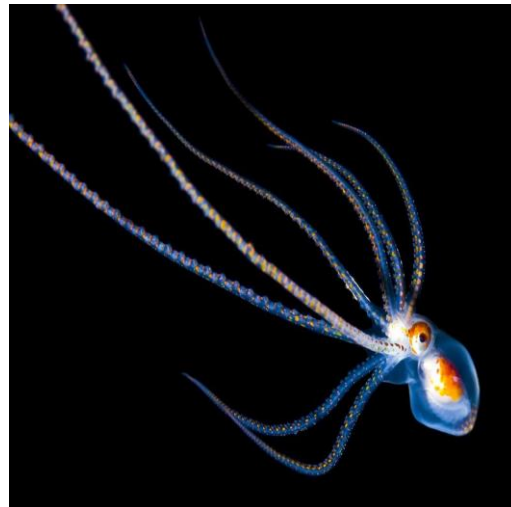
- Only 5-6 species of the genus *Nautilus* possess a true **external shell**.
- Shell is spiral, but unlike that of gastropods, it is divided by **septa** into a series of compartments.
- The living animal is found only within the **largest outermost chamber**.



- Skin of most cephalopods has **chromatophores** which help organisms in **camouflage**.



- Many have **photophores** that produce light (**bioluminescence**).



- Octopus and squid have an **ink sac**, used to confuse potential predators.



- Mantle cavity contains a **pair of ctenidia**.
- They have a **closed circulatory system** with **2 hearts: systemic** and **branchial**.
- The mouth is found surrounded by **8 or 10 arms**.
- Have a high degree of **cephalization** (concentration of sensory and nervous tissue at the anterior end of the animal).
- Cephalopods have a large, complex, highly differentiated **brain**.

- Each cephalopod has **2 eyes**.
- Eyes of all **octopuses and squids** are **image-forming** and have a lens. They are similar to vertebrate eyes.
- Eyes of *Nautilus* are **image-forming but lack lens**.



End of Chapter 12