Biology Lecture 3&4

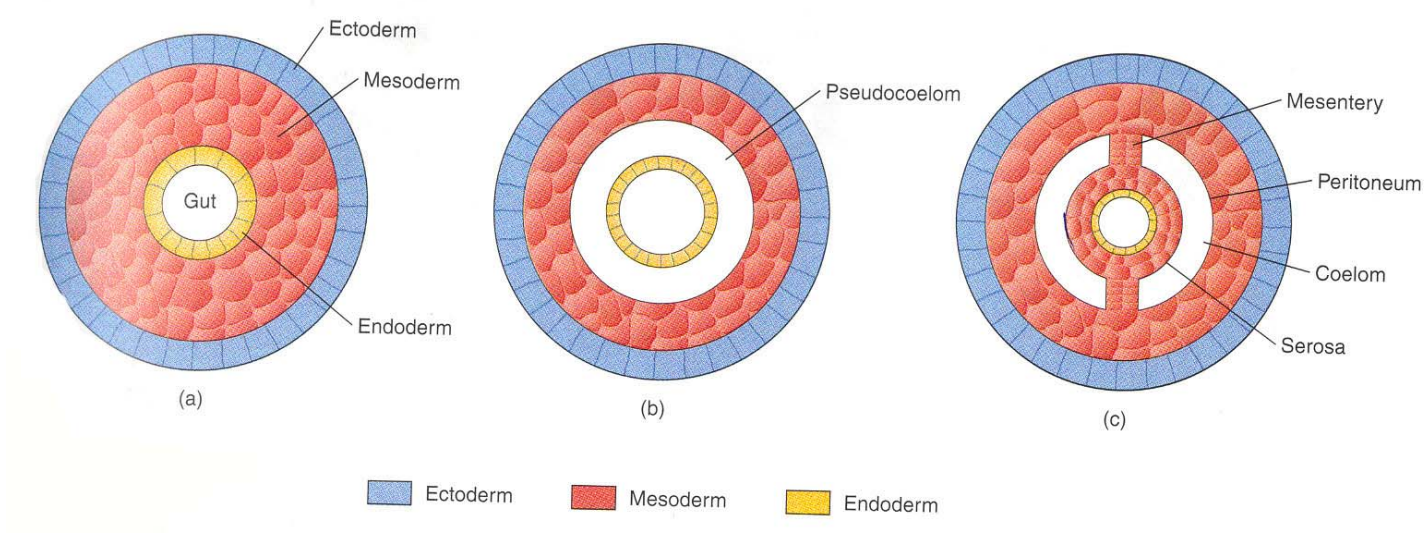
Development of Body Cavity:

Body cavities are characteristics of triploblastic animals (protostomes and deuterostomes). Body cavity is essentially a fluid filled space between the body wall and the digestive tube. Triploblastic animals can be grouped into three groups based on their body cavity:

1) Acoelomates (no body cavity)
2) Pseudocoelomates (body cavity between mesoderm and endoderm)
3) Coelomates (body cavity developed within the mesoderm, mesoderm envelopes the internal organs)

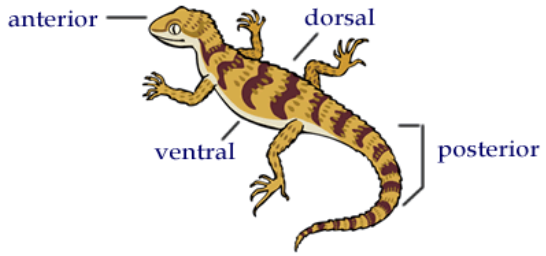
Body cavity is great because allows the development of complex organ systems. The body cavities support, cushions the internal organs and allows them to grow and move independently of the body wall. Body cavity could also function in locomotion by acting as a hydrostatic skeleton that the muscles could contract and expand on. This hydrostatic skeleton is more efficient in coelomates since they have better control of the movement of its fluids inside the body cavity. Last but not least, body cavities allows the gonads to expand, allowing some organisms to store and release a large number of gametes.

Pseudocoelom probably evolved from a process of simplification from more than one group of coelomates.



(a) Acoelomates (b) Pseudocoelomates (c) Coelomates

Bilateral Symmetry and Cephalization:



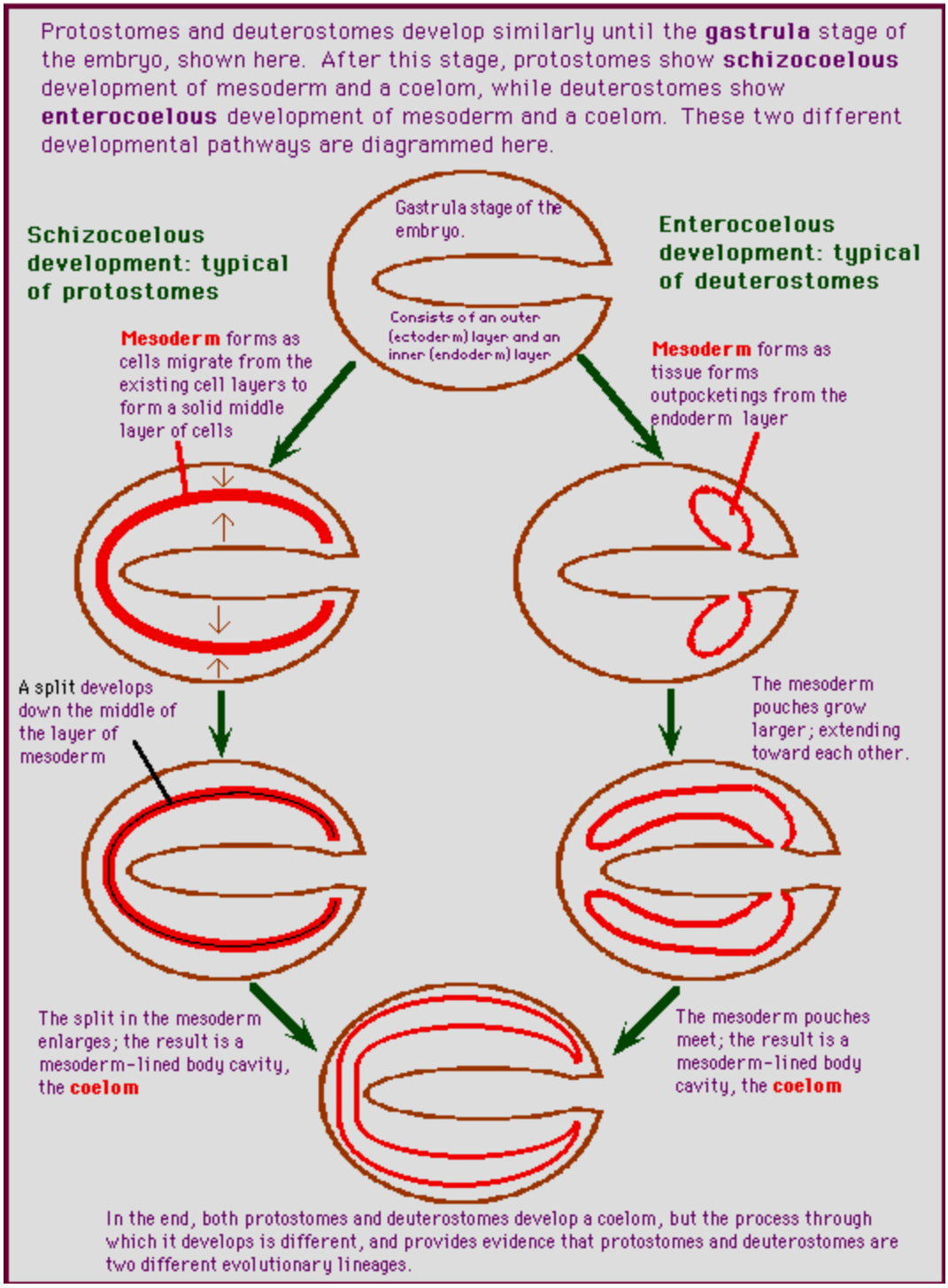
Bilateral symmetry is characteristic of animals that can move around rapidly. Bilateral symmetric animals can be divided into mirror images by a single plane connecting the ventral and dorsal side and passes from the anterior to the posterior side. Bilateral symmetry also allows parts of the body to evolve in different ways.

Since bilateral symmetric animals in general tend to be motile, a process called **cephalization** is generally associated with it. Cephalization is an evolutionary trend in which much of the nerve cells and sensory organs are concentrated at the anterior side of the animal, forming what's known as a brain. This trend evolved since a bilateral symmetric animal's anterior end usually experiences new environments first. Thus, much information processing is required "on the spot".

Protostomes and Deuterostomes:

Triploblastic animals are divided into two groups: protostomes and deuterostomes. These two groups are two independent lineages that have several key differences from each other.

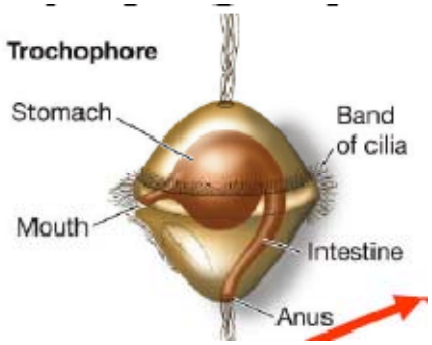
1. Schizocoelous vs Enterocoelous
   In protostomes, the coelom is formed from a method called schizocoelous. The mesoderm is a solid mass formed by the migration of cells from existing cell layers. This solid mass then splits in the middle to produce the coelom.
   In deuterostomes, entercoelous development occurs. The mesoderm is formed by pockets budding off from the endoderm layer. The inside of these pockets becomes the coelom.
2. Mouth vs Anus
   In protostomes, the blastopore becomes the mouth. The anus then develops later from a second opening (unless the animal has blind gut). In deuterostomes, the blastopore becomes the anus. The second opening becomes the mouth. Thus, protostomes are animals in which the mouth forms first whereas deuterostomes are animals in which the anus forms first.
3. Ventral vs Dorsal
   Protostomes have a ventral nervous system as well as a heart that is located dorsally. Deuterostomes have a dorsal nervous system and a heart that is located ventrally.
4. Hard Skeleton
   In protostomes, the hard skeleton is located externally while in deuterostomes, the hard skeleton is located internally.



Protostomes:Lophotrochozoans and Ecdysozoans

The protostome group is further split into two groups, the lophotrochozoans and the ecdysozoans. The major difference between them is that lophotrochozoans use cilia for movement and grow by increase in the size of their skeletons. Some lophotrochozoans have a larva form called **trochophore**. This type of

larva has bands of cilia around it for both locomotion and feeding. Not all lophotrochozoans have this larva form.



Ecdysozoans, on the other hand, do not use cilla for movement and grow by molting their external skeletons.

Flatworms

The simplest members of the lophotrochozoans are the flatworms. These flatworms are the first animals to have a head (cephalization) and triploblastic cell layers. Having triploblastic cell layers means that they possess true organs since mesoderm is required for the formation of organs. They are acoelomates, meaning that the only internal space inside them is the digestive cavity.

Their digestive cavity, however, is incomplete. This means that it has one opening that serves both as the mouth and the anus. The cavity is very branched out and functions as both food transport and digestion. Both extracellular and intercellular digestion occurs in flatworms. Large food particles are broke down via extracellular digestion and then ingested by phagocytosis by cells lining the digestive tract for intracellular digestion.

Flatworms lack a circulatory system for carrying nutrients and gases around. Thus, they are flattened dorsoventrally to allow all cells to be within diffusion distance for gas exchange. Their highly branched digestive cavity solves the problem of nutrients by carrying the food to all parts of the body.

Flatworms have a simple nervous system consisting of a cerebral ganglion at the head, where most of the neurons are concentrated. Longitudinal nerve cords run off from the ganglion into the rest of the body. Eyespots located on the head contains inverted pigment cups with light sensitive cells that allow flatworms to distinguish light from dark.

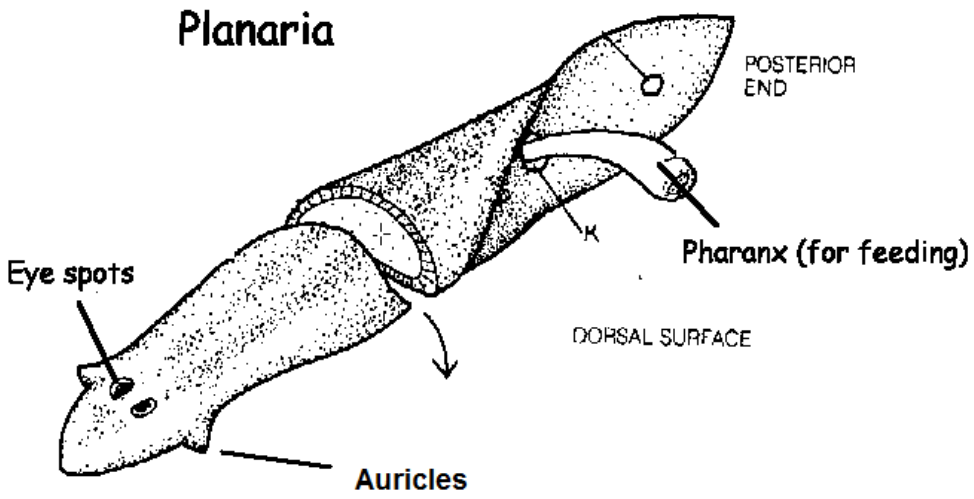
They also have an excretory system. It is made up of a network of fine tubules that run throughout the body. At the side branches of these tubules are specialized cells called **flame cells**. These flame cells have cilia on them that help to move water and excretory substances into the tubules and out through the pores. Flames cells mostly function in regulating water balance of the organism. Most of the excretory substances diffuse into the gut and goes out through the single opening.

Many flatworms are heramaphrodites, meaning that they produce both eggs and sperms. Fertilization occurs internally. They are also capable of asexual regeneration, each part generating into an entirely new flatworm.

Locomotion in flatworms is by cilia.

Flatworms are divide into three groups: **planarians, flukes** , and **tapeworms.**

Planarians are free living flatworms find usually in freshwater habitats. They have flapping ears called **auricles** that actually serve as organs of chemoreception (smell). Their digestive system consists of a single opening (mouth) that contains a tube like structure called **pharynx.**



The other two groups, the flukes and the tapeworms, are internal parasites. They often have complex life cycles involving intermediate hosts. They also have structures like hooks and suckers for attachment to the host.

The typical life cycle of a blood fluke (**schistosoma)** is as follows:

Mature fluke (resides in the blood vessel of the intestine) → sexual reproduction → fertilization egg passed to the intestine and goes out with the feces → egg develop in water as a ciliated larva → infect freshwater snails as its intermediate host → produce asexually on the snail and develops another type of larva with a penetrating head → penetrate skin and blood of humans

Tapeworms are unique in that they absorb nutrients from the host's intestine. Thus, they have no need for a mouth of a digestive system and have consequently lost them. Instead they have suckers on their "heads" called **scolex** that will attach it to the host's intestine. Tapeworm's body consists of long chains of segments called **proglottids.** Each proglottid is a complete reproductive machine carrying both male and female reproductive organs and many eggs. These segements are shed along with feces.

The intermediate host of a tapeworm is a cattle. The larva spends its time encysted in the muscle tissues of the cow. When humans eat infected beef, the digestive juice release the larva. The larva attaches itself to the intestine and matures into adult tapeworm. Sexual reproduction occurs within the human intestine and proglottids are shed along with feces. When cattles eat grass containing these feces, the cycle starts again.

Digestive tract vs Digestive cavity:

Digestive cavity is a gut that is incomplete-has only one opening. Digestive tract is a gut that is complete-has two opening, one becomes the mouth and the other becomes the anus. Digestive tracts first evolved in protostomes and deuterostomes but the flatworms have lost it and have only digestive cavities. Thus, the flatworms are an exception. Digestive tract allows specialization of sections of the gut, sequential food processing and allow animals to eat and excrete waste at the same time.

Nematodes: (Roundworms)

Nematodes are actually ecdysozoans, not lophotrochozoans. They are discussed first because they are pseudocoelmates. They are unsegmented worms like the flatworms.

The pseudocoel serves as hydrostatic skeleton that the longitudinal muscles can work on. (Nematodes only have longitudinal muscles) This form of movement is alot more efficient than cilia movement of the acoelmates.

Nematodes have a digestive tract but they lack a defined circulatory system. Circulation is mostly accomplished by fluids moving within the pseudocoel. They also lack a respiratory system and most of the gas exchange takes place on their cuticle.

They are covered by a thick but flexible **cuticle**. This cuticle molt as they grow and this is what defines them as ecdysozoans.

There are about 50 species of nematodes that parasitize humans. The two that were discussed in lecture are the Guinea worms and the Filaria worms.

Guinea worms have copepod (a type of small arthropod) as the intermediate host. These copepods can be picked up by drinking dirty water. Guinea worms reproduce sexually in the human host and then travel down to the lower extremities. They form blisters in the skin that burst when in contact with water. The female then releases larvae into the water that are picked up by the copepod.

Filaria worms causes elephantiasis, blockage of the lymph vessels. Their intermediate host is the mosquito. The larvae of these worms block the lymph vessels and thus prevent the circulation of the lymph fluids. This causes lymph fluid accumulation in the lower half of the body.

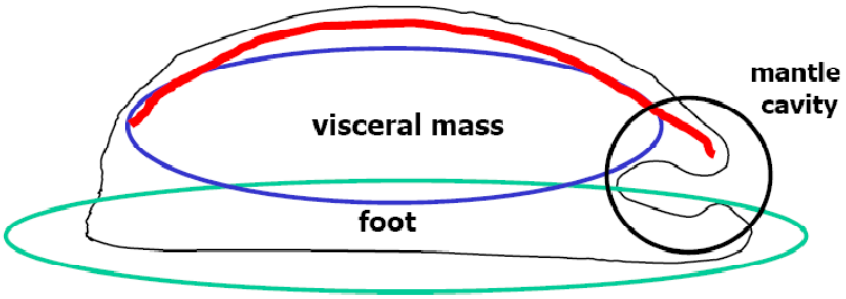
Mollusks

Mollusks belong in the group protostome and more specifically in the lophotrochozoans. Mollusks include clams, oysters, snails, slugs and squids. They are the second largest group in terms of species.

(After arthropods) Mollusks have all the major organ systems present in complex animals. Segmentation has been lost in all but one group of mollusks. (Chitons)

Mollusks usually have the following characteristics:

1) Broad and muscular foot used for locomotion
2) Body organs concentrated as a **visceral mass** located above the foot
3) A thin sheet of tissues called the **mantle** that covers the visceral mass and contains glands that secrete proteins and calcium carbonate that make up the dorsal shell



Most mollusks have a shell. All mollusks except the cephalopods have open circulatory system. This is a system where blood bathes tissues directly rather than enclosed in blood vessels. Blood pressure in this system tends to be low and not all tissues are efficiently oxygenated. However, since most mollusks are slow moving animals, this system is quite adequate.

In the case of aquatic mollusks, respiration occurs through gills contained in the mantle cavity formed by the overextending of mantle. Terrestrial mollusks have lost gills and instead have a highly vascularised tissue below the mantle cavity that serves as a "primitive lung".

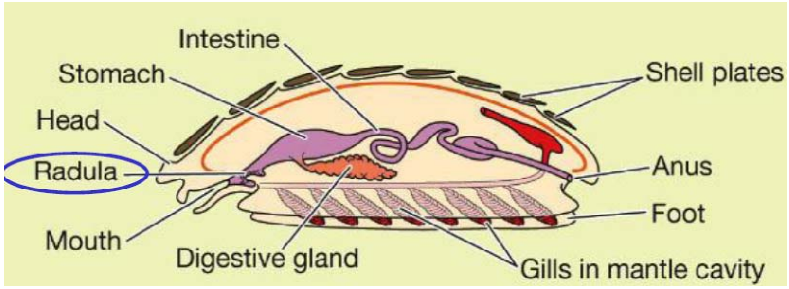
Mollusks also have a rasping (scraping) structure called the **radula.** It is a tongue that is used for scraping algae off rocks. Some mollusks have their radula modified for used in predatory purposes.

There are four major group of mollusks:

a) Chitons
b) Gastropods
c) Bivalves
d) Cephalopods

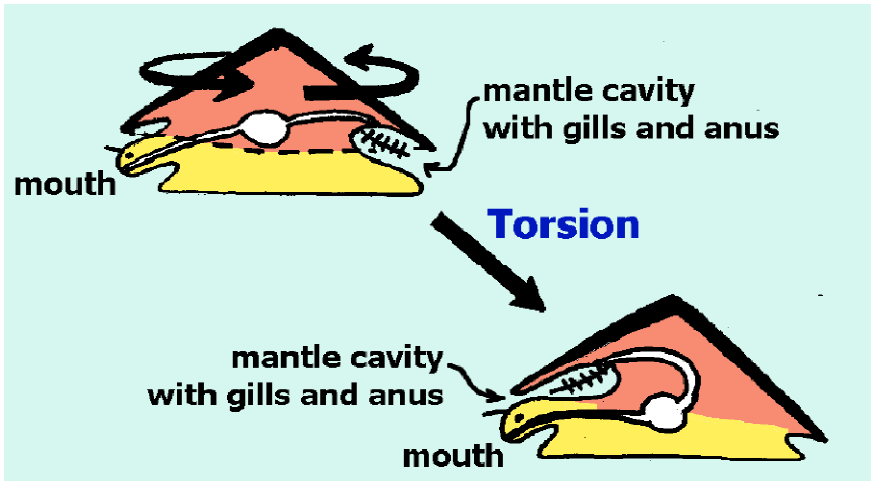
Chitons:

Chitons are the only mollusk that still possesses segmentation. The segmentation is in the form of eight overlapping calcium carbonate plates that serve as their shell. They are adapted to intertidal life by having multiple gills located under mantle cavity and a large muscular foot with good suction. They can also roll into a ball to protect the inner vulnerable parts. Most chitons are herbivores and use radula to scrap algae off rocks.



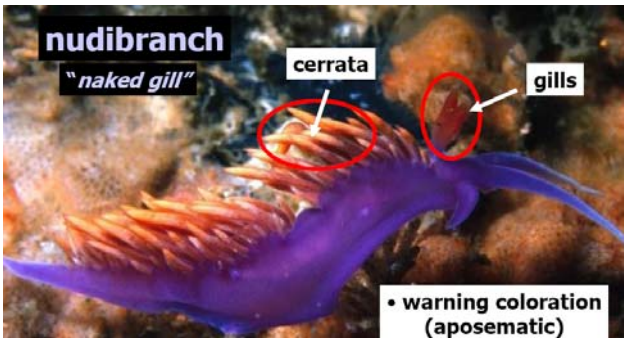
Gastropods:

Gastropods include snails and slugs. They are unique in having the feature called **torsion.** Torsion is the twisting of visceral mass, gut and nervous system permanently up to 180 degrees. This is due to uneven growth on both sides of the visceral mass. As a result, anus and gills lies above the head. There are two hypothesis to explain this torsion effect. One is that torsion allows better balance. The other theory is that torsion moves gills to the front and thus allows gills to be more effective by not sucking up the dirt.



Gastropods also possess coiling of their shells, often in a particular direction. This coiling is independent of the torsion of the visceral mass.

Gastropods are the only mollusks that live in the terrestrial environment. Most are hermaphrodites. **Cone snail** have their radula modified into a toxic harpoon that looks like a worm bait**. Nudibranch** have naked gills that are not enclosed in a mantle cavity. They also have **aposematic** coloring that warn predators away. Nudibranch also feed on tentacles of cnidarians and ingest unfired cnidocysts that they attach to their cerrata (“horn”) to use as their own defense mechanism.



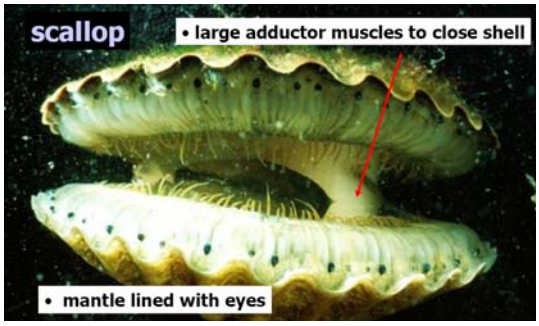
Bivalves:

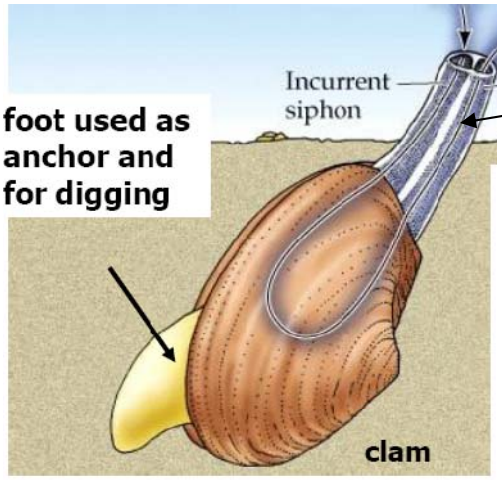
Bivalves are the only mollusks to have lost cephalization. They have a hinged two part shell that extends over the side of the body as well as the top. Their mantle cavity is modified to form a siphon used for filter feeding. Water coming in through the incurrent siphon and goes past the gills. Gills are covered with a sticky mucus that trap any food particles contained in the water. Cilia moves the trapped food particles to the mouth. Thus, the gills functions in both respiration and filter feeding.

Most bivalves are quite sessile and they have a compressed foot that they use for burrowing into mud and sand. They are also able to release **byssal threads** through a special gland that allows them to "cement" to the substrate during tidal periods.

Since bivalves are mostly sessile, they are broadcast spawners (release their gametes into the water) and they are also hermaphroditic.

Scallop is used as an example of bivalves. They have powerful adductor muscles that enable them to clap their shells together and move rapidly across the seafloor to escape predators. They also have a large number of eyes lined around the edge.





Cephalopods:

Cephalopods are fast swimming predatory animals with a closed circulatory system and a reduced shell located internally. Their mantle cavity is modified with a funnel like siphon that is used in jet propulsion. Jet propulsion is the main locomotion mechanism of cephalopods and this allows them to move faster than other mollusks.

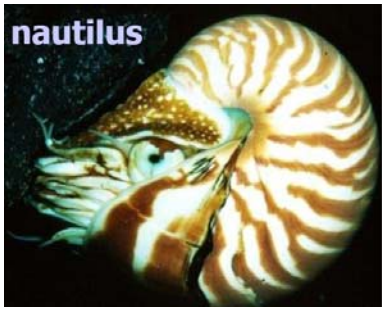
Their mouth is equipped with two horny beaks made of chitin that are used to tear prey apart. Tentacles are used to capture prey, beaks tear them apart, and radula is used to pull the prey to the mouth.

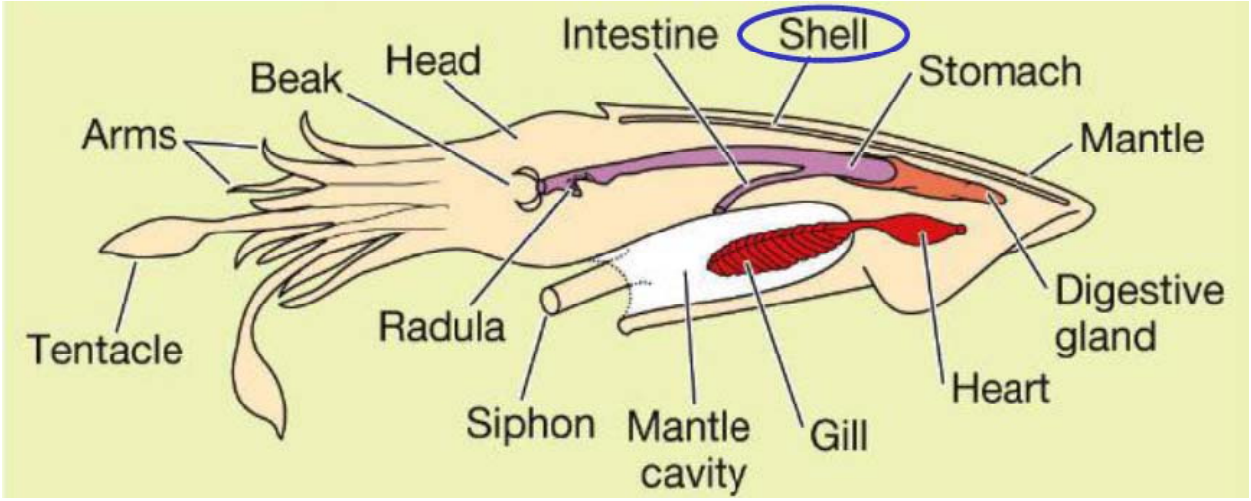
Unlike other mollusks, cephalopods have separate sexes. The female dies after laying eggs. Fertilization is internal.

Cephalopods are also able to change colors by using **chromatophores.** These are patches of pigments that contracts and expands to condense and dilute the coloring. This allows the cephalopods to fit into their background, display messages , and display elaborate courtship rituals.

Cephalopods do not have the trochophore larva commonly present in the lophotrochozoans.

Nautilus is the only cephalopod with external shells. The shell is chambered and grows every year. Nautilus lives in the newest and the largest chambers and pump air into unused chambers to maintain buoyancy.





Segmentation:

Segmentation is the building of a body from similar segments. There are many advantages in having segmentation. First, increase in body size is relatively easy since one could simply copy the segments. Function of each segment can also be controlled easily through separate nerve centers (ganglion) located on each segment. Locomotion is also facilitated since each segment can contract its muscles independent of other segments. The segments can also be specialized to perform different functions.

The segments are connected by circulatory and digestive systems.

Locomotion with segmentation is achieved by contracting the circular muscles first to force the anterior segments forward. Longitudinal muscles then take over by contracting and pull the posterior segments forward. Setae located on each segment grab on to the substrate during contractions to prevent backslip.

Annelids:

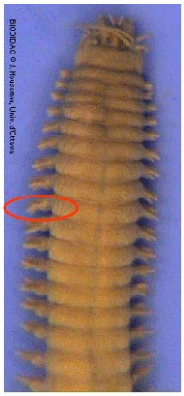
Annelids are segmented worms with a coelom.

Gas exchange occurs through the epidermis via diffusion. Annelids have a closed circulatory system with ventral and dorsal blood vessels and aortic arches acting as "hearts". The dorsal carries blood to the anterior end while the ventral carries blood to the posterior end. Nervous system is composed of a pair of cerebral ganglia at the anterior end, ventral nerve cord, and segmental ganglia that coordinates the muscle contractions of each segment.

Digestive system is the digestive tract divided into sections. The different specialized sections of the digestive tract are the pharynx, esophagus, crop, gizzard, intestine and the anus.

Annelids are divided into three major groups: polychaetes, oligochaetes, and leeches.

Polychaetes means many setaes. Each segment has many setaes and pairs of paddle like flaps called **parapodia.** Parapodia increase surface area for respiration and is also used for locomotion and feeding.



Polychaetes have separate sexes and are broadcast spawners external fertilization. Polychaetes are mostly marine.

Oligochaetes means few setae. An example of oligochaetes is earthworms. Most of the oligochaetes are detririvores. This means that they eat decomposing organic matter. Oligochaetes are hermaphrodites with external fertilization through the mucus cocoon produced by the clitellum. Fertilized eggs develop directly to young worms that look similar to adults. There is no larva stage. Oligochaetes are mostly terrestrial.

Leeches do not have setae. They are parasitic or predatory and have segments specially modified to form suckers at the anterior and the posterior end. Leeches are mostly freshwater with some terrestrial.