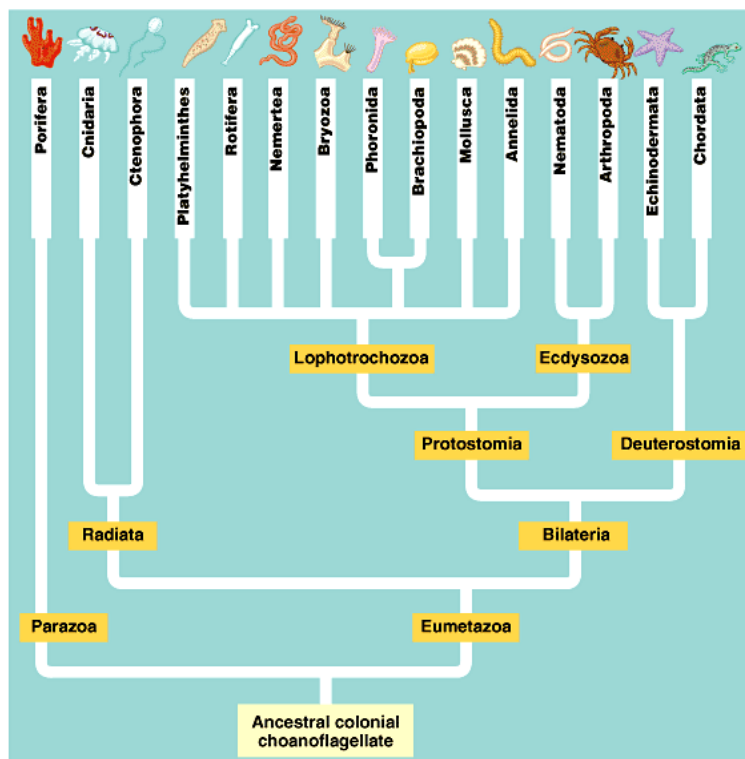


Animal Diversity Part I

Introduction

One of the primary goals of the second half of Biol 106 is to understand evolutionary relationships among animals and to gain an appreciation for the diversity of animal form and function. The huge diversity of animals requires us to divide our survey of different animals into a number of labs. Because of time limitations, we will consider only the major groups of animals, but your textbook can provide information about other groups represented by few or little known species.

The study of animal phylogeny is an important and ongoing scientific investigation. Because there are differing hypotheses regarding the evolutionary relationships between animals, we will use a simplified phylogeny (Figure 1) to help us organize and understand the enormous diversity among animals. It is helpful to group animals according to certain unifying characteristics. The largest grouping of animals is the phylum (plural phyla). As you have learned in lecture, there are a few simple questions one can ask about animals to put them into different phyla. The first question is, “What type of **symmetry** does the animal exhibit?” Animals can be **asymmetrical**, that is, possessing no organized body plan. Only the Sponges fall into this category. Animals can also be **radially symmetrical**, where the body is arranged around a central point at *all stages of life*. Many in the phylum Cnidaria (pronounced “knee dare ya”) are radially symmetrical. All other animals are **bilaterally symmetrical**, that is, their bodies can be bisected into two identical, but mirror image halves.

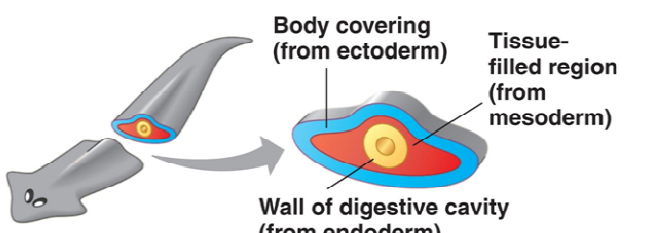
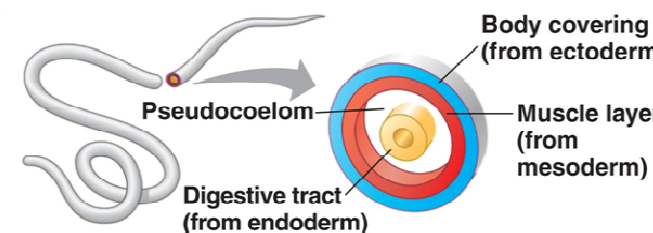
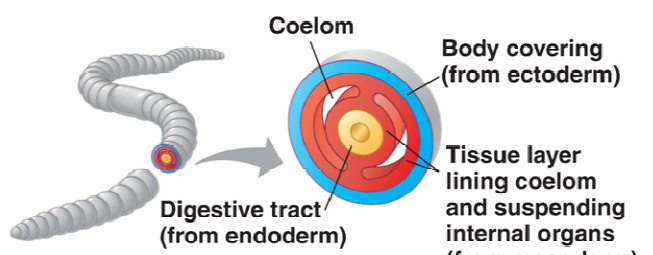


Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

Figure 1. Simplified phylogeny of animals based on **symmetry**, absence or presence and number of **tissue** layers, absence or presence of **body cavity**, and **type of development** characterize different groups.

Another important consideration is whether **tissues** are present, and how many tissue types are present. Sponges possess no true tissues. Cnidarians, such as jellyfish and sea anemones, have only two tissue layers, ectoderm and endoderm. For the rest of the animals, three tissue types are present: the **ectoderm** forms the outer layer and eventually gives rise to skin and nervous tissue; the **endoderm** forms the interior of the embryo and gives rise to the lining of the digestive, respiratory and reproductive tracts; the **mesoderm** layer, sandwiched between the other two, eventually gives rise to muscle, organs, and supportive tissues.

Triploblastic animals, those possessing three tissue layers, are further classified by whether or not they have a body cavity called a **coelom** (pronounced “sea loam”). The coelom, entirely surrounded by the mesoderm, provides space in the body for specialized organs, an efficient circulatory system, and reproductive structures. It separates the muscles of the digestive tract from the muscles of the body wall, allowing for more variation in movement. This fluid-filled cavity also provides hydrostatic force against which muscles can act. In the following figure (Fig. 2), note the arrangement of the three tissue types in **acoelomates**, **pseudocoelomates**, and **coelomates**.

<p>Acoelomates – no body cavity; Members of the Platyhelminthes are acoelomate</p>	
<p>Pseudocoelomates – fluid-filled cavity is located between the endoderm and mesoderm; Nematodes and some others are in this group</p>	
<p>Coelomates – body cavity is entirely enclosed by mesoderm; mesenteries connect the mesoderm layers; organs are suspended in the coelom; Annelids, Arthropods, Echinoderms, and Chordates are coelomates.</p>	

Images from Campbell, 8th Edition

Figure 2: Body cavities of triploblastic animals

We have placed most images at the end of this lab so that you can choose to print or not print them. They will be available in the lab.

Phylum Porifera: Sponges

Sponges are the simplest of the multicellular animals. They are the only animals that do not exhibit obvious symmetry in their body organization. They have aggregations of different cell types but do not have true tissues. It is possible to disassemble a sponge into a pile of individual cells and within weeks, the various cell types will aggregate into their former structure. They are characterized by numerous canals and chambers that open to the outside via pores. Sponges are supported by a skeleton of secreted collagen or **spongin** protein and may have embedded structures called **spicules**, composed of calcium carbonate or silica.

Sponges come in a variety of shapes and sizes, from large branched structures or giant cup shapes to flattened inconspicuous forms. They feed by drawing water through numerous pores in their bodies and trapping detritus, bacteria, and plankton carried in the current. The name Porifera refers to this porous structure. Sponges do not have nervous, circulatory, or digestive systems. Digestion takes place in individual cells, that is, **intracellular digestion**. For most of their lives, sponges are also sessile, attached to a substrate such as rocks. Only when reproducing sexually or asexually might they become planktonic and drift in the current until eventually attaching to a suitable substrate.

Exercise 1 - Sponge Internal Structure, *Grantia*—prepared slide

1. Obtain a prepared slide of *Grantia*. Focus on the longitudinal section. Under low power, identify the **spongocoel**, the open central cavity. Note the multiple chambers radiating to the spongocoel. Each chamber is a radial canal that opens to the spongocoel. On the outside of the body, openings called **ostia** allow water to move in between adjacent radial canals. Entry into the radial canal is gained via multiple openings, seen in slide sections as small breaks in the wall of the radial chamber.

The radial canals are lined by specialized cells unique to sponges, called **choanocytes** (collar cells), each of which has a beating flagellum. The combined action of the flagella draws water from outside through the ostia, into the radial canal, into the spongocoel, and out through the large opening. You will not be able to see the cool amoebocytes, but these are a class of wandering sponge cells that are involved in various functions including producing spicules and delivering sperm cells to eggs. Use Figure 3 to help identify some of the structures you see.

2. Observe a preserved specimen of *Grantia* under a dissecting microscope. Note the flattened base where the sponge attaches to the substrate. Look for needle-like calcareous spicules. You may also see loose spicules on the bottom of the container.
3. Observe the sponges on display in lab. Please just lightly touch these fragile specimens. Notice the familiar bath sponges on display. These soft resilient skeletons are made up of spongin protein and lack spicules.

Phylum Cnidaria (c is silent): sea anemones, corals, and jellyfish

Most cnidarians are predators. You may be familiar with some cnidarians, such as sea anemones, corals, and jellyfish. All cnidarians are **diploblastic**, meaning they have two tissue layers: **ectoderm** and **endoderm**. Between the two tissue layers is a gel-like layer, the **mesoglea**. Within the body is the **gastrovascular cavity** which functions both in digestion (hence, gastro-) and in the distribution of digested food to the parts of the body (hence, vascular). A single opening serves as the entrance to the gastrovascular cavity, within which prey is digested. Cnidarians lack an anus, therefore, undigested material exits through the mouth. The phylum name comes from the **cnidocytes**, specialized cells containing stinging structures called **nematocysts**. Cnidocytes are primarily concentrated on the tentacles, but also occur all over the epidermis. They are used for defense and for capturing prey. If you have ever been stung by a jellyfish, then you were stung by nematocysts. In some species of jellyfish, the sting can be lethal to humans.

No central nervous system is present in cnidarians, but a nerve net of interconnecting nerves coordinates movement. Cnidarians have radial symmetry. Reproduction is both asexual, through budding, and sexual. In sexual reproduction, each fertilized egg develops into a ciliated larva called a planula larva. Generally, cnidarians have two body forms through which they progress during their lifetimes: a sessile **polyp stage** and a free-floating **medusa stage**. As you examine cnidarians more closely, ask yourself how the features of the body design are adaptive for a predatory life style.

Exercise 2 – *Hydra* prepared slides

1. Examine a prepared cross section (C. S.) of *Hydra*, a common freshwater cnidarian. The cavity within is the gastrovascular cavity, lined by the endoderm. The outer layer is the ectoderm, termed the epidermis. Between the two tissue layers is the gel-like mesoglea, seen here as a thin dark line. Nerve cells, impractical to see here, reach between the layers.
 - a. **What is the symmetry of *Hydra*?**
 - b. **Sketch and label the *Hydra* cross-section based on what you observe from the slide.**

2. Examine a prepared whole mount slide of *Hydra* budding. WARNING! This is a thick slide so be sure to start on low power and remember to use only the fine focus adjustment on 40X (please avoid crunching the lens into the slide!)
 - a. Is the hydra in a polyp or medusa stage?
 - b. What type of reproduction was this hydra undergoing?
 - c. Can you determine the hydra's symmetry from this slide?
 - d. Make a sketch of this slide based on your observations. Use the poster of the hydra life cycle on the side bench to help you label your drawing.

ACOELOMATES – Phylum Platyhelminthes: flatworms

The Platyhelminthes, or flatworms, have over 10,000 described species. They are divided into three groups, the free-living Turbellaria and the parasitic Trematoda (flukes) and Cestoda (tapeworms). The majority (70%) are parasitic. Platyhelminth bodies are triploblastic and bilaterally symmetrical and flattened, with a distinctive head at the anterior end. They have a gastrovascular cavity with a single opening and no coelom. The nervous system is organized into a pair of lateral nerve cords and an anterior enlargement, the **cerebral ganglion** or “brain”. Excretory organs, called **nephridia** (sometimes referred to as flame cells) are present. Flatworms lack specialized organs for circulation and gas exchange. Reproduction can be both asexual, through budding, and sexual. Most species are hermaphroditic, i.e., each organism possesses both male and female organs, though self-fertilization is rare. Life cycles often are complicated and may involve multiple hosts.

How do you think flatworms get oxygen and get rid of CO₂?

What features of flatworms enable them to survive using this method gas exchange?

Exercise 3 - *Dugesia*—Planarian

1. Obtain a living planarian (*Dugesia*) in a small culture dish and observe the movements of this animal with the aid of a dissecting microscope. Identify anterior and posterior ends, dorsal and ventral sides. The paired dark spots at the anterior end are eyespots, which detect light. There is a single muscular opening to the gastrovascular cavity called the **pharynx**. If the living individual has eaten recently, the gastrovascular cavity should be dark and visible.
2. Examine the prepared whole mount slide of a planarian. The pharynx lies within the middle of the animal and opens into the extensive gastrovascular system. With this general arrangement of regions in mind, now examine a cross section slide.

3. Study the slide of the planarian in cross section. Sections are present from various points along the body so different internal structures will be present. (Don't be fooled by air bubbles or open spaces that may have been produced during preparation of the slides.) Identify the gastrovascular cavity. The lining of the gastrovascular cavity arises from the endoderm. The outer surface of the planaria arises from ectoderm. The mesoderm gives rise to structures lying between. Under 40X power, find a fringe of cilia. Based on this and your preceding observation of live movement, **what is the basis for locomotion in this planarian?**
4. **Sketch a whole planarian and next to it sketch a representative cross-section based on your observation of the slides.**

PSEUDOCOELOMATES – Phylum Nematoda: round worms

Phylum Rotifera: rotifers

A body cavity formed between mesoderm and endoderm is termed a **pseudocoelom**. Nematodes (round worms) and rotifers are in this group. Rotifers are microscopically small aquatic animals. They have a complete digestive tract and move rapidly by use of **cilia**. Nematodes are an extremely successful group, occupying marine, freshwater, and terrestrial environments. Over 15,000 species of Nematodes have been described. They are both free-living and parasitic.

Many nematodes cause diseases in domestic animals, humans, and agricultural crops. A free-living nematode, *Caenorhabditis elegans*, is a model genetic organism that scientists study.

Exercise 4 – *Ascaris* prepared slides

1. Obtain a prepared slide of a cross-section of *Ascaris*. This nematode is a common intestinal parasite of humans and domestic animals.

Surrounding the outer surface of the body is the translucent cuticle secreted by the epidermis. Just under the epidermis is the frayed-appearing body musculature which includes only longitudinally oriented muscle fibers. In the center of the cross-section is the intestine whose wall is derived from endoderm. The space between muscles and intestine is the **pseudocoelom**. Interspersed in the pseudocoelom, between intestine and body wall, are the gonads: oviducts/uterus or testis/vas deferens. These animals are either female or male. Reproduction is sexual with internal fertilization. The musculature is interrupted at 3 and 9 o'clock by the lateral line (the lateral lines are visible as two lines running along the length of the body; in nematodes they contain nerves and excretory vessels). The small hole within the lateral line is the cross section of the excretory canal. Seen in cross section, the dorsal and

ventral nerves are at 12 and 6 o'clock. As in the flatworms, circulatory and respiratory systems are absent.

2. **Draw a cross-section of the *Ascaris* based on your observations from the slide.** Use the diagrams provided in the photo atlases available in lab to help you label your sketch.

COELOMATES

Coelomates have a fluid-filled body cavity, called a **coelom**, formed within the mesoderm. There are two major groups of coelomates: **protostomes** and **deuterostomes**. Each group includes distinctive features of embryology, reviewed on pages 660-661 in your textbook. Among the most distinctive features is one related to embryonic development and adult body orientation. In early development of animals, cells undergo dramatic movement, called **gastrulation**, that involves in-folding of cell layers which produces an opening called a **blastopore**. In protostomes, the embryonic blastopore eventually becomes the mouth; in deuterostomes the embryonic blastopore eventually becomes the anus.

Phylum Mollusca

The first group of **protostomes** we will examine are the Molluscs, a huge phylum comprising over 110,000 living species. Molluscs include gastropods (snails and slugs), bivalves (clams), cephalopods (squid, and octopi), and chitons. The mollusc body is composed of a **muscular foot**, **visceral mass**, containing the major organs, and a **mantle** that covers the visceral mass. The nervous system is comprised of ganglia connected by nerve cords. All molluscs have a shell secreted by the mantle, although in some groups, like the octopi, the shell is inconspicuous. The coelom is usually reduced to a sac surrounding the heart, gonad, and **nephridia**. Many molluscs possess a specialized feeding structure called a **radula** that contains rows of teeth for rasping (Figure 4). In some classes, the head/foot region develops a set of tentacles. The foot is usually involved in locomotion, digging, or attachment.

We will concentrate on representative species from two groups: the bivalves and cephalopods.

Exercise 5 - Bivalves, clam

1. Select a clam to examine. The two shells, or valves, are joined at a hinge ligament. Open the valves by carefully inserting a spatula and prying the valves apart. Be careful not to hurt yourself.

The fleshy tissue found on the inside walls of the valves is the mantle. (Refer to the figures 4 and 5, and to the preserved dissected clam on display in lab.) Identify the foot, the tongue-like tissue near the open borders of the valves. Two sets of valve adductor muscles are present at opposite ends of the valve. When they contract, they pull the valves closed. Some bi-valves, such as scallops, swim by rapidly opening and closing the valves.

In about the middle of the soft tissue, are two gills (called ctenidium), the respiratory organs. To determine the anterior end of the clam, follow the gills to one end and locate two small flaps, the labial palps. These are at the anterior end of the animal. The labial palps cover the mouth. At the posterior side of the visceral mass is the siphon with two openings. Water is drawn into the incurrent opening by the beating action of cilia on the gills. It then flows across the gills and finally flows out through the excurrent opening.

Food particles are sieved out by the gills, caught up in strings of mucus, and carried by cilia to the labial palps which direct the food into the mouth and pass it into the esophagus. Then the food particles go into the stomach. If your clam is fresh, you may notice a gelatinous rod, called a crystalline style, inside a sac. This rod contains enzymes and rotates within the sac to help digestion.

Trace the route of the water and food in your clam.

A view through the smaller oval window in the soft tissue just next to the hinge shows the heart. (Note where it says ventricle, anterior and posterior aorta in Figure 5).

2. **Make a sketch of the soft tissues you have identified, based on what you actually see on the clam.**

Exercise 6 – Cephalopoda, Squid (see Figure 6)

1. Place a squid in a dissecting pan. The head/foot region includes the head, tentacles, and arms. There are a pair of long tentacles and eight shorter arms. Notice the suction cups on the tentacles. Between the eyes, is the siphon. The head is also equipped with a sharp beak and radula. The mantle covers the tube-shaped body. Squid are one of the fastest swimming invertebrates. They can open the mantle around their heads, trapping water underneath, and then force water out through a small opening to propel them through the water. The lateral fins at the posterior end aid in steering.

What direction does the squid move in the water?

2. Place the squid on its dorsal surface, siphon facing you. With scissors, make a long cut along the body from the siphon to the base of the fins, and lay open the flaps of the body. Feathery gills are present in the midline. At the base of each gill is the branchial heart. The squid has a closed circulatory system.

What route does water take to reach the gills?

3. If the squid is female, the ovary may occupy most of the apex. If your squid is a male, small testis are to be found near the apex of the body, along the midline. The gut extends to the apex. In both sexes, a silvery ink sac lies close behind the siphon.

4. Trace the digestive system. Begin by inserting a blunt probe into the mouth, noticing the jaws that must be parted. The tip of the probe enters the esophagus. Keeping the probe in place, try to follow the esophagus further where it enters the stomach (sometimes difficult to distinguish) and into the cecum (Figure 6). From the cecum, the digestive tract turns toward the head and exits near the base of the siphon.

Why would this location, near the base of the siphon, be a beneficial place for the anus?

5. Push the head to one side to discover a pair of large ganglia. Several large nerve cords radiate out from these ganglia to the body.

6. Squid have excellent eyesight. Remove the eye and examine the cornea, the film-like substance, and the hard lens.

7. Dissect out the **pen** that lies dorsal to the visceral organs and extends from the free edge of the collar to the apex of the mantle. This is the “shell” of the squid.

Make a labeled sketch of the internal anatomy of the squid based on what you actually see in the dissection

An unusual squid: The Hawaiian Bobtail Squid has a kidney-shaped lobe in its mantle cavity. This organ is filled with bioluminescent bacteria that act like a light bulb. Behind the light organ is reflective tissue that reflects the light down through another tissue that functions as a lens. The effect is very similar to a flashlight. The bobtail squid feeds at night, but does not need light to spot its prey. **What do you think is the purpose of the light organ?**

Figure 3: Body plan and internal structures of a simple sponge A) general structures of Asconoid sponge B) Horizontal section of sponge

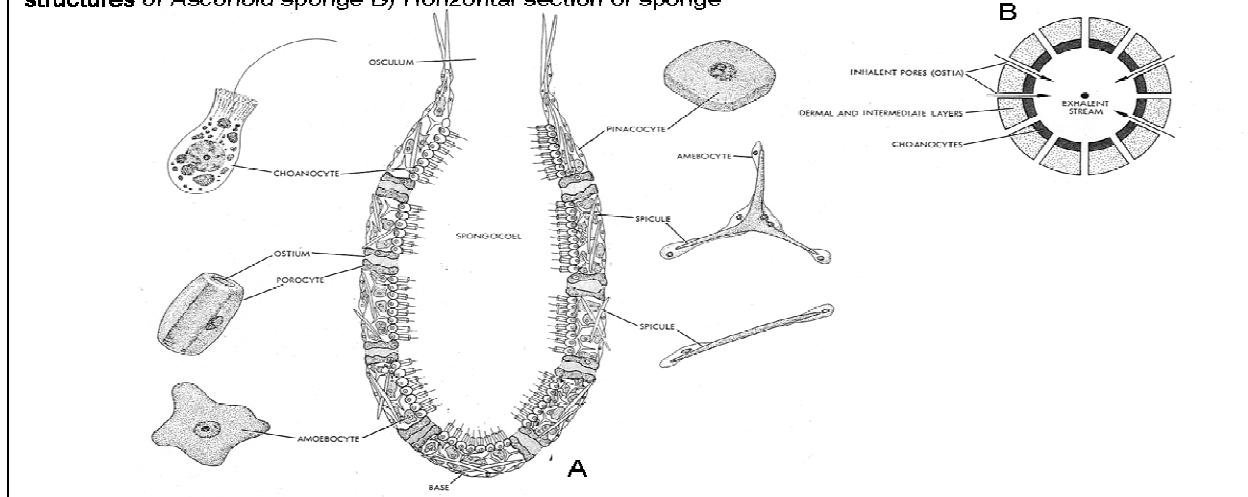


Figure 4: Three representative groups of Molluscs

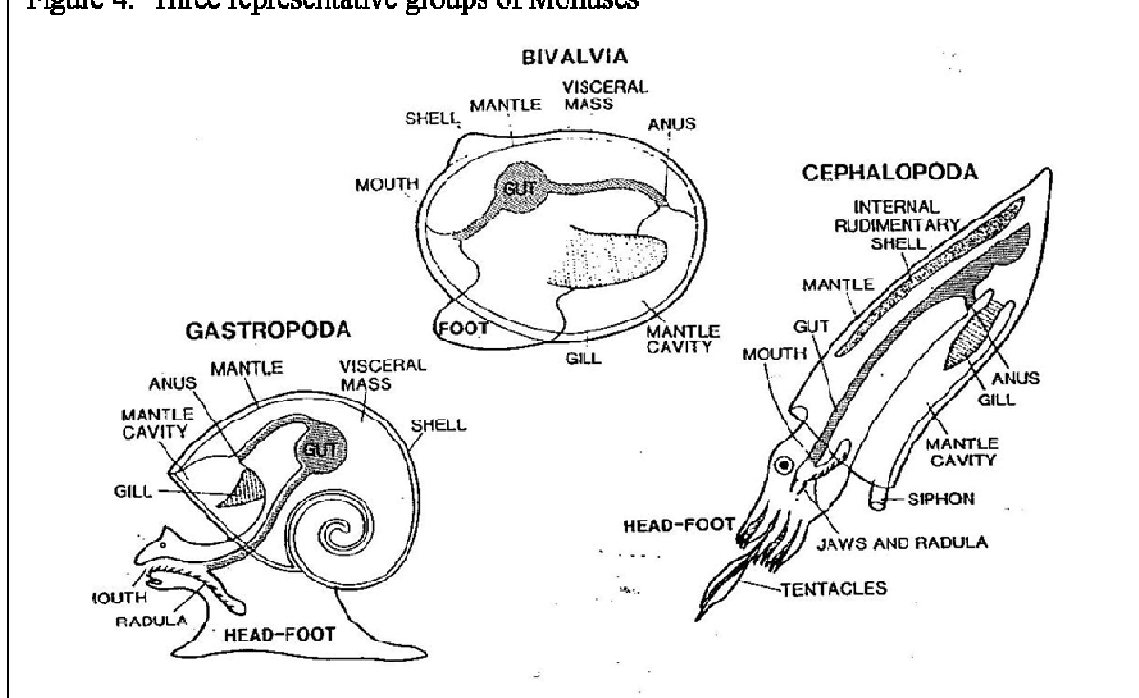


Figure 5: Internal Structures, Clam

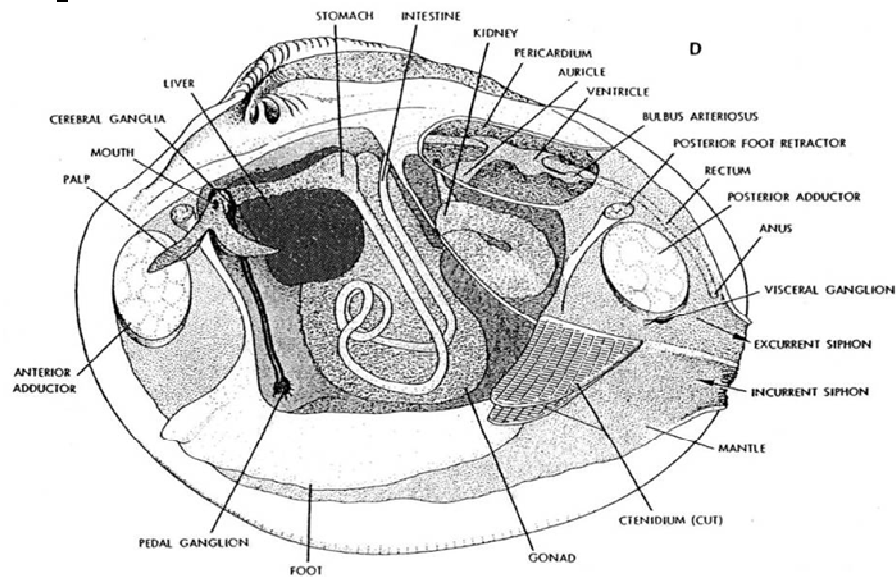
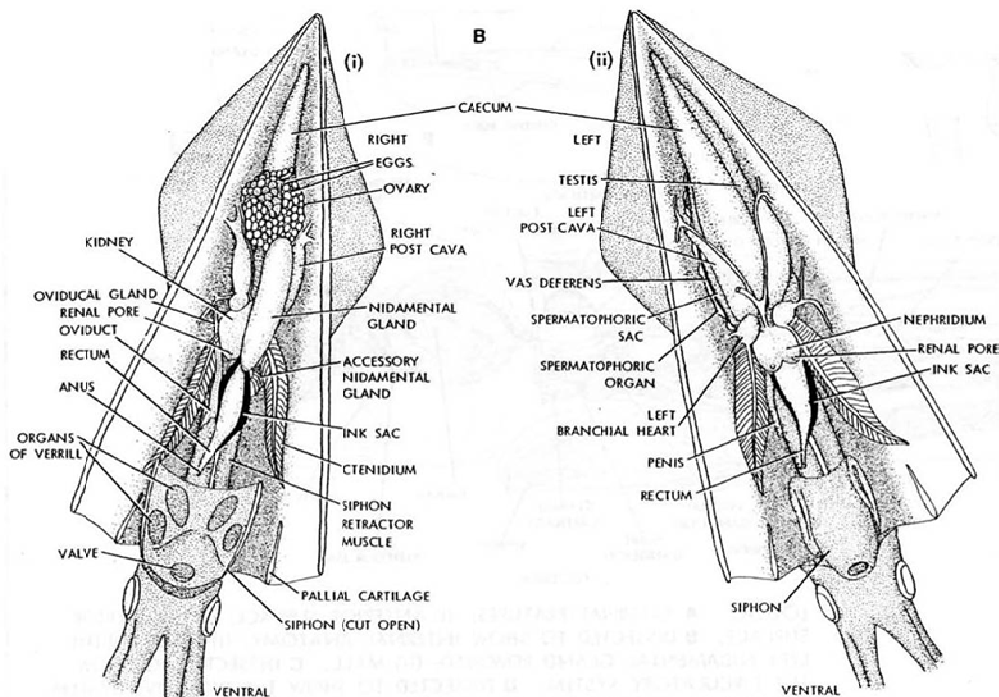


Figure 6: Internal Structure, Squid



Note: Images of Sponge, Clam and Squid from: The invertebrates: Function and form. A laboratory guide by IW Sherman & UG Sherman, 2 Ed 1976.