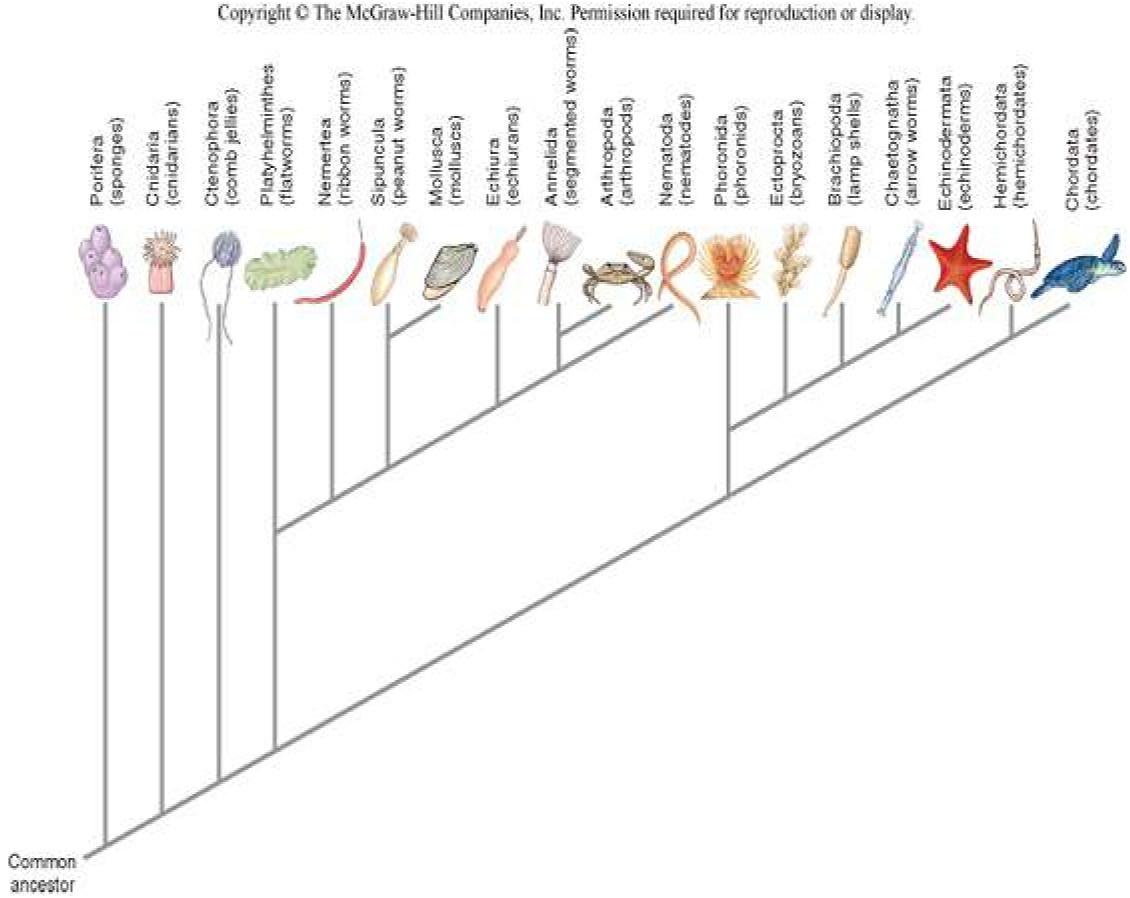
Marine Life: Life on the Benthos II

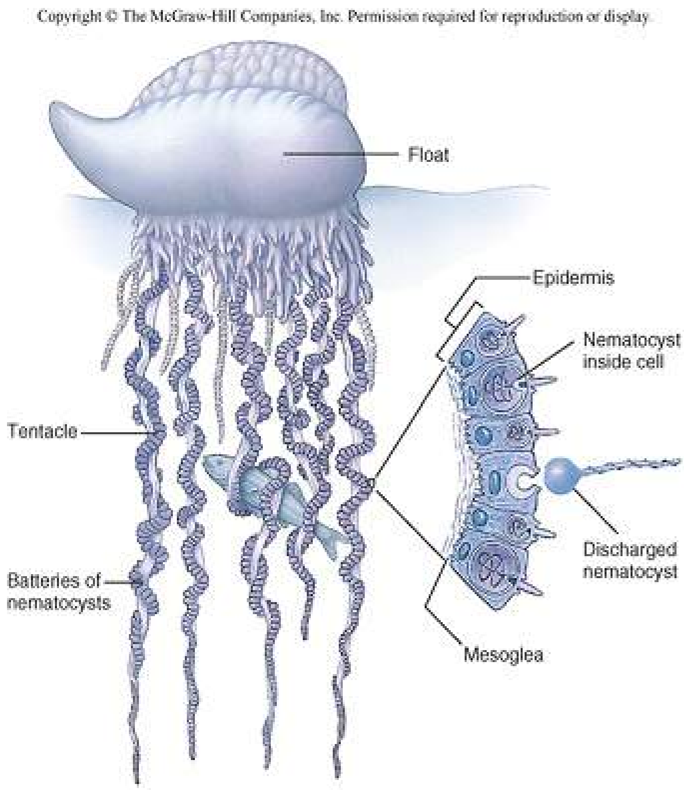


Evolutionary cladogram of the major marine taxa. The organisms are more complex and/or derived as you move from sponges to chordates.

Phylum Cnidaria Sea Jellies (NOT jellyfish), sea anemones, corals, hydra, etc. -

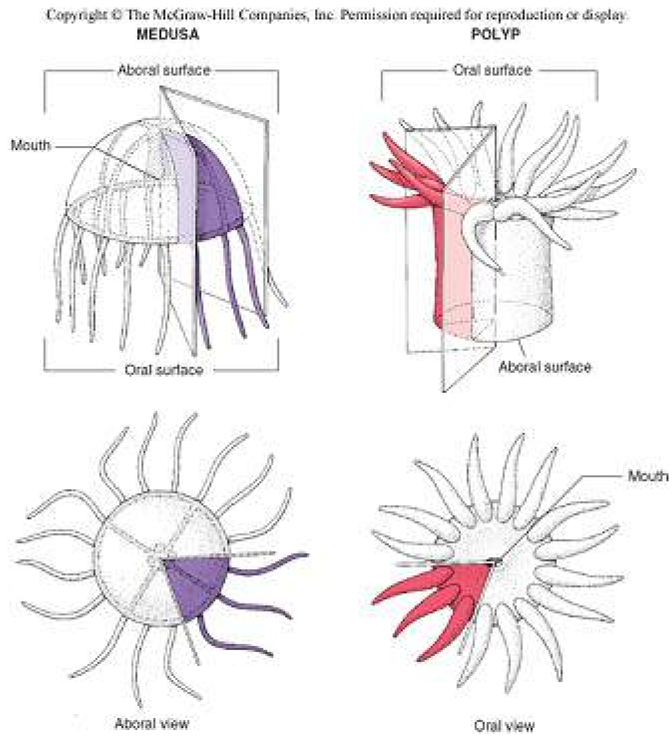
Key characteristics:

First major phylum with true tissue types. These organisms are *diploblastic* (2 true tissue types) that derive from the development of the embryo. The *ectoderm* has specialized cells for the outer covering or epidermis of the Cnidarian, but also the cells and tissues of the nervous system (called the nerve net). The *endoderm* are the tissues that make up the reproductive organs and the very simple blind sac-gut (digestive system). Cnidarians lack a true mesoderm tissue layer, but instead has a characteristic layer called the *mesoglea*. The mesoglea is a jelly-like substance that is a carbohydrate-protein complex and gives Cnidarians their easily identifiable "jelly'like" constitutions. Most Cnidarians also have specialized structures called *cnidils*. These structures, in turn, contain nematocysts. These are the stinging cells that are the identifying characteristic for the group.



The Portugese man-o-war (*Physalia spp*.), a holoplanktonic Cnidarian (Class Hydrozoa), with the nematocyst highlighted.

There are 3 important subgroups for the phylum Cnidaria. Class Hydrozoa, which includes the hydra and the sometimes dangerous Portuguese man-o-war. Class Scyphozoa, which includes all of the sea jellies (NOT jellyfish...), which are mostly planktonic, but many have benthic early life history stages. Class Anthozoa includes the sea anemones and corals which are all benthic. Some of these critters have planktonic larval stages, but the adult stage is benthic.



Cnidarians exhibit radial symmetry. Sea anemones and corals (polyp stage as adults, right) and sea jellies (medusa stage as adults, left). Radial symmetry is a simple body plan.

Each anemone is round, with a mouth in the middle. The mouth is surrounded by feeding tentacles that have stinging cells capable of capturing small crustaceans, fish and anything that happens to touch them that cannot get away. The tentacles feel sticky to humans, but we are only feeling their 'sticky' cells. The real stinging cells of the aggregating anemone cannot penetrate our hands so it is safe to touch them. But there are stinging cells that might irritate sensitive flesh so I always warn my students that 'kissing' anemones while entertaining for me, is generally not allowed.

Solitary Starburst Anemone (*Anthopleura sola*, above) showing radiating lines on the oral disk and feeding tentacles. Image courtesy Genny Anderson.

The aggregating anemone, *Anthopleura elegantissima*, dominates southern California rocky shorelines from sea level to 2.5 feet above sea level, not because it is a good competitor for space, but because the sea star has removed all mussels and most everything else with a shell (barnacles, snails, limpets). The sea star does not prefer to eat (or even touch) the anemones, so the anemones exist here without a predator and without any space competition with the shelled species.

Rock at Devereux Point spanning 2.5 feet. Top of rock is High Tide Zone, middle of rock to the water is Mid Tide Zone, tide is about zero (above). The aggregating anemones below the musseles to the water line. Image courtesy Genny Anderson.

Two and a half feet above sea level, the meeting of mussels and aggregating anemones (above). Image courtesy Genny Anderson.

Food that is gathered by the tentacles is pulled to the mouth where it is ingested and digested. They are very simple animals, without a complete digestive tract, and thus there is no anus (hence blind sac-gut). So, ingested material that is not digested (like shells and bones) must be regurgitated back out the mouth. Sounds rather unpleasant, but this explains why sometimes the tidepool anemones look like they are turning inside out. Wayward periwinkle snails, if they have toppled from their high perch, may be swallowed by these anemones, but the snail will usually keep its trap door operculum closed until the anemone tires of its presence. Then, when the anemone spits it out, the periwinkle snail starts its long trip back up the rock to its preferred (and safe) Splash Zone (more about the intertidal zone later).

This benthic species is one of the most exciting (to me) in the tidepools, not because of what it does while we are watching at low tide, but because of what it does at high tide. At high tide, this species can split down the middle, pull apart and reform, resulting in two identical (but smaller) individuals. Each of these divides repeatedly until there are hundreds of aggregating anemones, all crowded together (thus the name aggregating). Each animal in the group is genetically identical, a clone. It highlights a neat adaptation for Cnidarians in general, because they can reproduce both sexually and asexually.

Aggregating Anemone clone, lower half under water (open) and upper half above water (closed) pictured above. Image courtesy Genny Anderson.

The most exciting thing happens when two clones meet (this is the cool part!). Members of the same clone extend their tentacles at high tide and do not mind touching members of their own clone … but, should a member of another clone be touched, they fight until one moves or dies. There are special fighting tentacles (that are deflated and not visible until a clone war starts) tucked just under the regular tentacles and the outside of the body. These special fighting tentacles are called acrorhagi and during a clone war they are inflated. They look different than the regular tentacles, being shorter, rounder, and very white. These acrorhagi are fully illustrated later in this lesson when discussing the starburst anemone.

The clone war is a slow motion confrontation with the clonal adversaries stretching toward their enemy to touch the acrorhagi. The acrorhagi have nasty stinging cells that damage the tissue of whatever they touch. Back and forth for hours these anemone enemies fight until one moves or dies. This behavior leaves wonderfully obvious anemone-free areas in the Mid Tide Zone wherever two clones meet. We don't have to do DNA analysis to know there are two (or more) clones present on the intertidal rocks. Other critters may use these anemone-free areas to travel through the Mid Tide Zone. We would be able to witness similar activity over time with subtidal anemones and tropical corals.

Anemone free area between two aggregating anemone clones (above left), Close up of anemone free area (above right). Image courtesy Genny Anderson.

But wait! There's more. The aggregating anemone not only asexually reproduces to form clones, but once a year it releases eggs or sperm into the water as a broadcast spawner. Its planktonic larva is the source of the original anemone on the rocky shore that forms each clone. These anemones are separate-sexed so each clone is either all male or all female.

Before we get continue with our discussion of other invertebrate groups, you should be introduced to the starburst (or sunburst) anemone, *Anthopleura sola*. Closely related to the aggregating anemone, this species was given its own name only two years ago. Up until then it was known as a form of aggregating anemone that lived below sea level in Southern California and did not clone, remaining solitary. There is another solitary sea anemone that looks similar, called the giant green anemone (*Anthopleura xanthogrammica*) that lives intertidally in the cooler waters of Central and Northern California but it lacks the radiating lines on the oral disk and is generally not found in tidepools south of Point Conception, the major faunal break between cooler water environments to the north and warmer water environments in the south.

Open Starburst Anemone showing feeding tentacles (above left), Closed Starburst Anemone (above right). Images taken at low tide, courtesy Genny Anderson.

This anemone isn't sick, this starburst anemone regurgitating (turning inside out to remove undigested material in its stomach). This behavior happens for all Cnidarians. Image courtesy Genny Anderson.

Like the aggregating anemone, the starburst anemone also has fighting tentacles, called acrorhagi.

Starburst anemone with a few acrorhagi inflated (club shaped and white) on left (above).

It fights with its neighbors, using these acrorhagi, to remain a little more than tentacle distance apart. If two starburst anemones touch their feeding tentacles they inflate their acrorhagi (generally deflated and hidden between the feeding tentacles and the side of the anemone) and fight until one of them moves (not exactly a big draw for Pay-per-view).

Acrorhagi fully inflated on Starburst Anemone (above)

Thus they maintain even spacing in the Low Tide Zone. When tidepooling it is the starburst anemone that may often be caught in the middle of a fight, with its white, blunt acrorhagi inflated. As they fight (touching each other with their acrorhagi) the white areas of the acrorhagi become tattered. The white is a concentration of stinging cells and when touched, to an enemy, it will slough off - to keep on stinging the enemy again and again. Eventually one anemone moves away from the tentacle-reach of its neighbor to stop the fight.

Starburst Anemone war (just beginning) above left, Starburst anemone war after a few hours (tattered acrorhagi) above right. Keep in mind that these battles take hours. Images courtesy Genny Anderson.

Tattered acrorhagi of Starburst Anemone (above). Image courtesy Genny Anderson.

It is interesting to look at the different color patterns on the tentacles and oral disks of these starburst anemones. The various shades of green come from a combination of the natural color of the anemone and from green-colored symbiotic algae that grow in their tissues. This symbiotic algae is a species algae called zooxanthellae. These are a specialized type of dinoflagellate found in the tissue of many corals, a few species of clam, and some anemones. Anemones found under rocks or in the shade have little symbiotic algae so are generally very pale. The various striping on their tentacles is genetic and serves to show how each is unique (unlike the clones of aggregating anemones where each clone member is identical).

Green starburst snemone (from symbiotic algae) above left, white starburst anemone (in the shade) above right. Images courtesy Genny Anderson.

There is also variation with in populations of these anemones (as well as with other organisms).

Starburst anemone with yellow striped tentacles (above left), starburst anemone with white spotted tentacles (above right), and other variation occur as well. Images courtesy Genny Anderson.

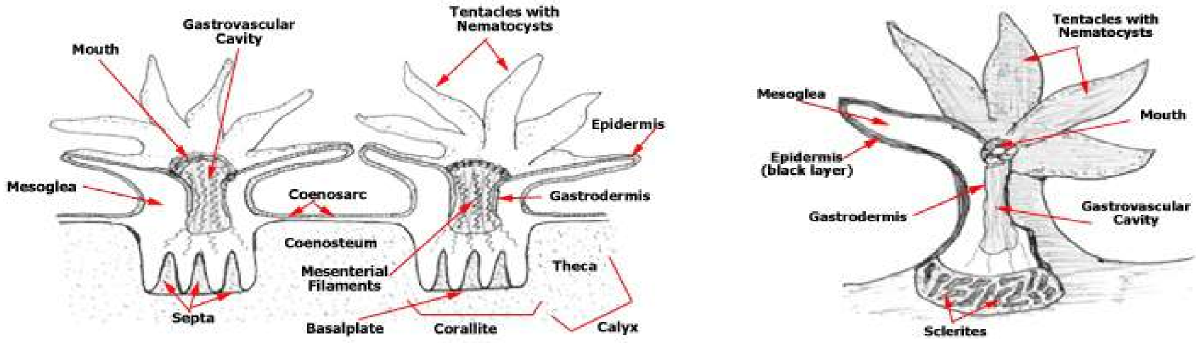
Back to symbiosis for a second. Symbiosis reinforces the observation that organisms cannot, will not, do not live in isolation. Living things need other living things, either directly or indirectly, for their survival. Symbiosis can be defined as organisms that live in very close association. Included here would be organisms that live right next others, on other organisms, or in other organisms. These relationships may simple or complex, and may involve more than two unrelated species. Symbiosis may also be very general (like the flea that may suck your blood, as well as your dog or cat), or species specific (zooxantellae and coral). There are three major forms

of symbiosis we will consider:
Mutualism - occurs when both species in the association benefit from the association.

Commensalism - occurs when one organism benefits from the relationship, and the other is unaffected (does not benefit or is not harmed).

Parasitism - oocurs when one organism benefits at the expense of another organism. This may be the most complex of all symbiotic relationships. There are many examples of species specific parasite-host relationships (more about all of these as we continue).

Gorgonians are soft corals found in temperate and tropical seas. An animal like this one is made-up of 1,000's of polyps.



Anatomy of a hard coral (left) and a soft coral (right). Both are colonial and may host symbiotic zooxanthellae.

Corals reproduce asexually like the anemones and sexually. Many tropical hard corals will synchronously release gametes into the water column (this is a great example of *broadcast spawning*). Remember that the coral colonies are either male or female. A combination abiotic (environmental) factors are cues for this spectacular release.

Coral broadcast spawning. Coral 'smoking', left as the colony releases sperm. Eggs being released by the coral colony on the right.

Fertilization, which is possibly aided by sperm attractants (biochemical compounds to increase fertilization success), produces planulae larvae that are able to free-swim by day two. The larval stage of coral (and some of the other Cnidarians) are planktonic and may spend considerable time in the water column. Now, in the grasp of tides and currents, the tiny new coral embarks on a grand voyage that can last for months and carry it hundreds of miles from its origin. If the speck of life somehow survives the ever-hungry mouths of plankton-pickers, filter-feeders, and jelly plankton, it will one day mysteriously sense suitable hard substrate below, settle (this process is called recruitment), and begin producing a tiny calcium skeleton – the genesis of a great coral colony that could live for hundreds of years. Millions of larvae must be produced to insure the survival of the species because most larvae will not survive.

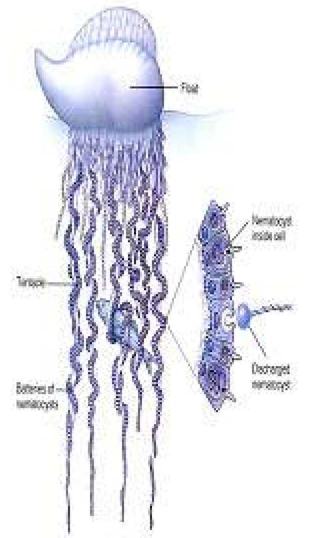


FIGURE 6.7 A diagrammatic representation of the Portuguese man-of-war (Physalia physalis). It consists of a colony of specialized polyps, one of which forms a gas-filled float that may reach 30 cm (12 in) in length. The long tentacles, here contracted, are armed with nematocysts notorious for their ability to sting swimmers.

Two representatives of the class Hydrozoa. The colonial hydrozoan *Macrorhynchia phillipina* is a small, feather-like cnidarian found in warm and a few temperate habitats (left). *Physalia physalis* is a surface dwelling hydrozoan. The different parts of the animal are specific colonies with specific functions. For example, the float polyps keep the man-o-war at the surface, and there are defensive, reproductive, and digestive polyps too.

Phylum Ctenophora (pronounced "Teen-á-for-a") - Comb jellies

Comb jellies are not benthic organisms, but holoplanktonic representatives of the gelatinous zooplankton community. They are presented here because they are closely related to cnidarians. Like cnidarians, they are diplobastic having an endoderm and ectoderm, but lacks the mesoderm layer. Like the cnidarians, ctenophores lack a true mesoderm, but instead has meoglea.

The comb jellies differ in some important ways. First, they lack cnidils with nematocysts. Instead, these organisms have structures called *colloblasts*. These are 'sticky' cells which help comb jellies capture prey, and are not used for defense. Ctenophores also have eight ciliated comb rows (called ctene, pronounced "teeny") that help these critters move through the water column (but never independent of the major currents).

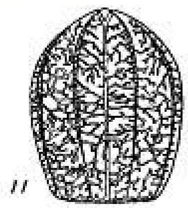
The major subgroups in the phylum Ctenophora is based largely on whether or not the comb jelly has tentacles. Sometimes comb jellies are called 'sea grapes', and while most species are small a few can be very large.

B. Ctenophores (Phylum Ctenophora)

- 8 comb rows of cilia

Pleurobrachia - feeding w/ colloblasts

Boroe - voracious predator - engulfs prey



Top (above, A below) represents Class Tentaculata. They trap prey with colloblasts. Bottom (above, B below) is a representative of the Class Nuda. They lack tentacles and engulf prey. Some species grow ver large.

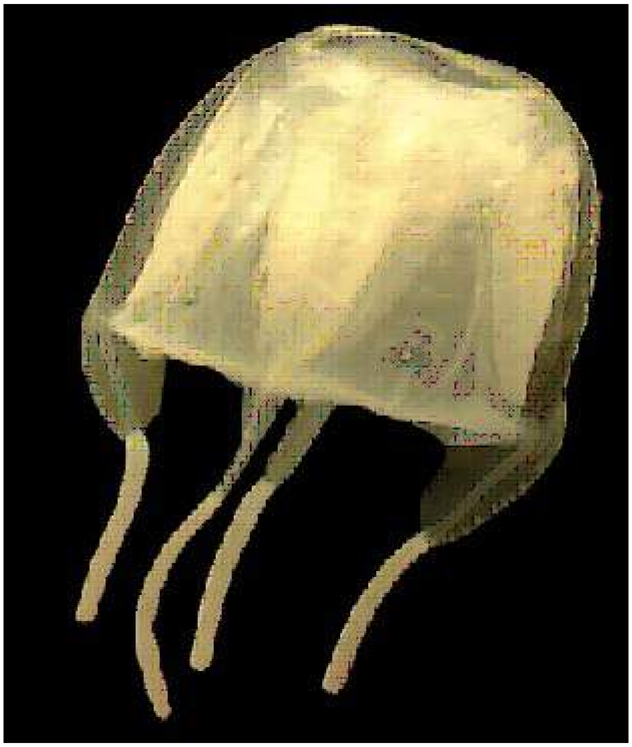
A

B

Some comb jellies are not shaped like those on the previous page, but unusual and stunning!

Venus' girdle, Cestum veneris, is a comb jelly found in the mesopelagic realm (500 - 1000 m) in oceans around the world. They may grow to 2 m in length, and trap planktonic organisms for food. If you look carefully, you can see the eight ciliated comb rows (ctene).

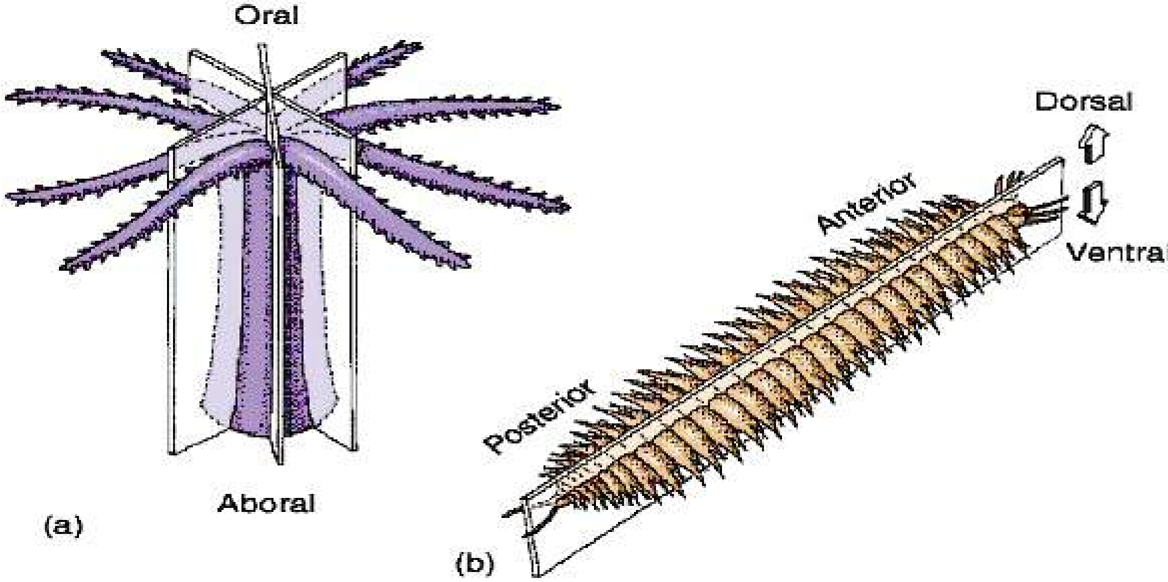
The real reason I presented the comb jellies is talk about a well known and infamous group called the box jellies. The used to be grouped with the Ctenophora, but most biologists group them with the cnidarians. In general, the cubomedusae release more powerful toxins than other jellies (they are responsible for numerous injuries and few deaths around Australia and Southeast Asia every year. A few species have well developed 'eyes' and pursue prey. Like the sea wasp (*Chironex fleckeri*), the irukanji (*Carukia barnesi*) has been responsible fr more deaths, but is much smaller and found in deeper waters. On shore wind and currents cause these jellies to move into shallower environments where people recreate. Antivenin (antivenom) has been produced and is usually administered by the first responders (usually lifeguards). The stings from either species is extremely painful, and frequently, the survivors are left scarred.



The box jelly *Chironex fleckeri*, left, and the irukanji (*Carukia barnesi*) above right. The smallest sea jelly is also reportly the most venomous animal in the world.

Something to think about as we continue. Why do the cnidarians and their relatives produce venom? It is possible that the mechanisms were in place for competitive purposes (recall the battling sea anemones), and that for some cnidarians, these systems were enhanced through time.

The first animal phylum we discussed (Porifera) has mostly asymmetrical representatives (with a few exceptions), and all lack true tissues. The animals I the phyla Cnidaria and Ctenophora are diploblastic (having 2 true tissue types) and all exhibit radial symmetry. The next step in evolution will mean a fundamental change in the body plan (or *bauplan*) of living things. The next few groups of organisms exhibit bilateral symmetry. Critters that exhibit bilateral symmetry may be divided along a single plane to get two identical halves. This body plan allowed for the development of the head and brain, as well as the central nervous system. Moreover the dorsal (back) and ventral (belly) surfaces are different. The change in symmetry allowed for great changes in animal life, helping to maximize diversity.



The differences between radial symmetry (A) and bilateral symmetry (B).

Phylum Platyhelminthes - flatworms

Flatworms are the simplest bilaterally symmetrical critters. They are called flatworms, because they are dorsoventrally flattened. They are also the simplest animals where the tissues are organized into true organs and organs and organ systems. So flatworms have a true brain (not a nerve net) and a light sensitive 'eye spot' and also a mesoderm. This tissue layer in embryos' give rise to musculature, reproductive system, etc. Some flatworms are free living (not parasitic) and are carnivorous. Most of these exhibit negative photo-taxis. When exposed to light, they move toward the dark (they have 1,000's of cilia that beat in coordinated waves on the ventral surface of the worm). Most of these belong to the Class Turbellaria.

(a)

Flatworms have remarkable powers of regeneration and can regrow lost parts. If divided in half in the middle of the 'eye-spot', one worm can become two at the completion of the division. Some flatworms are hermaphroditic. Some hermaphrodites have fully functional male and female gonads. Others start life as one gender, then switch to the opposite gender. A trick these animals can do only once (more later).

(b)

Free living flatworms in a mating ritual called 'penis fencing'(no, I'm not making this up...). They compete and one worm tries to penetrate the skin of the other with its needle like penis t inject its sperm. The first to succeed wins! The loser, has to heal and develop eggs (better luck next time).

Flatworms in the class Trematoda include all of the flukes, which are parasitic flatworms. There are over 6,000 species of fluke and most have extremely complex life histories. Flukes may occur in species specific hosts and are common in fishes, sea birds, and whales.

Flatworms in the class Cestoda are all parasitic tapeworms. They have long bodies that consist of one unit that has suckers, hooks, or a combination to stay attached to the intestinal wall of the host. Tapeworms lack a mouth and a gut, so absorb nutrients through the body wall (which is also surrounded by a cuticle). Like the flukes, tapeworms are species specific with respect to host, and their life histories may be amazingly complex. The longest tapeworms appear to be found in sperm whales (lengths to 15 m long). Tapeworms in humans may be up to 3 meters or so in length (aaaaaghhhh!).

Eye flukes in a flatfish (left, yes I said in the eye of a live flatfish!) , and a tapeworm removed from a minnow (below). Note the size of the tapeworm relative to the host! For additional images, do a Google image search for tapeworms and fluke (amaze your friends and neighbors!).

The above images are one of the reason why marine biology has always fascinated and occasionally grossed me out at the same time! Both the flukes and tapeworms reproduce sexually. Moreover, reproduction is directly related to the distribution of intermediate and final host for these organisms, making things extremely complex.

Phylum Nemertea - ribbon worms

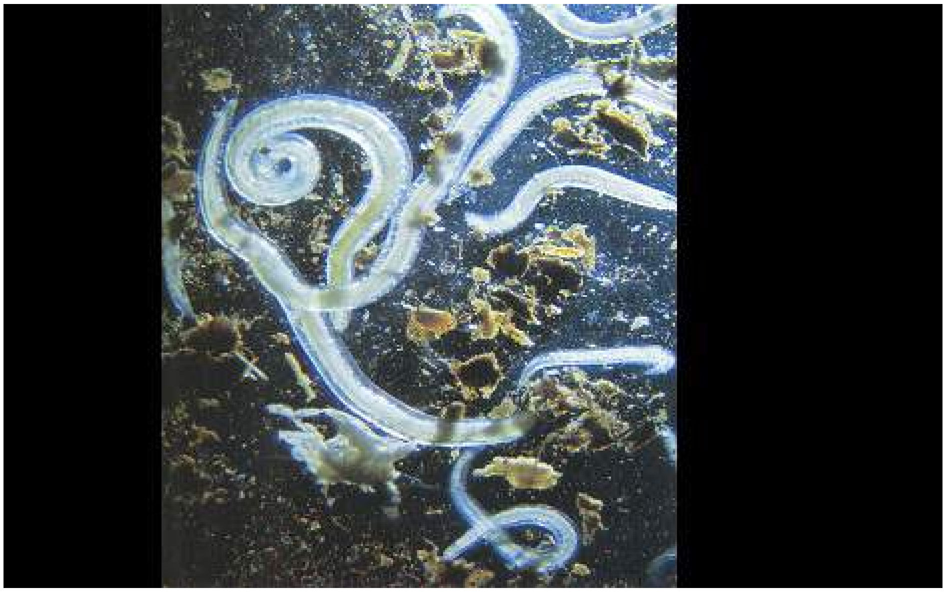
We could spend most of the semester discussing worm groups. They are abundant and ecologically important. We are only covering the major ones or the minor groups with important evolutionary significance. This is one such group. In the old days when I was first introduced to this group, it was called Rhynchocoela, referring to the cavity in the head of these worms. The present name reflects the significant differences between this group and the Platyhelminthes. Ribbon worms have a complete digestive tract (mouth, gut, and anus). They also have a circulatory system, and a proboscis which is used to capture prey (usually worms and crustaceans). This group is almost exclusively marine with most of the about 900 species occur in oceans worldwide. These worms are very elastic and the proboscis may extend a meter or more beyond the body, with one species reaching a length of 30 meters.

A ribbon worm found at low tide. These unsegmented worms demonstrate more complex organization that flatworms. There is a great illustration in your text in chapter 7.

Phylum Nematoda - the roundworms

The roundworms are rarely seen, but they are the most numerous (and possibly the most diverse, more so than the insects, stay tuned) organisms on the planet. Roundworms can be found in just about every habitat you can imagine, form salt ponds, hot springs, polar ice caps, deep sea hydrothermal vents, to a whole host of tissues in other organisms. The are mostly small and are sexually dimorphic. The females are much larger, and the males are "J" shaped in the posterior end. The evolutionary advances over the ribbon and flat worms include a hydrostatic skeleton, and a complete digestive system that occurs within the body cavity. Longitudinal muscle lines the cavity and allows for limited movement (most roundworms can whip back and forth), and pushes against the fluid making up the hydrostatic skeleton.

The exact number of species is subject to debate, with new species being described every year. Estimates range from 10,000 to over 25,000, but some biologists believe there may be as many as 500,000 undiscovered species (wow). Most of the known nematodes are parasitic and they too have very complex life cycles like the flukes and tapeworms. Use caution when consuming raw seafood like *sashimi* and *ceviche*, because nematode parasite early life history stages may be present (only go to trusted sources, not Bob' Sushi Mart).

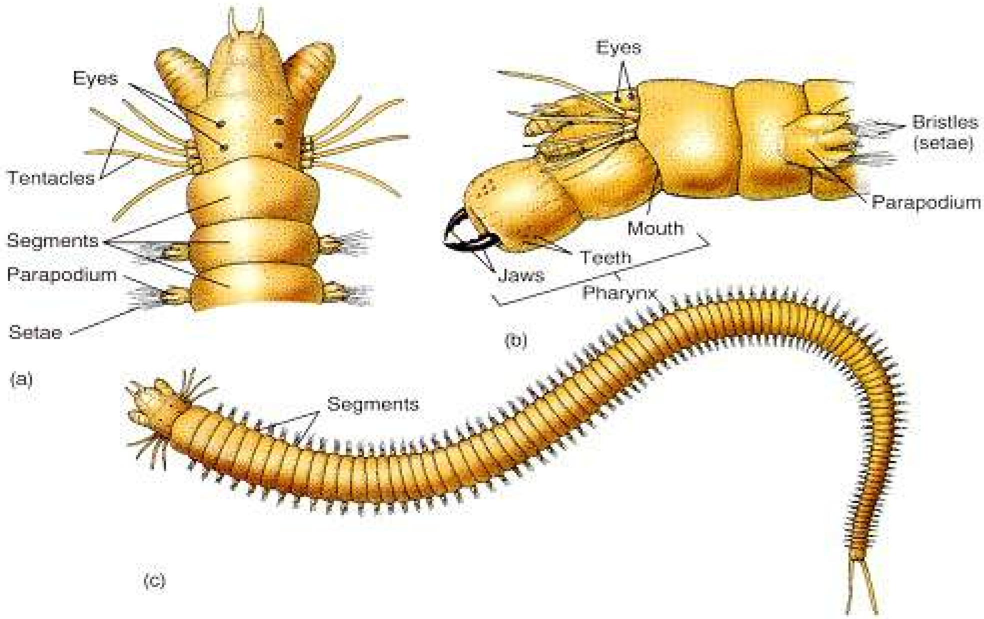


One of the few species of free-living roundworm. Roundworms can be very abundant in the organic rich sediments of the world oceans at all depths, salinity, and temperatures.

Phylum Annelida - segmented worms

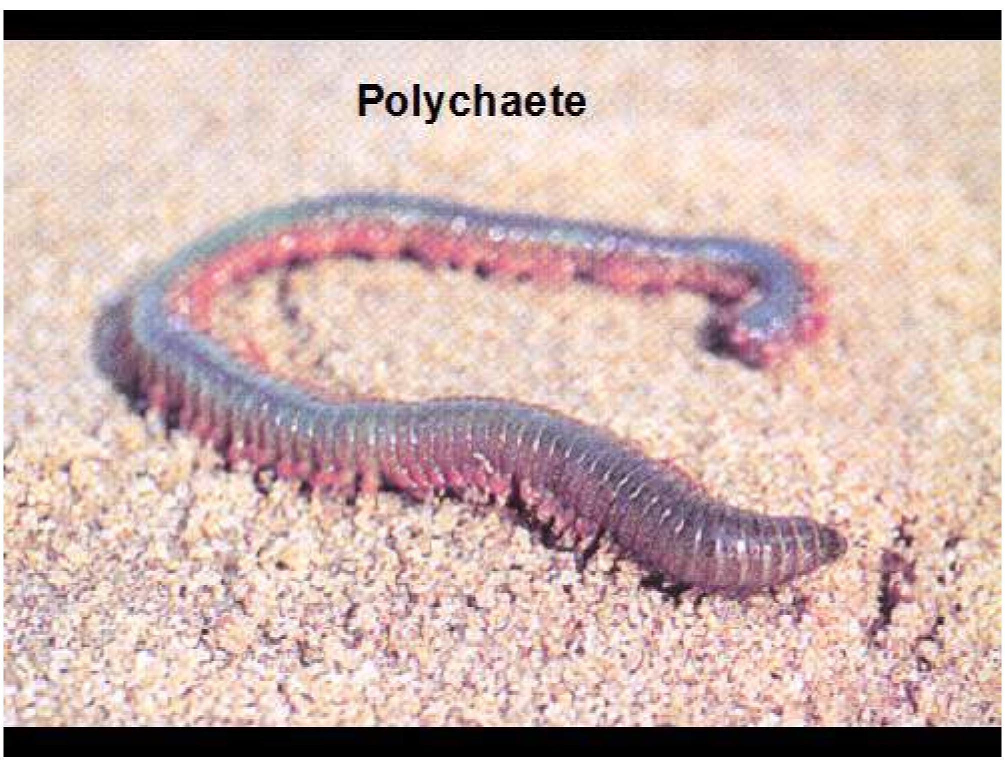
There are maybe 20,000 species of segmented worms, which include earthworms, and many species of marine worm, some of which construct tubes. Segmentation is an evolutionary advance that would lead to more complex developments. The segments can be clearly seen as rings on the body. Unlike the other worm groups covered thus far, this group has a true coelom (body cavity), and is surrounded by a different type of tissue that is derived from the mesoderm. Unlike the roundworms, each segment has longitudinal and circular muscles that allow for more controlled movement.

There are three major subgroups based an morphological (and ecological differences) between them. Segmented worms in the class Polychaeta are very distinct. Each segment has a pair of parapodia that aid in locomotion. There are bristles called setae on each of the parapods. Loosely translated, polychaete means many setae. Some polychaete worms have pronounced setae, they may be heavy for burrowing, they may be easily shed and cause any organism (including us) pain, or they may be modified for building and living in tubes. There are about 10,000 species in this class. Some of these worms are carnivorous, others are deposit or suspension (filter) feeders if they are tube-dwelling. All are sexual reproducers, and most have planktonic larval stages. The trochophore larval stage occurs in this group and a couple of others (strongly suggesting a common evolutionary ancestor).



The external anatomy of the typical polychaete worm.

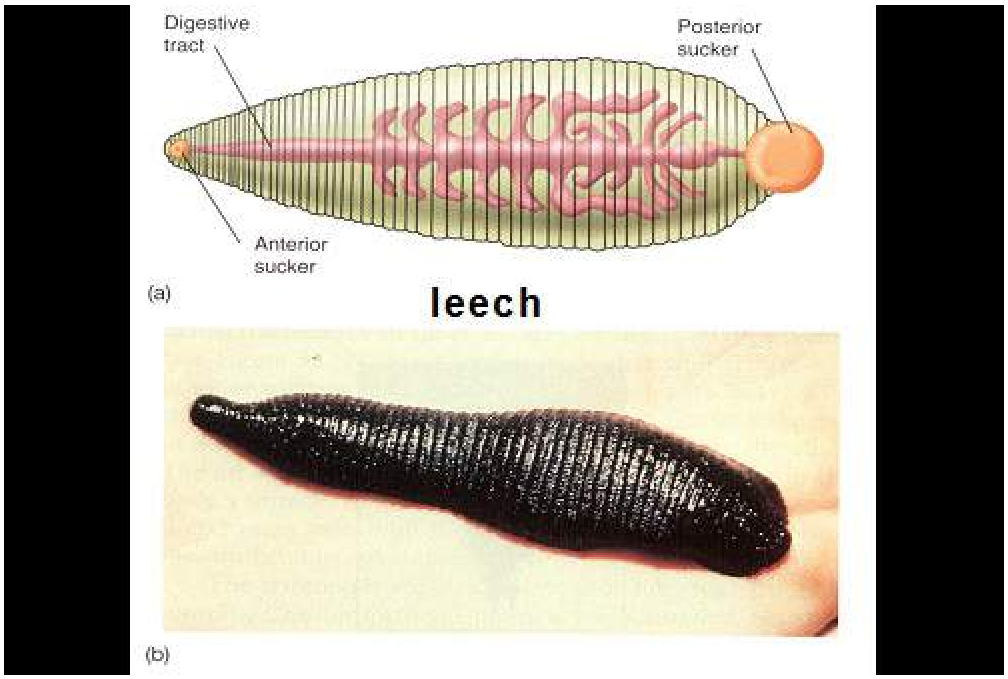
There are a few species of polychaete worm that are commensal with other organism, like those that live on sea stars ans sea urchins.



The sand polychaete worm, *Neresis spp*. These worms are a favorite bait of surf anglers and if they are not handled carefully, they can inflict a painful bite.

Class Oligochaeta includes the earthworms, night crawlers, etc. These worms are characterized with less obvious parapodia and fewer or shorter setae. Terrestrial and freshwater forms are familiar and important. Marine species tend to be smaller. All are important deposit feeders.

Segmented worms in the class Hirudinea make up the last group. While most leeches are found in freshwater environments, marine leeches can be very abundant and found on fish and invertebrates. Leeches have numerous adaptations that allow them to live off the body fluids of their host, but they are not vectors (carriers) of any known infections. This is one of the reasons why they are closely studied by scientists.



Leeches are segmented worms that are analogous to 'vampires'. Special enzymes in the saliva enhance blood flow, prevent clotting, and acts as an anesthetic. One species, *Hirudinea medicus*, is used regularly in major hospitals around the world.

We have covered a tremendous amount of information, but we are only half through our survey of major marine groups. We will tackle more of these in our next lecture section. I encourage you to investigate these groups. Time and page constraints do not allow for all of the detail these groups warrant.

Special note: This was saved as a *.pdf file. Each should be much easier to open, even on slower machines. If this works well, the rest of the documents this semester will be in the same format. Assignment #6 will follow soon.