The Invertebrates

Simply put, invertebrates are animals without backbones or vertebrae. This group of animals includes at least 22 phyla. Only one, the phylum Chordata, includes within it the vertebrate animals. To give you a feel for the number of species of invertebrates, of the phylum Chordata which are mostly vertebrate animals, there are only approximately 39,000 species. Compare that to the phylum Arthropoda and the class Insecta which may have over 1 million species - and that's just one class within one of the 22 phyla. The insects alone are the most successful animal species of planet earth.

So what characterizes invertebrates? First, they are eukaryotic, multicellular animals. There is specialization of cells to from tissues, organs, and systems. They are, for the most part, motile but there are some sessile species. They are heterotrophic but many are symbiotic. Sex cells arise from multicellular structures and an embryo is produced. The main difference between invertebrates and vertebrates is the production of a vertebral skeleton.

Organization

Multicellular animals (both vertebrates and invertebrates) exhibit symmetry. Two forms of symmetry are found in invertebrates: radial and bilateral. An example of radial symmetry is the starfish where 5 or more arms may radiate out from a central disk, much like the spokes of a wheel. Bilateral symmetry is a characteristic of the insects. Think of a grasshopper. If you were to cut the grasshopper from head to tail, each half of the body would form a mirror image of the other. This is bilateral symmetry. Generally, bilateral symmetry is better adapted to movement and radial symmetry is more adapted to a sessile or sedentary life-style.

Both vertebrates and the more evolved invertebrates exhibit metamerism (or segmentation). Think of the segments of earthworms. That's metamerism. Metamerism arose on two separate occasions in the animal kingdom: the annelids, which include earthworms; and the chordates, which include the vertebrates. In segmented animals, some structures run the length of the organism and through each segment or metamere, *e.g.* gut, nerves, blood vessels. In other cases, some structures may be restricted to individual metameres.

Multicellular animals may also have body cavities. A body cavity is a fluid-filled cavity found between the body wall and internal organs and serve several functions: (1) hydrostatic skeleton (2) a circulatory medium (3) space to accumulate excess fluids (4) location for maturation of sperm/eggs and (5) increased surface area for organs. Some invertebrates have no body cavity and are said to be acoelomate. Other's have a body cavity which arises from a persistent blastocoel and they are referred to as pseudocoelomate. A third type of cavity is the true body cavity or coelomate animals where the body cavity arises from mesodermal tissue.

Multicellular animals fall within two groups: protostomia and deuterostomia. These groups are based on the embryological development of the animal. Four aspects of the embryo may be examined to determine whether an animal is a protostome or deuterostome.

Determinate *vs* Indeterminate Cleavage

When a zygote (fertilized egg) divides by mitosis to form a two-cell, then again to produce four, again to produce eight, etc. the question arises at what point does a cell cease being an entity and become specialized, *e.g.* blood cell? Those cells whose fate is sealed early are said to undergo determinate cleavage and are considered protostomes. Those whose cell fate is determined later are said to be indeterminate and deuterostomes.

Spiral *vs* Radial Cleavage

When cells divide by mitosis in the embryo, they either line up one directly over the other or are offset to one side. If offset, they exhibit spiral cleavage and are protostomes. If they fall directly under one another, they exhibit radial cleavage and are deuterostomes.

Blastopore Development

When the cells of the embryo continue to divide the cells form a hollow ball. In one case, the cells push inward into the hollow sphere and begin to grow into the space. Two layers are differentiated: ectoderm - the outer layer of cells and endoderm - the inner layer of cells. This process is called invagination. This is pretty much similar to blowing up a balloon, tying it off to prevent air loss and then pushing your finger into the interior of the balloon without popping it. Where you finger enters is the opening to the endoderm and this is called the blastopore.

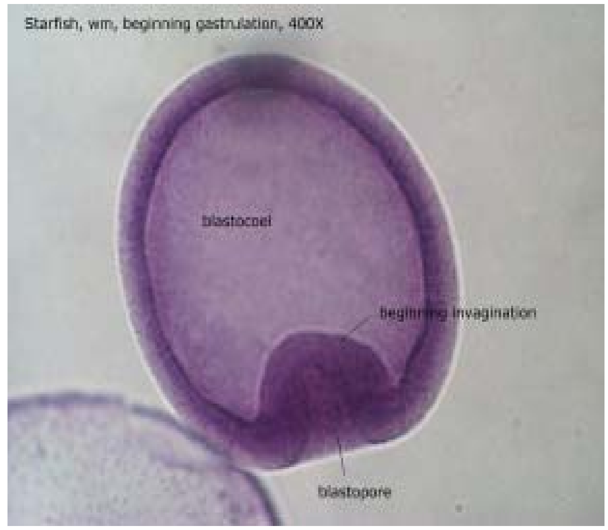

Figure 1. Blastopore development.

In a second case, cells at one end of the embryo may overgrow the cells at another end. This process is called epiboly. As they continue to overgrow, these cells now push inward into the hollow sphere much like the first case. Again, a blastopore develops through a process called involution. If the blastopore in the embryo becomes the anus of the animal, it is a deuterostome. If the blastopore becomes some other structure - such as the mouth - it is a protostome.

Mesoderm Formation

Once ectoderm and endoderm forms, a middle layer (mesoderm) of cells arise. If individual cells from the endoderm squeeze out between the ectoderm and endoderm to form mesoderm and this mass splits to form the body cavity, it is a protostome. If the mesoderm arises from puckering of endoderm, it is a deuterostome.

Synopsis of Key Invertebrate Phyla

I. Asymmetrical
- A. Phylum Porifera (approximately 5,000 species) - the sponges

II. Radial Symmetry
- A. Phylum Cnidaria (approx. 8,900 species) - jellyfish, anemones
- B. Phylum Ctenophora (90) - comb jellies

III. Bilateral Symmetry
- A. Protostomes
  - 1. Acoelomates
    - a. Phylum Platyhelminthes (12, 700) - flatworms, flukes, tapeworms
    - b. Phylum Mesozoa (50) - marine parasites
    - c. Phylum Rhyncocoela (650) - nermerteans
    - d. Phylum Ganthostomulida (80) - aceolmate worms
  - 2. Pseudocoelomates
    - a. Phylum Rotifera (1500) - rotifers
    - b. Phylum Gastrotricha (400) - gastrotrichs
    - c. Phylum Nematoda (10,000) - roundworms
    - d. Phylum Nematomorpha (230) - hairworms
    - e. Phylum Acanthocephala (500) - endoparasites
  - 3. Schizocoelomates

a. Phylum Priapulida (8)
b. Phylum Sipunculida (250) - marine worms
c. Phylum Mollusca (80,000) - mussels, clams, squid, octopods
d. Phylum Echiruida (60)
e. Phylum Annelida (8,700) - segmented worms, earthworms
f. Phylum Pogonophora (80)
g. Phylum Tardigrada (180) - water bears
h. Phylum Onychophora (65)
i. Phylum Arthropoda (923,000) - insects, crayfish, shrimp, crabs
j. Phylum Pentastomida (70)
k. Phylum Phornoida (15)
l. Phylum Bryzoa (4000)
m. Phylum Entoprocta (60)
n. Phylum Brachiopoda (260)

B. Deuterostomes
1. Phylum Chaetognatha (50)
2. Phylum Echinodermata (5,300) starfish, sea urchins, sea biscuits
3. Phylum Hemichordata (80)
4. Phylum Urochordata (1600)
5. Phylum Chordata (39,000)

Phylum Porifera - The Sponges

If you've ever been SCUBA diving or snorkeling, you've probably seen some marine plants. One thing you perhaps mistakenly identified as a plant is a member of the group of animals known as sponges. As a matter of fact, it wasn't until 1765 that biologists recognized sponges were not plants but indeed animals. There are over 5,000 species of sponges and all but 150 of those are marine. The others are freshwater. Sponges grow attached to just about any substrate, mostly in shallow water. They range in size from the giant loggerhead sponges that would take up a good size wash tub to the smallest which may be the size of a bean. The shape of the sponge is affected by where it grows, the availability of space, and the prevailing water currents. As a consequence, sponges may take a variety of shapes.

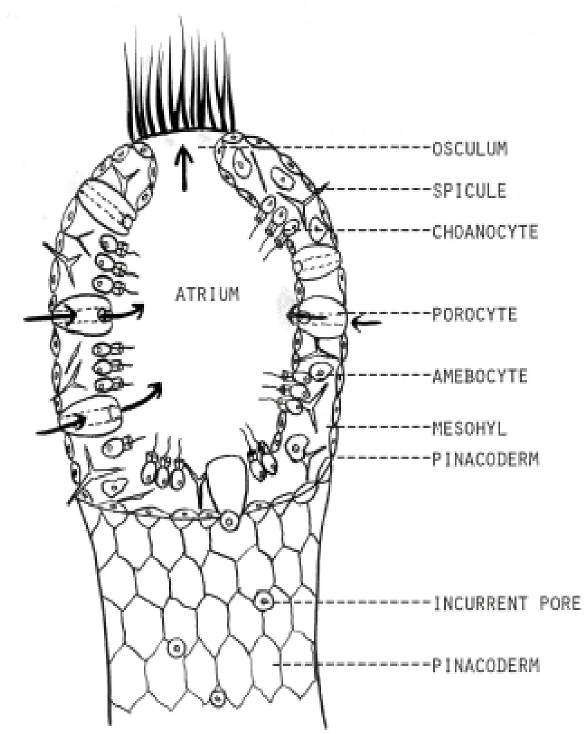

Figure 2. Asconoid body type. Cell types in sponges.

Whatever the type of sponges, there are three basic body types:

1. asconoid - sponges with simple pores and a central chamber,
2. syconoid - sponges with complex pores and a central chamber, and

3. leuconoid - sponges with complex pores and no central chamber.

Openings into the body of sponges are called pores. Pores allow water to enter or exit the sponge. Pores that allow water to enter are called **ostia**. Pores that allow water to exit are called **oscula**. Often, pores lead into a central chamber called the **atrium** or **spongocoel**. If they don't lead to an atrium, they lead to channels or canals. Both the atrium and canals are lined with specialized cells called **choanocytes**. These have a collar around them with a single flagellum. Water currents set up by the flagellum pull water under the collar to trap food. If you remember from the Protista lab, you studied a group of protistans called choanoflagellates. Some biologists feel the choanoflagellates gave rise to the choanocytes of sponges.

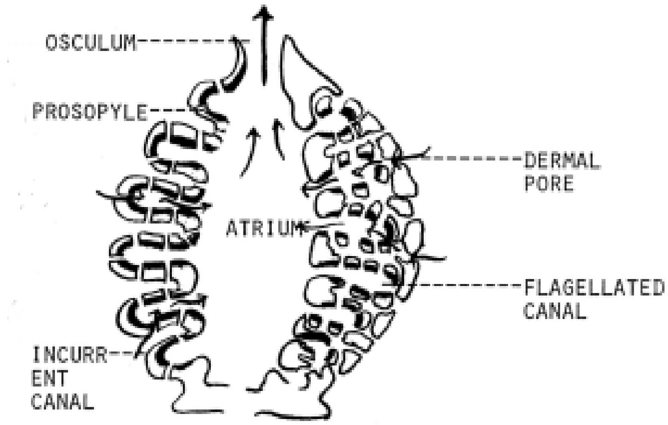

Figure 3. Syconoid body type.

The cells of a sponge are loosely organized around some type of skeleton. The skeleton is either composed of **spicules** (rod-shaped structures) or **spongin fibers**, or both. Spicules are composed of either calcium carbonate or silicon dioxide, depending upon the species. Spongin fibers are proteins.

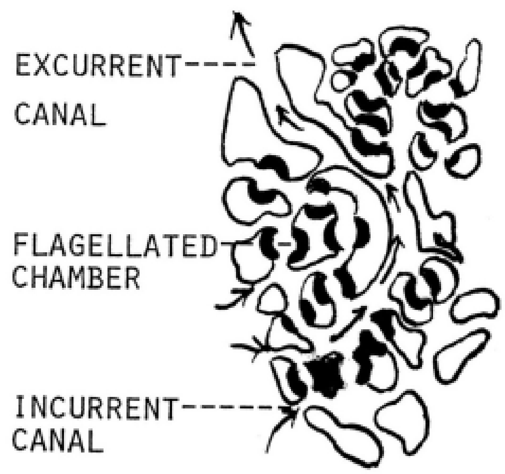

Figure 4. Syconoid body type.

Asconoid Sponges

Asconoid sponges offer the simplest body plan. They are all rather small in size and are often tube shaped. Water enters through ostia and circulates around the atrium by water currents set up by the choanocytes. Water eventually exits by a single, large opening called the **osculum**.

☐ Observe the preserved sample of the asconoid sponge called *Leucosolenia* (Gr. *leukos* = white, *solen* = pipe). *Leucosolenia* is a marine species found below low tide on boulders, along jetties in rather turbulent water. Budding of additional sponges from the parent is common. Some species may reach 25 mm in height.

☐ Obtain a prepared slide of *Leucosolenia* whole mount. Try to observe any ostia and notice any spicules present.

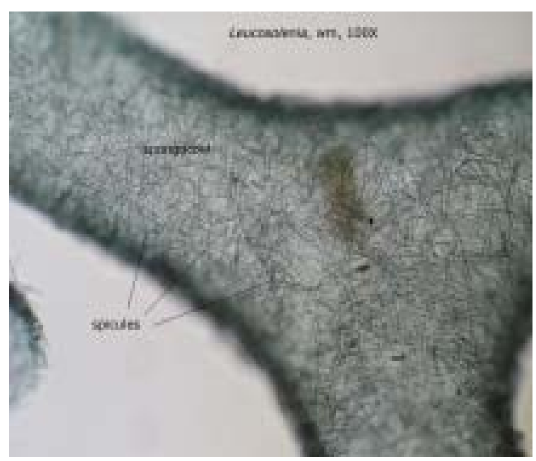

Figure 5. Leucosolenia, *w.m.* 100X.

Syconoid Sponges

At first glance, syconoid sponges appear similar to the asconoid, but in reality, they are a step up on the evolutionary ladder. Observe the preserved specimen of the genus *Scypha* (formerly the genus *Grantia*). *Scypha* belongs to the class Calcispongiae; thus, its spicules are composed of calcium carbonate. It is found in the same habitat as *Leucosolenia*.

□ Compare the preserved specimen of *Scypha* with that of *Leucosolenia.*

□ Obtain a prepared slide of *Scypha* (*Grantia*) longitudinal and cross section. The body wall of *Scypha* is more complex and is thrown into invaginations from both the outside and atrial side of the sponge. Choanocytes are limited to the canals and are not found in the atrium. Look at the longitudinal section and look for the **osculum, atrium, spicules,** and **canals.**

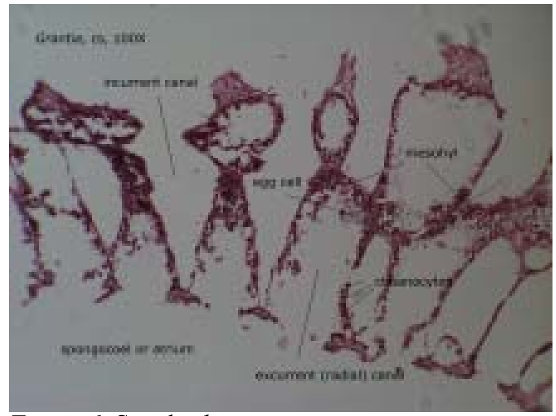

Figure 6. Scypha *l.s.*

Leuconoid Sponges

Leuconoid sponges have the most complex of body plans. They are most often found in colonies which grow so closely together that individual members are lost to the complexity of the colony. There does not appear to be any central chamber or atrium.

□ Obtain a preserved specimen of the common bath sponge. The common bath sponge is an example of a leuconoid sponge. This sponge is found in Florida on rocky bottoms to depths of 15 meters. Individuals may live to be 50 years old and grow to be quite large. What you are looking at is really the spongin skeleton of the animal. In Florida, sponges were commercially collected and dried (to kill the cells) and then sold. Greek immigrants created a large commercial sponge industry in south Florida, especially in the Florida Keys. Viruses wiped out a major portion of sponges on the east coast and the sponge industry has since moved to the west coast of Florida, particularly in the Tampa area. Natural sponges are still used today in household cleaning, but more importantly in the medical profession. Natural sponges can be repeatedly sterilized by autoclaving whereas cellulose and plastic sponges cannot.

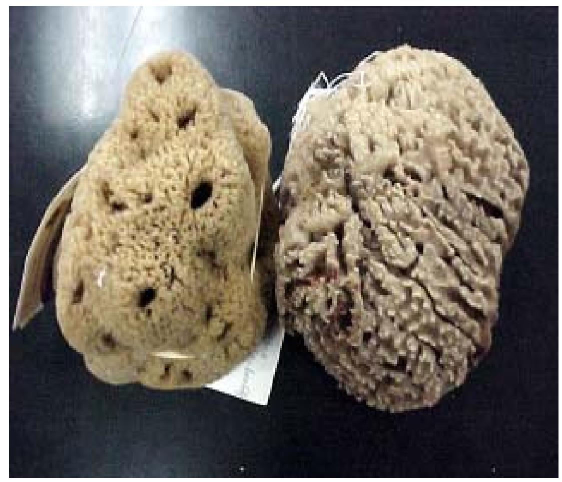

Figure 7. Common bath sponges.

□ Observe other representatives of the phylum Porifera. Try to determine their body types.

Sponges may reproduce asexually by either budding or fragmentation. In addition, they may produce **gemmules.** These are clusters of specialized sponge cells called amebocytes surrounded by spongin fibers and spicules. These break off the sponges and are carried by water currents to new locations. The amebocytes divide and produce new sponges.

□ Obtain a prepared slide of gemmules. Look for the spicules and spongin fibers. See if you recognize any cellular components.

Sexual reproduction in sponges involves amebocytes which are totipotent. Some amebocytes develop into eggs and some may form sperm. A fertilized egg develops into a amphiblastula larva which escapes and swims to a new location. Once a suitable location is found, the larva inverts and turns the ciliated cells inward and becomes the adult sponge.

Phylum Cnidaria

This phylum includes what most people recognize as hydras, jellyfish, sea anemones and corals. The most distinguishing feature of this group is its radial symmetry. However, they are also characterized by (1) an internal space for digestion - the **gastrovascular cavity** and (2) a body wall of three layers: **epidermis** (outer layer), **mesoglea** (middle layer) and **gastrodermis** (inner layer).

Two different structural types are found within the phylum: the **polyp** and the **medusa**. The polyp is typically sessile and the medusa is free-swimming. The polyp is tubular or cylindrical in shape with an **oral** end with mouth and an **aboral** end which attaches to the substrate.

The medusa looks like an umbrella or bell with the convex (**exumbrella**) side upward and the concave side (**subumbrella**) bearing the mouth that points downward. Both the polyp and medusa may have tentacles which aid in feeding and defense.

Most of the cnidarians are marine. There are a few freshwater forms. There are approximately 9,000 living species. There are three classes: Hydrozoa, Scyphozoa, and Anthozoa.

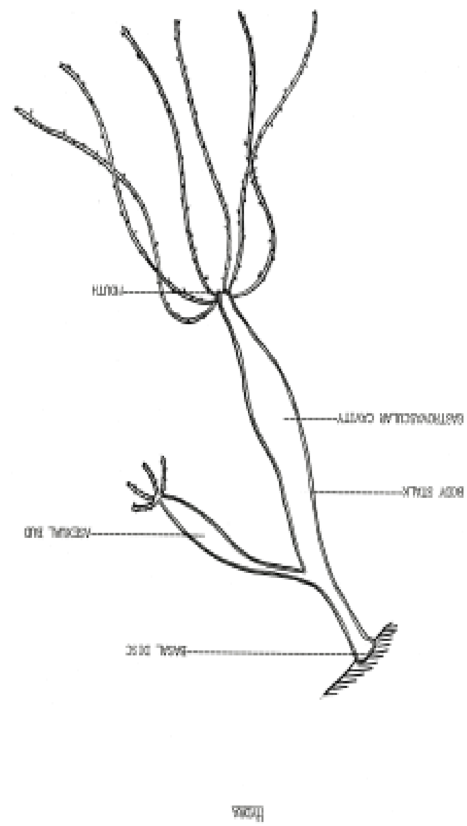

Figure 8. Polyp of Hydra.

Class Hydrozoa

Hydrozoans are often attached to rocks, shells or wharf pilings and may be overlooked as "seaweeds." The only freshwater members of the Cnidaria belong to the class Hydrozoa. Members of the class may exist as either the polyp form or the medusa form with some species having both forms in their life cycle. The mesoglea is never cellular and the gastrodermis lacks stinging cells called **nematocysts** but they are found in the tentacles.

The genus *Hydra* is a freshwater species with only the polyp stage. The size ranges from a few millimeters to over 1 cm in length. The aboral end attaches to a substrate by a **basal disk**. The oral end contains the mouth surrounded by 6 tentacles.

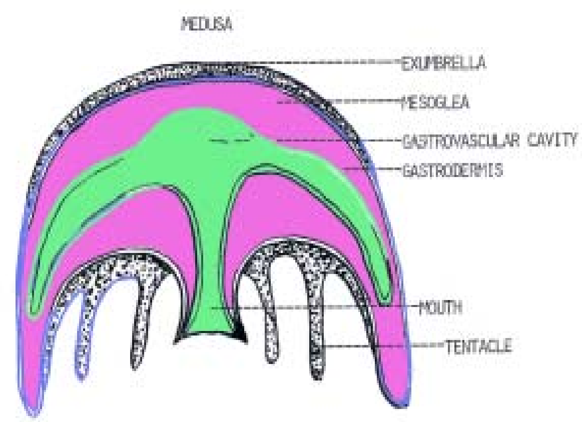

Figure 9. Medusa.

☐ Obtain the living culture of *Hydra* and use the pipette provided to remove one or more from the culture dish. Careful! They are stuck to the sides of the glass and you need to take care to loosen them from the surface. Place them in the watch glass provided along with a little water from the culture dish. Count how often the *Hydra* contract within a five minute period. These contractions tend to be rather rhythmic but their function is unknown. Perhaps they facilitate movement of food within the gastrovascular cavity.

Obtain the prepared slide of *Hydra* whole mount engorged with food. Notice the **tentacles, mouth, stalk, oral,** and **aboral** ends.

☐ Obtain a prepared slide showing the nematocysts of *Hydra* which have been removed and stained. *Hydra* use the nematocysts for (1) capturing prey (2) defense and (3) anchorage. You should be able to see several complete **cnidocytes** (cells which form nematocysts). There are three basic types of nematocysts: (1) volvent - tangles the prey with a coiled filament (2) penetrant - armed with barbs and toxin and (3) glutinant - sticks to the prey or surface.

☐ Obtain a prepared slide of *Hydra* budding. Budding is a form of asexual reproduction in the species. It begins as an extension of the epidermis and then includes the gastrodermis. Note the bud looks identical to the parent. There may be several buds on a single parent. The bud is capable of feeding while attached to the parent.

☐ Obtain a prepared slide of *Hydra* showing early ovary development. Look for a reddish or brownish swelling on the lower half of the stalk. *Hydra* is mainly dioecious and produce eggs in the fall to allow the species to overwinter after fertilization. The fertilized egg is protected with a chitinous shell.

☐ Obtain a prepared slide of *Hydra* showing the testis. A testis usually forms in the upper part of the stalk. The fully developed male testis looks very much like a human female breast.

☐ Observe any other specimens of the class Hydrozoa available in lab. In particular, look for the Portuguese Man-Of-War, the genus *Physalia*. These can cause severe stings. The Man-Of-War is actually not the jellyfish or medusa stage but a colony of polyps.

Class Scyphozoa

This class includes those animals most people recognize as jellyfish. The medusa is the dominant form in the life cycle. The medusae range in size from 2 to 40 cm, depending on the species. However, the bell of *Cyanea capillata* may reach 2 meters in diameter.

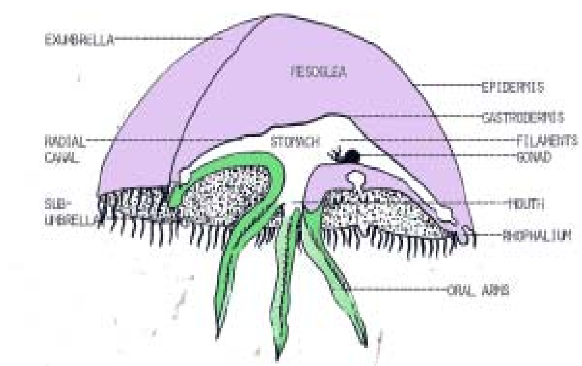

Figure 10. Medusa stage of Scyphozoan.

Coloration of the jellyfish is often brilliant. Sex organs and other internalized structures are often deep orange, pink, or other colors and are visible through the transparent and lightly colored veil.

Over 200 species have been described and they may inhabit seas from the Arctic to the tropics. Unfortunately for swimmers, they are often found close to shore and their armory of stinging nematocysts may cause problems.

One species, *Chironex fleckeri*, a tropical species, can produce stings so dangerous as to cause death. On the coasts of Australia, human death has been recorded in as little as 3 minutes.

Several features set this class apart from the Hydrozoa. The bell margin of the medusa is often scalloped to form lobes called **lappets**. The mouth is stalked to form a **manubrium** and there are four or eight frilly arms which aid in gathering prey to the mouth. Tentacle numbers around the bell can be as few as 4 or in the hundreds.

Located between the lappets are nerve concentrations called **rophalia**. Each one contains two sensory pits, a statocyst (balance structure) and often an **ocellus** or eye.

Scyphozoans are dioecious and the gonads are located in the gastrovascular cavity.

Aurelia

The most studied example of a scyphozoan in biology lab is the genus *Aurelia*. It has a complex life cycle which includes the adult medusa that produces egg and or sperm that are fertilized externally. The fertilized egg develops into a planula larva.

The larva is free-swimming and spends some time moving about. Finally it settles and changes into a polyp form called the **scyphistoma**. The scyphistoma buds to forms a complex structure called the **strobilus**. Each strobilus buds off young, immature medusae (called **ephyrae**) which mature into the adult jellyfish.

☐ Observe the adult *Aurelia* under the dissection scope. Locate the **oral arms, gonads, tentacles, exumbrella, subumbrella, radial canals,** and **rhophalium**.

☐ Observe any additional specimens of the class available in lab.

Class Anthozoa

This class does not have a medusa stage - only the polyp form. They are either solitary or colonial in nature and are sessile. The class includes those animals recognized as sea anemones, corals, sea fans, and sea pansies. This is the largest class of cnidarians with over 6,000 species.

The polyp form of this animal differs greatly from the polyp forms of the other two classes. First, the mouth leads into a tubular structure called the **pharynx.** The pharynx takes up more than half of the stalk and gastrovascular cavity. The gastrovascular cavity is divided by **mesenteries** or **septa** which run longitudinally. The edges of the mesenteries are three-lobed and carry nematocysts.

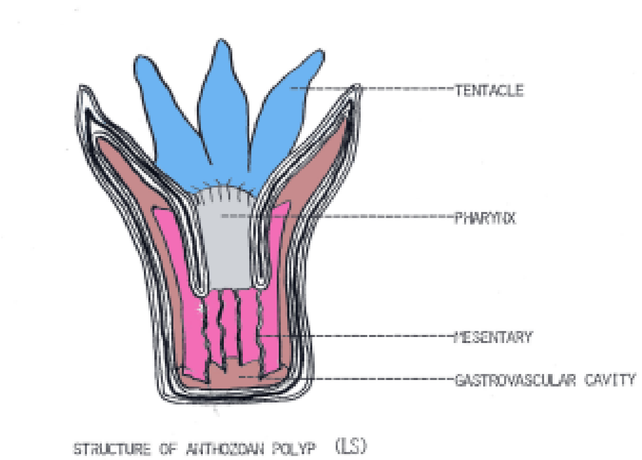

Figure 11. Anthozoan polyp.

Metridium

These are solitary polyps with numerous tentacles surrounding the mouth.

☐ Obtain a preserved specimen and a dissection tray. Using a pair of scissors or scalpel, cut through the mouth longitudinally down the animal and through the base along one side. Open the animal up by folding back the two halves. Observe the following features: **mouth, siphonoglyph, pharynx, mesenteries, gonads, mesenterial filaments** and **tentacles.**

Be sure to dispose of your dissected specimen in the biohazard bag provided. Wash and clean the dissection tray and dissection tools.

☐ Look at various forms of stony or scleractinian corals on display. Also look at the various forms of octacorallin corals (sea fans and sea pens). All these are members of the class Anthozoa.

Phylum Platyhelminthes - Flatworms, Flukes, Tapeworms

These are the first bilateral animals we will study in the animal kingdom. With bilateral symmetry comes mobility. The anterior end of the animal will meet the environment first and will bear a large number of sensory devices. There are four classes: Turbellaria, Monogenea, Digenia, and Cestoda. Of these, the last three are entirely parasitic.

Members of the phylum are characterized by a dorsoventrally flattened, acoelomate body with a single opening for ingestion of food and elimination of solid wastes. The osmoregulatory function is carried out by **protonephridia**. The species are all hermaphroditic.

A most unusual feature is the flagella of the biflagellate sperm. Instead of the almost universal 9+2 configuration of microtubules in cilia and flagella in eukaryotic species, the flattworms have a 9+1 configuration of microtubules.

Class Turbellaria

These include those animals called planarians. However, there are over 3,000 different species in this class. Most are aquatic and most of those are marine but there are some terrestrial forms. One terrestrial form, *Bipalium kewensis*, is found in temperate and subtropical regions. It gets its specific epithet from the famous Kew Gardens in England where it was first found in the soil of a flower pot from the New World. Size of members of the class may vary from microscopic to 60 cm in length.

The Genus *Dugesia*

These are freshwater organisms often found in streams and creeks crawling on the undersides of rocks.

☐ Obtain a watch class and place in it a live *Dugesia* from the culture dish provided. Observe it under the dissection scope for its movements. Note the gliding motion. By what means does it glide along the surface?

☐ Next, feed the animal a piece of egg yolk provided. How do you think it detects its food? Notice the method of eating. Look for yolk in the digestive tract of the animal.

☐ Obtain a prepared slide of a planarian whole mount. Try to identify the **pharynx, eye spots, auricles,** and **digestive tract.**

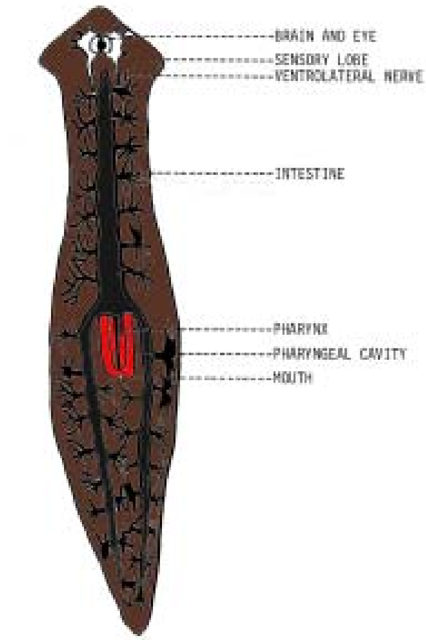

Figure 12. Dugesia.

Class Monogena

This class derives its name from the fact it has but a single host in its life cycle. These are parasitic on marine and freshwater fish, some amphibians, reptiles, and invertebrates. Most are ectoparasites.

Examples are *Polystoma integerrimum* found in the bladders of frogs and toads, *Benedenia melleni* that is parasitic on the eyes of a variety of marine fishes, and *Dactylogyrus elegans* which parasitizes the gills of carp. *Polystoma* synchronizes its life cycle with that of the frog to such an extent that when eggs are shed into the water by the frog, the larval stage of *Polystoma* is released to parasitize the gills of the developing tadpoles.

Unfortunately, we generally don't have any specimens of these for laboratory study.

Class Digenea

The class gets its name from the two or more hosts required in the life cycle. With over 6000 species, it is the largest of the four classes of flatworms. They are entirely parasitic, and unfortunately, humans are often one of the hosts. The host in which the adult stage of the parasite is found is called the primary host. Other hosts during the life cycle are referred to as intermediate hosts. Commonly, the intermediate host is an invertebrate and the primary host is a vertebrate.

A typical life cycle involves five larval stages. It begins with the hatching of an egg to produce a free-swimming **miracidium** larva. This larva finds a mollusk and makes its way into the digestive gland of the mollusk. The miracidium metamorphoses to a **sporocyst** stage. After a period of time the sporocyst gives rise to germinal masses of cells which form the **redia larva**. Redia, in turn,

A typical life cycle involves five larval stages. It begins with the hatching of an egg to produce a

free-swimming **miracidium** larva. This larva finds a mollusk and makes its way into the digestive gland of the mollusk. The miracidium metamorphoses to a **sporocyst** stage. After a period of time the sporocyst gives rise to germinal masses of cells which form the **redia larva**. Redia, in turn, develop into **cercaria** larva. The cercaria leaves the host and becomes free-swimming until it comes into contact with a second intermediate host. In the second host, it encysts to form the **metacercaria** larva. It encysts within the second host and that cyst is eaten by the final vertebrate host where the cyst hatches and forms the adult parasite.

☐ Observe the prepared slide of various cercaria of digenetic flatworms. Note the cercaria have a **digestive tract, suckers,** and a **tail.**

There are two representative genera normally studied in beginning biology: *Clonorchis sinensis* or the Chinese Liver Fluke and *Fasciola hepatica*, the Sheep Liver Fluke.

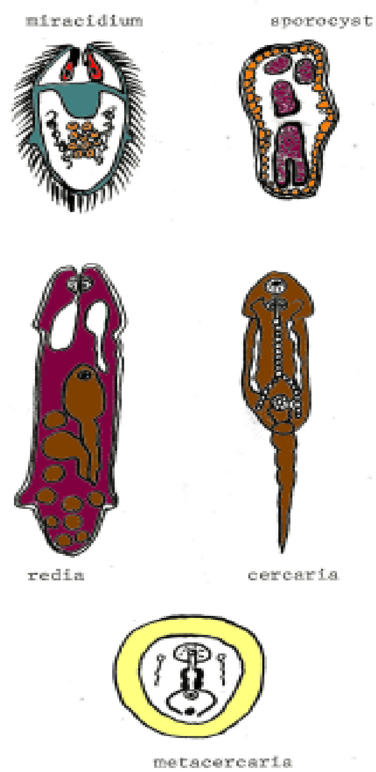

Figure 13. Larval types of Class Digenea.

Chinese Liver Fluke (*Clornorchis sinensis*)

The common name comes from the first description of the animal from an 1875 autopsy of a Chinese hospital patient. The liver was found to be enlarged and turgid with distended bile ducts filled with the adult parasite. The typical size of the worm is 10 to 25 mm in length. The intermediate host is a snail and fish. Humans are the primary host. The snail is infected by the egg, miracidium, sporocyst and redia while the fish plays host to the cercaria and meteacercaria larvae. Humans ingest the metacercaria by eating infected fish. The adult begins to deposit eggs 25 days after infection of the human and the human sheds the eggs in feces. Can you propose a possible method of transmission from the human, to the snail to the fish?

☐ Observe the whole mount preparation of *Clonorchis*. DO NOT USE HIGH POWER ON THIS SLIDE! Look for the following structures: **mouth, oral sucker, intestine, testes, uterus, ventral sucker, oötype, seminal receptacle, yolk glands,** and **pharynx.** What do you think are the functions of the oötype, seminal receptacle and yolk glands?

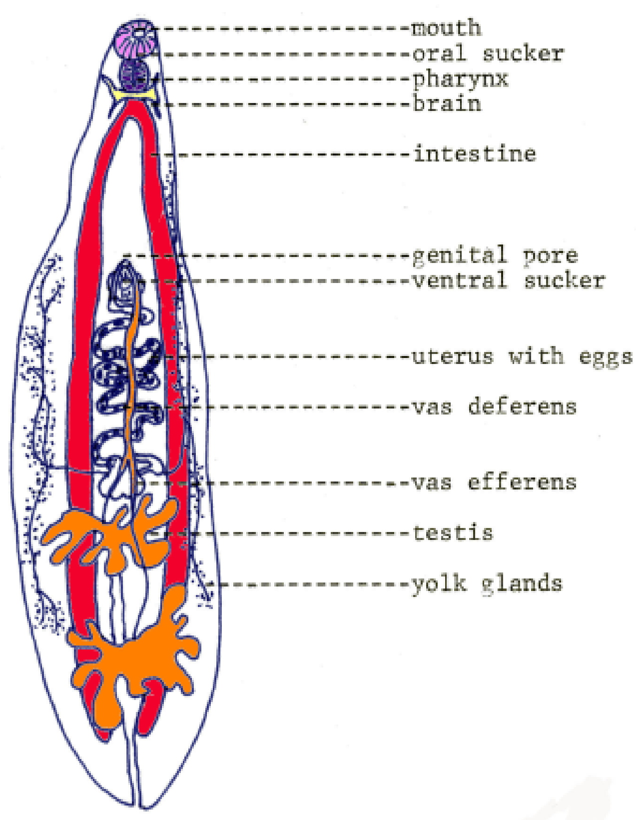

Figure 14. Clornorchis sinensis.

Sheep Liver Fluke (*Fasciola hepatica*)

This parasite has been known since 1379 and is often called liver rot. Leuckart and Thomas were the first to describe the life cycle and it was the first life cycle of a digenetic parasite elucidated. The animal may reach up to 51 mm in length and it lives in the bile ducts of many mammalian hosts, including humans. There is only one intermediate host - the snail but humans often get the parasite from improperly cooked mutton (the sheep eat the snail).

☐ Compare the slide of *Fasciola hepatica* with that of *Clonorchis sinensis.* Try to find some of the same structures.

Class Cestoda

This is the most advanced class of flatworms and includes those known as tapeworms. They are all endoparasitic with a protective layer called the tegument. There is no digestive tract. Why would you consider this an advanced trait?

The body of a tapeworm is divided into three parts: **head**, **neck** and **strobilus**. The head is a modified into a structure called the **scolex**. It has suckers and hooks to attach to a host, as well as a mouth. The neck is a narrow region just behind the head which simply joins the head to the strobilus. Individual segments of the strobilus are called **proglottids**. A proglottid ripe with eggs is referred to as **gravid.**

☐ Observe the proglottid under the microscope of *Taenia pisiformis,* the dog and cat tapeworm. Try to identify the **genital pore, vas deferens, oötype, ovary, vitelline gland, testes,** and **uterus.** You may have to scan several segments to see all the features. Also look for a gravid proglottid.

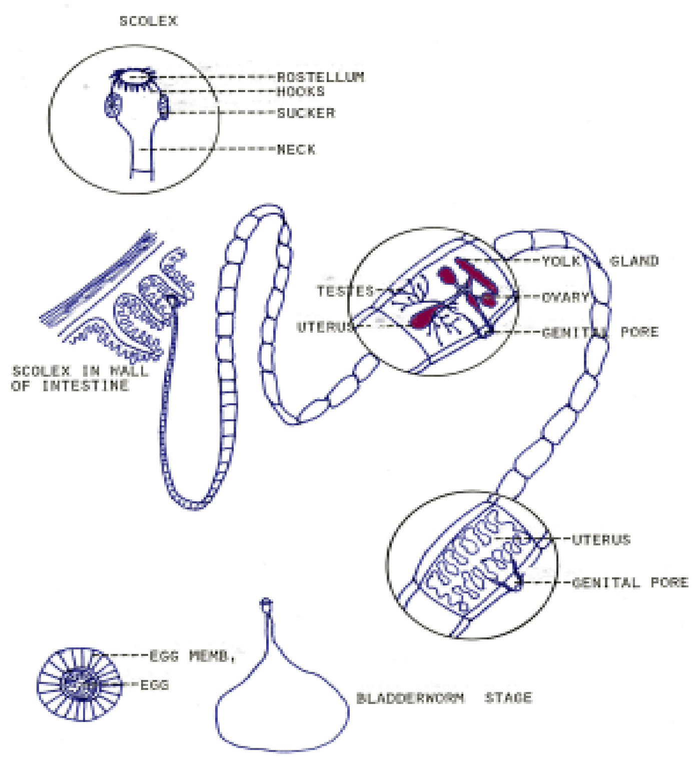

Figure 15. Tapeworm.

The Pseudocoelomates

This is an artificial grouping of several phyla, all characterized by the pseudocoelomate body cavity. Remember, the pseudocoel results from a persistent blastocoelic cavity in the embryo. We will look at two phyla: Rotifera and Nematoda.

Phylum Rotifera

This phylum contains terrestrial and freshwater animals called the wheel animalcules (due to the appearance of a ciliated crown at the anterior end of the animal called the **corona** which gives the impression of a spinning wheel. There are over 1500 species reported with some reaching a size of 3 mm (most are microscopic). The majority are freshwater.

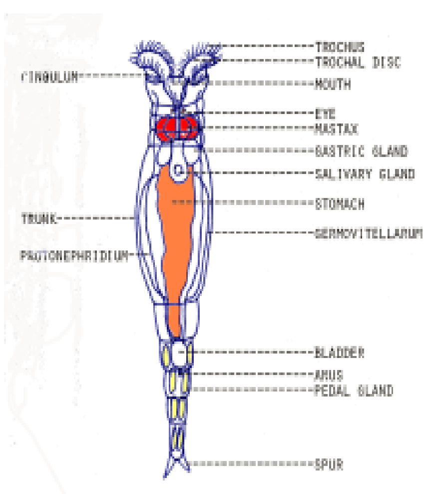

Figure 16. Rotifer.

The body is divided into three regions: **head, trunk** and **foot**. The foot attaches the animal to some surface and the head feeds by ciliary action. Rotifers are known for their ability to withstand severe desiccation by forming cysts. They may remain dormant for up to 4 years. They have been known to withstand temperatures as low as -272 degrees C.

☐ Place a drop of rotifer culture on a slide (try to get some vegetation with the dropper) and cover with a cover slip. Look at the vegetation for rotifers attached. Confirm with your instructor you have found a rotifer. Notice the peculiar feeding behavior and the periodic contractions of the body. Try to identify the **mouth, corona, mastax,** and perhaps, if you find a brooding female, **eggs.** Rotifers are capable of parthenogenesis. What does this mean?

Phylum Nematoda

These are commonly referred to as round worms. There are over 10,000 species described, but this is probably just the tip of an iceberg. They be found in marine environment, freshwater systems, and terrestrially. The numbers produced are astounding. One square meter of bottom mud off the Dutch coast was estimated to contain 4,420,000 nematodes!

Some examples of nematodes are the human ascrid (*Ascaris lumbricoides*), the American hookworm (*Necator americanus*), the parasite that causes trichinosis (*Trichinella spiralis*), and vinegar eels (*Turbatrix aceti*).

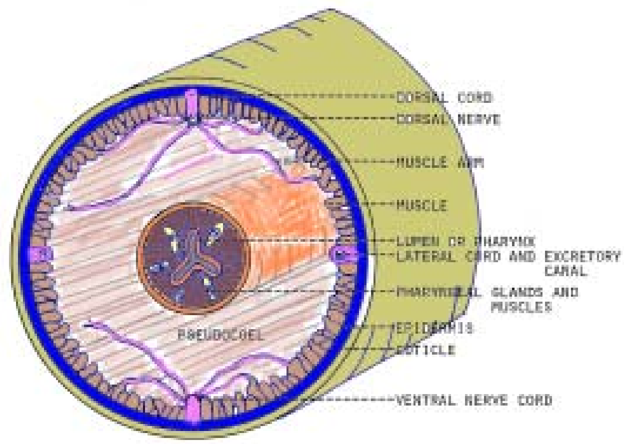

Figure 17. Cross section of a round worm.

Human Ascrid (*Ascaris lumbricoides*)

This round worm is most often found in the small intestine of children because of the habit of playing in soil close to dwellings contaminated with eggs. As many as 5000 worms may be found in a single host. The worm can actually penetrate the intestine and cause peritonitis. Toxic productions from the worm may produce convulsions and even dull the mental capacity of children.

Caution! Always wear gloves when handling ascrids and wash your dissection equipment and hands thoroughly upon completion of the dissection!

☐ Obtain a male and female ascrid. The male may be determined by looking for a smaller worm with a definitely hooked tail. Try to locate the head of each worm. Beginning at the head, slice through the body wall of the worm longitudinally about three quarters the length of the worm. Carefully spread the worm's body wall apart using pins to keep the body open. In the female, look for the **nerve chords, intestine, ovary, uterus, oviducts,** and **vagina.** In the male, look for **nerve chords, intestine, testis** and **vas deferens.**

Be sure to wash your dissection equipment and dissection tray with soap and water. Dispose of the worms in the biohazard bag provided.

☐ Obtain a prepared slide of *Ascaris*. It should have a cross section of both a male and female worm. Distinguish the male section from the female section. Try to identify **cuticle, epidermis, muscle layer, dorsal nerve cord, ventral nerve cord, lateral cord, pseudocoel, muscle arms, lumen of pharynx, muscles of pharynx, intestine, ovary, uterus, oviduct, eggs, testis,** and **vas deferens.**

This is a parasite of humans, pigs, rats, and other vertebrates and is the causative agent of trichinosis. Anyone eating infected under-cooked meat can come down with the disease. It is also found in deer. Both deer and pigs are often the source of human trichinosis.

When humans eat infected meat, their digestive system digests the cysts which release the parasite. Three days after release, the females are impregnated by the males. The males die and are eliminated via feces. The females burrow into the intestinal wall and produce juvenile worms. In three months time, a female may produce as many as 1500 juveniles. Juveniles invade the skeletal muscle of the diaphragm, the intercostals, the tongue, throat, and upper trunk.

Once in muscle tissue, this stage may lead to toxemia, heart inflammation, pneumonia, and kidney failure, sometimes all of these at once. The problem is the symptoms of the early stages may resemble influenza and thus be misdiagnosed. At a certain point, the juveniles forms calcified disks. Once encysted, the worms may remain alive for several years.

☐ Observe the prepared slide of *Trichinella* showing calcified disks in the skeletal muscle. Note each juvenile worm is surrounded by a fibrous sheath and a hyaline sheath. Connective tissue forms between the sheath and muscle.

Phylum Mollusca

Most are familiar with this group of animals. It includes clams, oysters, squids, octopods, and snails. Other than the arthropods, this is the largest group of animals. There are over 65,000 extant species and 35,000 extinct. Seven classes are recognized by most taxonomists:

1. Class Monoplacophora
2. Class Polyplacophora - the chitons
3. Class Aplacophora
4. Class Gastropoda - the snails
5. Class Bivalvia - clams and mussels
6. Class Scaphopoda - tooth shells or tusk shells
7. Class Cephalopoda - octopods, squid, cuttlefish.

We will concentrate on the Bivalvia and Cephalopoda.

Class Bivalvia

This class includes clams, oysters and mussels. The shell is composed of two valves, thus the name. The shell completely encloses the body and a **foot** becomes laterally compressed within the shell. There are paired gills which are enlarged and folded into a W shape and used for food gathering. Where the **mantle** attaches to the shell, a scar forms, called the **pallial line**. Additional scarring of the shell occurs where muscles attach.

☐ Obtain an empty bivalve shell. Place the two halves together as they would normally occur. Look on the outside for a slightly raised area on the top of the shell. This is the **umbo** and the umbo always points toward the anterior end of the shell. Now that you know anterior end from posterior end, open the shell and look at the scars on the shell surface. Look for the **anterior retractor, anterior adductor, posterior pedal retractor,** and the **posterior adductor scars.** Also look for the **hinge ligament** on the outside of the shell and the **teeth** on the inside of the shell which prevent the valves from side slippage.

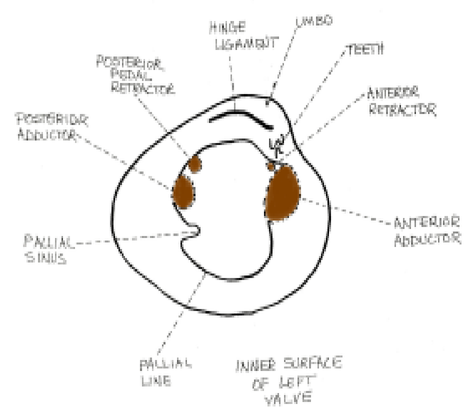

Figure 18. Bivlave shell.

☐ Obtain a preserved clam and place in your dissection tray. Notice the clam should have a small wooden peg inserted between the valves. Carefully place the blade of your scalpel between the valve openings and using a slicing motion, cut back toward the anterior end of the shell trying to sever the anterior retractor and anterior adductor muscles. Repeat the process by slicing back towards the posterior end cutting the posterior pedal retractor and posterior adductor. This should allow you to carefully open the valves of the shell to reveal the animal within. Try to keep all the animal in one valve of the shell as you spread the valves completely open.

Try to locate the paired **gills, labial palps**, **mouth, mantle** and **foot**. Flip one half of the mantle out of the way and remove the corresponding set of gills from the animal. Look towards the umbo and notice at the very top near the teeth there is a membranous area. Use a sharp probe and remove the membranous material and look for the **heart** with two **atria** and a single **ventricle**.

Carefully make a slice into the foot with a scalpel, cutting from anterior end of the foot to the posterior end of the foot. Slice as far up as you can and remove 1/2 of the foot. Look for the **intestine**, **stomach, gonads,** and **digestive gland.** Dispose of your specimen in the biohazard bag provided. Be sure to clean your dissection tray and dissection tools.

Class Cephalopoda

This class includes squids, cuttlefish, and octopods. Less familiarly, perhaps, is the chambered nautilus. There are some 650 species extant with a fossil record of over 7500 species.

The circle of tentacles is the characteristic feature of this class. Locomotion is by jet propulsion as well as fins. The class represents the largest of invertebrates species - the giant squid *Architeuthis*. It may reach a body length of 16 meters with tentacles 6 meters long. Giant octopods are fiction. The largest, the Pacific coast species of *Octopus punctatus*, may reach a body size of 36 cm even though the tentacles may reach 5 meters in length.

☐ Note the dissected model of the squid *Loligo*. It is a littoral animal found off the east coast of the United States from Maine to South Carolina. Winter habits are little known but in spring and early summer, squid form schools of more than 100 to breed near shore.

Phylum Annelida

This phylum is composed of segmented worms and includes the familiar earthworms and leeches, and the not-so-familiar clamworms. There are both freshwater and marine species as well as terrestrial species.

The most distinguishing feature of the phylum is metamerism. Metamerism arose in two different places in the animal kingdom - here, and in the phylum Chordata. The head, or **acron**, is technically not a segment, nor is the tail, or **pygidium**. Each segment is divided by a transverse **septum** that separates one compartment of the coelom from the other. The septum is composed of a double layered membrane called the **peritoneum** (lining of the body cavity); one layer each from each side of the cavity. The muscularture, lateral nerves, blood vessels, and excretory organs are also segmentally compartmentalized. Other structures, such as the intestines and longitudinal nerves, run through each segment.

There are three classes in this phylum:

1. Class Polychaeta (literally, many hairs),
2. Class Oliogochaeta (few hairs), and
3. Class Hirudinea - the leeches.

Class Polychaeta

☐ Observe the preserved specimen on clamworm, the genus *Nereis*. These are fairly large animals, ranging in size from 40 to 45 cm in length. The coloration varies from steel blue to green with orange and red blotches. This worm typically lives in tubes formed in sand or mud. The tube is lined with mucus produced by the worm. Feeding usually takes place by the anterior portion of the worm extending outward from the tube. Supposedly, they are omnivorous. The only time the worms leaves the burrow is during mating season.

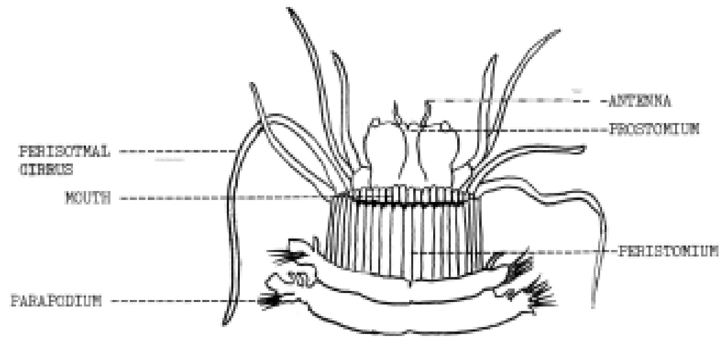

Figure 19. Nereis *anterior end.*

☐ Try to identify **tentacles, palps, prostomium, inferior peristomial cirri, superior peristomial cirri, peristomium, eversible pharynx, jaws,** and **parapodia.**

Class Oligochaeta

The common earthworm, *Lumbricus terrestris*, belongs to this class. This animal may be found in moist earth in Europe and North America. It stays in its burrow during the day in response to light and humidity but comes out at night.

☐ Observe the preserved specimen provided. The number of segments may be well over 100. Note you can readily distinguish the dorsal and ventral surfaces of the animal by the light coloration of the ventral surface. The first "segment" is the **prostomium**. Ventral to it is the mouth. Count back from the first true segment to segment # 15. Look carefully at the animal's ventral surface and try to find the **male genital pores** found between two swollen lip-like structures. Look just above that at segment # 14 and observe the **female genital pores** which are less obvious. Look also for the **sperm grooves** on either side of the ventral surface posterior to segment 15. These provide a path for sperm during copulation. The animal can contract muscles to make the grooves more pronounced.

☐ Next look for segments 32 or 33 and notice the differences in the segments following. These segments are modified for the next 5 or 6 segments and form the structure called the clitellum. The clitellum contains glands which eventually secrete a protective **cocoon** around eggs.

☐ Lastly, run your hand back and forth the length of the animal's lateral surfaces. The rough structures you feel are **setae**. The earthworm has four pairs, two pairs ventrally per segment and two pairs dorsally per segment. What are their functions?

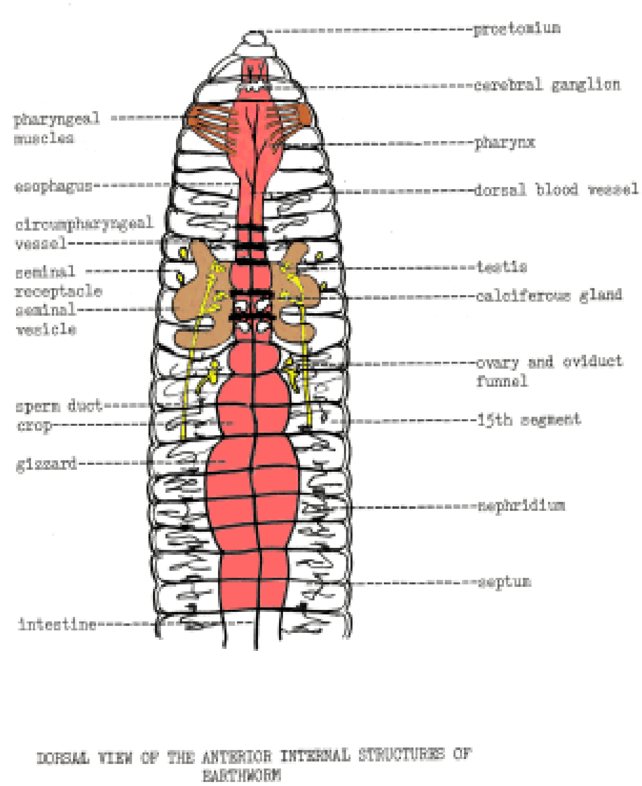

Figure 20. Lumbricus.

☐ Observe the dissected earthworm and try to correlate the structures you saw in your preserved specimen with the dissected specimen.

Dispose of your specimen in the biohazard bag provided. Be sure to clean your dissection tray and dissection tools.

Class Hirudinea

This class is collectively known as the leeches. There are over 500 species of marine, freshwater, and terrestrial forms. These are commonly thought of as bloodsuckers, but many are not parasitic. These, like the Oligochaetes, lack head appendages, have no parapodia, but are hermaphroditic and produce cocoons. The smallest are 1 cm in length but some may reach 30 cm in length. The medicinal leech, *Hirudo medicinalis*, often reaches 20 cm in length.

☐ Observe the leech provided. It is a medicinal leech. If the leech is living, you may pick it up. They will attach to you by their posterior sucker. Be carefully you don't let the anterior sucker stay attached too long or you will know the leech is feeding on you. You won't feel it slice into you and your blood won't clot at the opening for a short period of time. Why?

Phylum Arthropoda

There are more arthropods than any other phylum in the animal kingdom. One class in this phylum - the class Insecta - contains more species than any other animal group on earth. The arthropods represent the peak of evolution of protostomic animals. Scientists believe they probably evolved from a primitive group of polychaete worms.

The term arthropod means jointed foot. Arthropods are segmented and highly mobile even though they have an exoskeleton that restricts movement to some degree. They shed their exoskeleton at various times during their life. The shedding process is called **molting** or **ecdysis**. The old skeleton which is shed is called the **exuvia**.

The phylum is subdivided into three subphyla and several classes:

Subphylum Trilobitomoprha - the trilobites, known only from fossil records

Subphylum Chelicerata
- Class Merostomata - horseshoe crabs
- Class Arachnida - spiders, scorpions, ticks, and mites
- Class Pycnogonida - sea spiders

Subphylum Mandibulata
- Class Crustacea - crabs, shrimps, lobsters, etc.
- Class Insecta - the insects
- Class Chilopoda - centipedes
- Class Diplopoda - millipedes
- Class Symphyla - an obscure group called the symphylans
- Class Paurpopoda - another obscure group called the pauropodans.

Subphylum Chelicerata

The chelicerates are characterized by the first pair of preoral appendages modified as feeding structures - called the **chelicerae**. The body is divided into a **cephalothorax** and an **abdomen**. There are no antennae. **Postoral** appendages are called **pedipalps.**

Class Merostomata

This class is represented by the horseshoe crabs. The species we will concentrate upon is *Limulus polyphemus*, common to the Atlantic and Gulf Coasts. Horseshoe crabs live in shallow water on sandy bottoms where they plow their way through the sand. They may reach a length of up to 60 cm and the males are commonly smaller than the females. Their color is uniformly brown.

Limulus is a scavenger and feeds primarily on molluscs, worms, and bottom dwelling algae. Food is picked up by the pincers on the appendages and passed to the mouth.

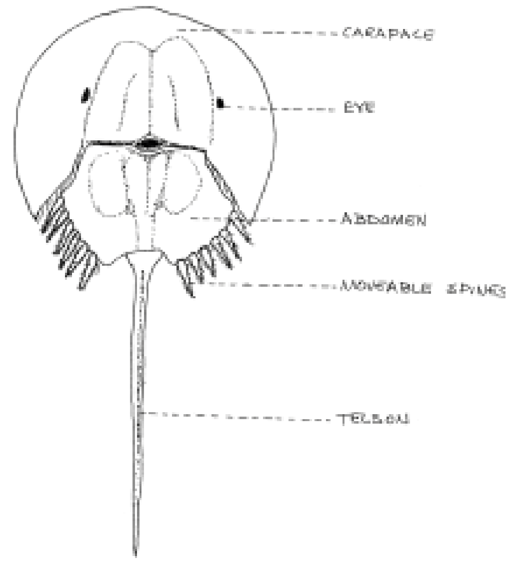

Figure 21. Limulus *dorsal view.*

☐ Observe the preserved horseshoe crabs provided. Note the cephalothorax is covered by a shield-like structure called the **carapace**. The design of the carapace is such that it allows the animal to push its way through the sand, much like a bulldozer. Look for the dorsal ridges of the carapace. To either side are found the lateral eyes. These are rather obvious but there is an additional pair to either side of the medial ridge which are smaller and not so obvious.

☐ Note the abdomen with the moveable spines attached along the edge. Also observe the **telson**. It is the result of a fusion of the last segments of the abdomen. True telsons have an exit for the anus. This one does not and should not be considered a "true" telson. What do you think is the function of the telson here?

☐ Turn the crab over to reveal the ventral surface. Look for the first pair of appendages at the anterior end. They are smaller than most of the others and are used for feeding. They are located close to the mouth. These are the chelicerae, from which the subphylum receives its name.

Posterior to the chelicerae are five pairs of walking legs. Observe the first four are similar in appearance. Compare the first pair of **postoral** appendages in the male horseshoe crab with the first pair of postoral appendages in the female. Note their differences. The male uses the hooked structures to hold onto the female during mating.

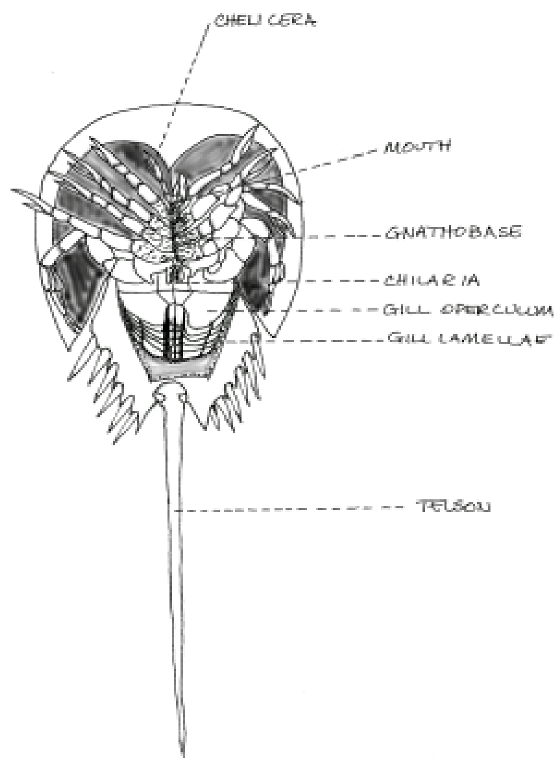

Figure 22. Limulus *ventral view.*

☐ Look at the bases of each leg and notice the first segment called the **coxa**. The coxa is modified in this animal with spines and hairs. They help maneuver food forward to the mouth.

The abdomen has six pairs of appendages. The first pair form a flap-like structure which covers the genital operculum. Lift the first flap and observe the genital opening beneath. Next are five flap-like structures which are segments modified as gills. The undersurface of each flap is formed into folds like the pages of a book and are thus called **book gills**. Each gill has approximately 150 lamellae (or pages).

At times, horseshoe crabs were so abundant on the eastern seaboard that settlers would haul them away in wagons and dump them in fields for fertilizer.

Class Arachnida

This group includes the familiar spiders, scorpions, mites, and ticks. The fossil record is old, dating back to the Carboniferous period with scorpions dating to the Silurian period. They are primarily terrestrial although some secondarily aquatic forms are found.

The move from the water to land was a traumatic experience for the ancestral arachnids and several features evolved to help this transition:

1. the cuticle became waxy to help prevent water loss,
2. the book gills became modified to use air and thus evolved into book lungs and tracheae, and
3. appendages became better adapted for terrestrial existence.

☐ Observe the garden spider provided. The body is divided into a cephalothorax and an abdomen. In the case of the spider, the abdomen is narrowly joined by a stalk called the pedicel. In others members of the class, the abdomen may be more broadly joined. In most arachnids, segmentation is reduced. The exception is the scorpion which retains much of the segmentation of the abdomen. How many walking legs do you see in this spider?

☐ Note the cephalothorax is covered by a carapace. Try to see the eight anterior eyes found on the dorsal surface of the carapace. Look for the chelicera. These are modified in spiders into fangs. The fangs fit into grooves of the chelicera. The pedipalps are short and leg-like in females but are boxing glove-like in males and are used for copulation. The male's pedipalps are inserted into the genital orifice of the female and broken off. Inside the pedipalps are sperm. Is this specimen a male or female?

☐ Observe the legs of the spider. There are eight legs in all spiders. Each leg consists of:

1. a basal coxa,
2. a small trochanter,
3. a long femur,
4. a short patella,
5. a long tibia,
6. a metatarsus,
7. a tarsus, and
8. a pretarsus composed of two or three claws.

☐ Identify the above structures. What structures are they similar to in humans? What do you think are the functions of the claws on the pretarsus? The abdomen is not visibly segmented except in the most primitive of spiders. Fortunately, segmentation is often indicated by color patterns. The abdomen is actually composed of some 10 segments. Look on the ventral surface of the abdomen, and try to find a transverse groove called the epigastric furrow. This is where the reproductive openings are found. These openings are in the center of the furrow with two spiracles with the book lungs on either side. (Book

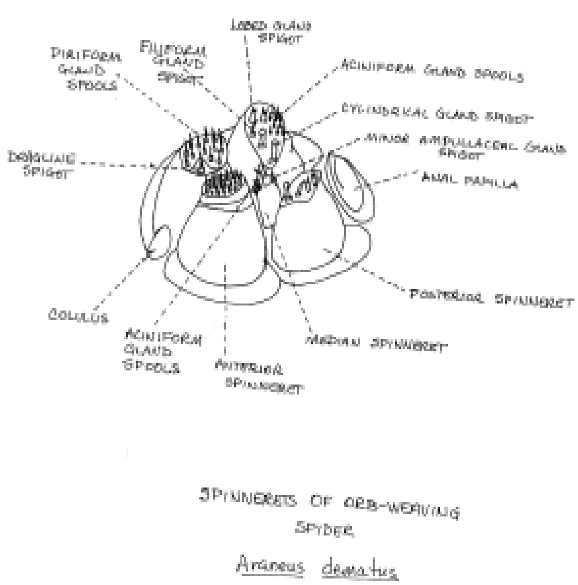

Figure 23. Spinnerets.

lungs are internal.)

☐ Look for the silk spinning devices at the end of the abdomen called spinnerets. Primitive spiders have eight, more modern spiders have six. Each spinneret is a structure that bears many spigots or openings for silk. What is silk? What are some functions of silk?

Class Crustacea

Remember the phylum Arthropoda is divided into two subphyla: Chelicerata and Mandibulata. The crustaceans, insects, centipedes, and millipedes are mandibulates. They have mandibles for feeding appendages and antennae for sensory structures. How does this differ from the Chelicerates? Crustaceans are primarily aquatic and differ significantly from the insects, centipedes, and millipedes.

There are some 26,000 species in this class and it includes some of the most familiar animals: crabs, shrimp, lobsters, and crayfish. Even though most are marine species, there are freshwater forms.

Class Insecta

More than 750,000 species of insects have been described, and some authorities put the number at over 1 million species. They are very successful in their domination of the land but they can also be found in aquatic environments. Only the deepest parts of the ocean have no insects. Their success in surviving today is probably due to the present of wings for flight; however, there are some insects that have no wings. Their influence on humans is tremendous. Over two-thirds of flowering plants depend upon insects for pollination. Pollinator species include bees, wasps, butterflies, moths, and flies. Many species are pests as far as humans are concerned such as mosquitoes, lice, fleas, bedbugs, and flies. Many insects are vectors of diseases that plague humans.

Insect vectors and the diseases they transmit include:

1. mosquitoes - malaria, elephantiasis, yellow fever,
2. tsetse fly - African Sleeping Sickness
3. lice - typhus and relapsing fever,
4. fleas - bubonic plague, and
5. houseflies - typhoid fever and dysentery.

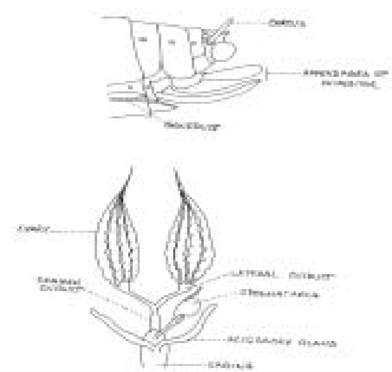

Figure 24. Female insect.

☐ Obtain a male and female grasshopper from the preserved container. How can you tell the difference in sexes? All insects have three major divisions of the body: the head, thorax, and abdomen. Locate these divisions on one of the two grasshoppers.

☐ Look closely at the head of the insect. Grasshoppers have chewing mouthparts. Look for a frontal flap of tissue called the labrum. This is somewhat like an upper lip. To the right and left (and underneath are the mandibles (jaw-like structures) which crush the material the grasshopper is feeding upon. Just below the mandibles are the left and right maxilla, each with an appendage called the palp. The maxillae and palps help manipulate the food. Underneath the maxillae are the labium with right and left labial palps, somewhat like the lower lip. Again, these help manipulate the food.

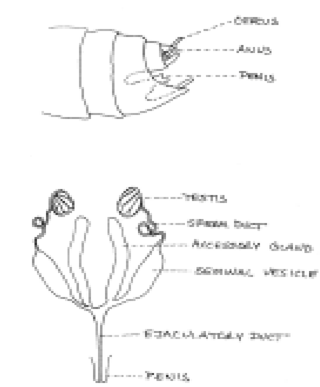

Figure 25. Male insect.

☐ Just behind the head is a dorsal shield-like structure called the prothorax. Just behind that is the mesothorax and metathorax. The first pair of legs are attached to the prothorax, the second pair of legs attaches to the mesothorax, and the large hind legs attach to the mesothorax. Just above the hind legs are the tympanic membranes, a pair of sound receptors. Dorsally, attached to the metathorax are two pairs of membranous wings.

☐ Look for the abdomen and note the number of segments. If you have a female, the last segments are modified into an ovipositor to help dig a hole in which to lay eggs. In the male, there is no ovipositor.

☐ Look at the hind legs. They are quite large and modified for jumping. The segment of the hind leg which attaches it to the body is called the coxa. The next segment is the trochanter, followed by the femur, tibia and tarsal segments.

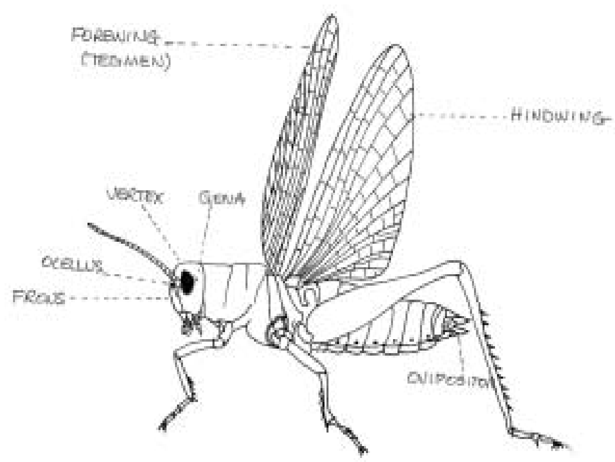

Figure 26. Grasshopper.

Dispose of your specimen in the biohazard bag provided. Be sure to clean your dissection tray and dissection tools.

Phylum Echinodermata

This phylum includes the familiar starfish, sea urchins, sea biscuits, and the perhaps less familiar sea cucumbers, brittle stars, and sea lilies. They are exclusively marine and are mostly benthic. Over 5,300 species have been described. These are the only major group of invertebrates that are deuterostomic. They generally exhibit radial symmetry but it is secondarily derived; the larval forms are bilateral. There is an external skeleton composed of calcareous ossicles that may articulate with one another as in the brittle star, or fused together to form a rigid structure called a test.

Class Stelleroidea, Subclass Asterioidea

These are the starfish. The body has rays or arms coming from a central disc. Over 1,600 species have been described, and they are found throughout the world, mostly in coastal waters. The largest concentrations are found in the northwest Pacific. They are often drab in color but there may be brilliantly colored forms of red, orange, green, purple, and blue. Most starfish are pentamerous (five arms), but fewer or greater numbers are possible. The arms are not sharply set off from the central disk. This means that the arms increase in width the closer you

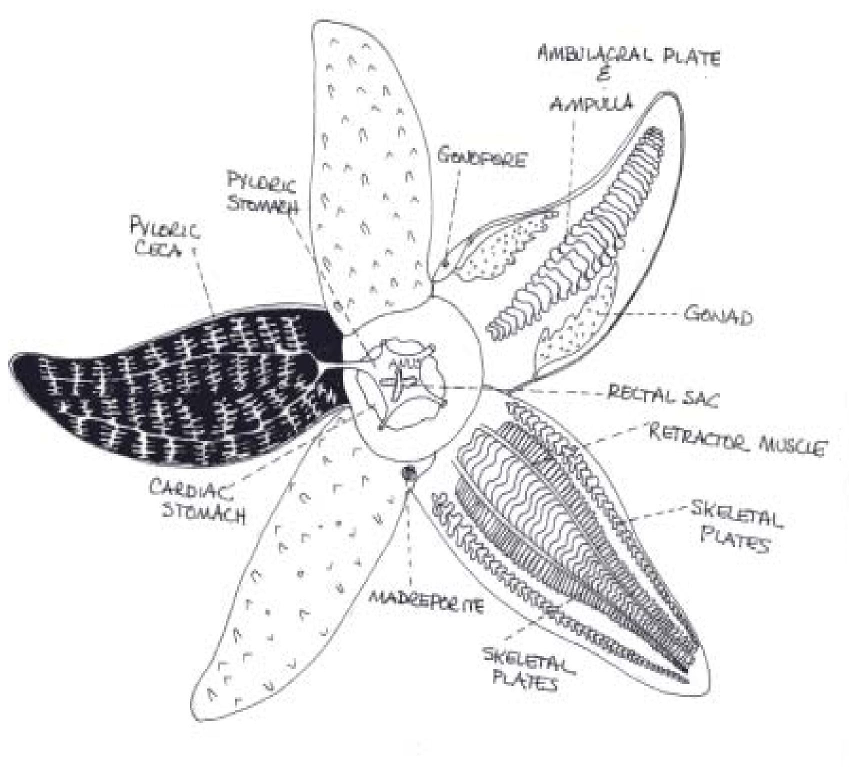

Figure 27. Starfish.

come to the base.

☐ Place the starfish provided with the mouth pointed upward (oral surface). You can tell the oral surface by the furrows that run the length of the arms (ambulacral grooves) on the oral surface. These ambulacral grooves contain two to four rows of tubular projections called tube feet. For what do you think the tube feet are used?

☐ Next locate the mouth. Do you see any teeth-like structures? At the tip of the arms are red pigment spots that serve as light detectors.

☐ Now place the animal on its aboral surface (the side opposite the mouth). Look for a stony disk located close to the base of the arms. This is the madreporite. The madreporite is part of the water vascular system in starfish and it serves as a sieve. It may be perforated by as many as 250 pores. It filters out of the sea water any debris. Water then enters the stone canal leading away from the madreporite (internal) and leads to the ring canal. The ring canal has leading off it to each arm radial canals. Each radial canal has numerous lateral canals that lead to tube feet. Associated with the ring canal are Polian vesicles and Tiedemann's bodies. The Polian vesicles store excess water and allow for water regulation. The Tiedemann's body produce coelomocytes. Water flows into the madreporite and then into the stone canal, then the ring, radial and lateral canal. Water then flows into the ampulla (bulb structure) of the tube feet. When water pushes into the tube feet from contraction of the ampulla, the tube foot extends. To retract the tube foot, water is pulled back into the ampulla and may go as far as the Polian vesicles. The entire system works like a hydraulic system.

Starfish and other members of this phylum have the epidermis of the animal modified into several structures. First are finger-like projections called papillae. These are thought to have a role in gas exchange. Additionally, this phylum often has jaw-like structures called pedicellariae. Pedicellariae are used to collect food particles that land on the surface of the animal, used to clear the animal of debris, and perhaps in a protective role. The number of jaws varies from two to three, depending upon the species, and the pedicellariae may be either stalked or sessile. Stalked forms are more common.

☐ Select one arm of the starfish. Insert the tip of a pair of scissors at the very end of the arm. Make a cut along the side of the arm. Continue to snip along the side of the arm toward the base of the disk. Cut along the other side of the arm, also to the basal disk. Cut up into the basal disk on both sides and remove the top flap of the arm.

☐ Look for the pair of digestive cecae on either side of the arms. Once food enters the stomach, it is passed to the digestive cecae where it is absorbed.

☐ Remove the digestive cecae or flip them back out of the way. Now look for the paired gonads just at the base of the disk. It is impossible to tell from this view whether the starfish is male or female.

☐ Look for the ambulacral plate which runs the length of the arm. It is composed of numerous interlocking bones or ossicles. Look to either side of the ambulacral plate and notice the ampulla of the tube feet. When the ampulla contract, the tube foot extends. When it relaxes, the tube foot retracts.

Dispose of your dissection in the biohazard bag provided. Be sure to wash out the dissection tray and clean your dissection tools.