Chapter 3: Phylum Cnidaria

Features of Cnidarians

Dimorphism

Most members of the Phylum Cnidaria exhibit two body forms (**dimorphism**), a **polyp** and a **medusa**. However, the polyp morph is more common, and each class of cnidarians contains members exhibiting this body form. In comparison, no members of the Class Anthozoa exhibit the medusa morph. Because the polyp body form is shared by almost all members of the Phylum Cnidaria, its anatomy will be discussed first.

A slide with a whole mount of ***Hydra***, a member of the Class Hydrozoa, will be used to investigate polyp anatomy (Fig. 2.1). *Hydra* can attach to the substrate by a **basal disc**, and this surface, because it is directly opposite of the surface containing the mouth, is referred to as **aboral** (**radial symmetry** anatomical position term).

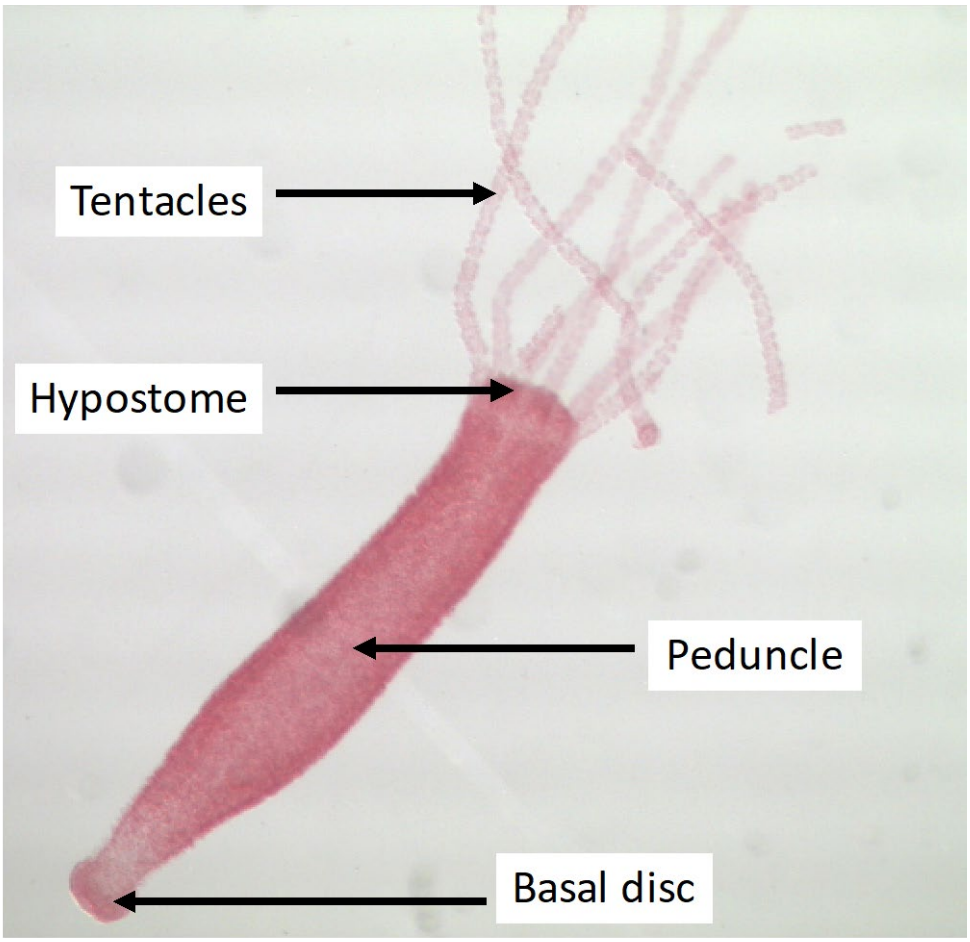

Figure 2.1. Micrograph of a whole mount of *Hydra*, with some important structures labeled.

The stalk, or stem, of the *Hydra* is called the column, or **peduncle**. It begins at the basal disc and extends to the bases of the tentacles. A cone-shaped section rests on the peduncle. The **tentacles** extend from the base of this cone. The cone is called the **hypostome,** and is at its apex is the **mouth**. The surface containing the mouth is referred to as **oral**.

As you observe the peduncle you will notice that the middle of it is lighter than the periphery. This difference in color is due to the presence of a cylindrical cavity, which occupies the interior of *Hydra*. The cavity is called the **gastrovascular cavity**. The only entry or exit into the gastrovascular cavity is the mouth, and thus this cavity is referred to as an **incomplete "digestive system."** Note, cnidarians are at the **tissue level** of organization, and as such, cannot have a true digestive system.

<u>Body wall</u>

All cnidarians possess a body wall that consists of three layers, the outer **epidermis**, the inner **gastrodermis**, and the **mesoglea** between them. In addition, the epidermis and gastrodermis contain varying cell types, which are unique to cnidarians. To study the three layers and the cells that make up the epidermis and gastrodermis, you will look at cross-sections (Fig. 2.2) and longitudinal sections of *Hydra*.

A cross-section of the body of a *Hydra* exhibits two layers of cells. The external layer is the **epidermis** (Figs. 2.2 and 2.3). It is one cell layer thick, and most of the cells are **epitheliomuscular** cells (Fig. 2.3), which appear rectangular. They have a nucleus bearing a conspicuous nucleolus. The other prominent cells in the epidermis are **cnidocytes,** and they are the feature that gives the name to the phylum. Cnidocytes contain organelles called **cnidae** (Fig. 2.3), which vary in their function. However, some cnidae (penetrants or **nematocysts**) contain a toxin, which allows the cells that contain them (stinging cells) to capture prey and defend against predation.

The surface of the epidermis is covered by a thin cuticle, which is very closely applied to the cell membranes. The basal portion of the cells rest on the **mesoglea** (Figs. 2.2 and 2.3). In *Hydra,* it is very thin, appearing as no more than a bounding line. It is non-cellular.

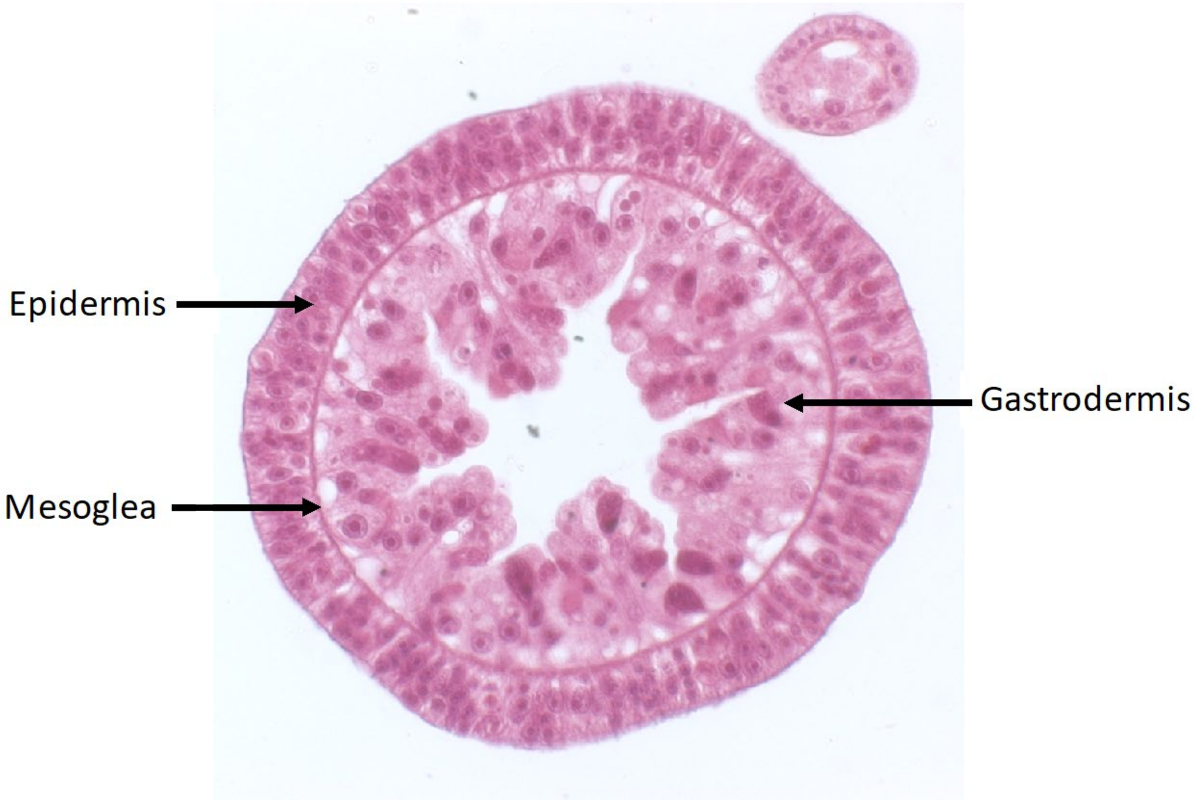

Figure 2.2. Micrograph of a cross-section of a *Hydra*, with the three layers of its body wall indicated.

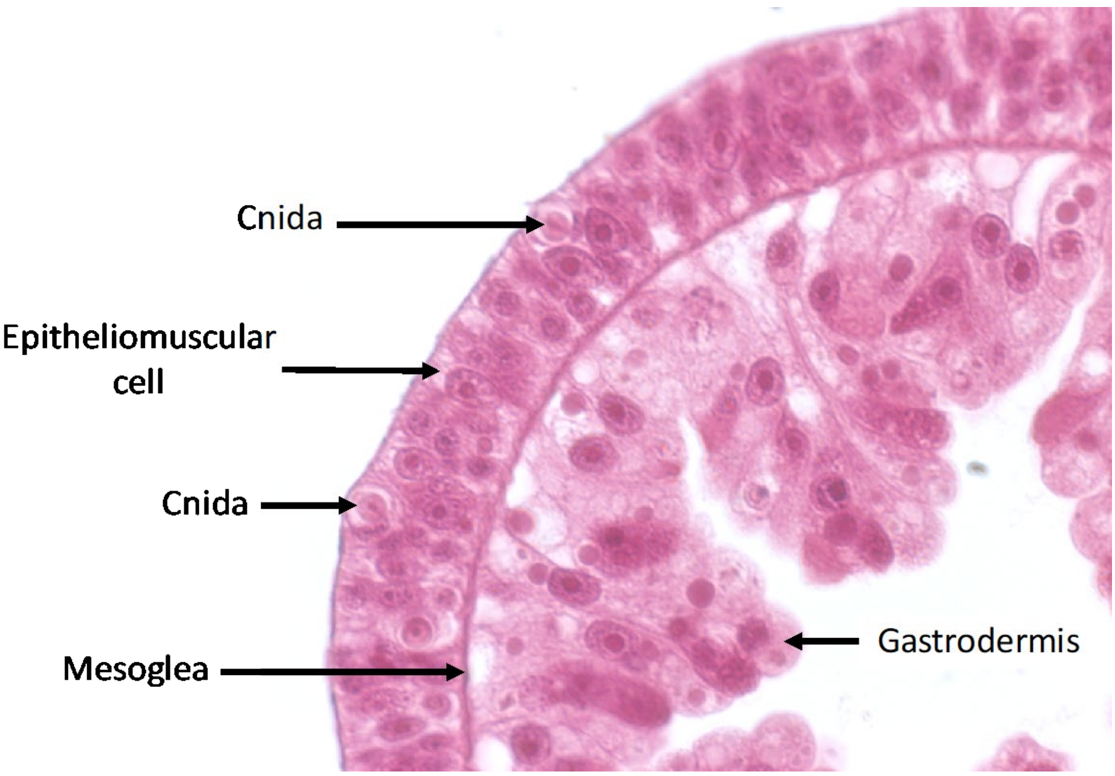

Figure 2.3. Micrograph of a cross-section of a *Hydra*, with cells and organelles in the epidermis, mesoglea, and gastrodermis labeled.

On the interior of the mesoglea is a second layer of cells, the **gastrodermis** (Figs. 2.2, 2.3, and 2.4). The two prominent types of cells in the gastrodermis are the **digestive cells** and the **glandular cells**. Both are large cells. The glandular cells are recognizable by numerous eosinophilic globules. The digestive cells do not have these globules, but may have vacuoles, which are not stained. Both cells have a small number of flagella projecting into the lumen (gastrovascular cavity or coelenteron) of the organism. The flagella have been altered too much to be visible in the preparations you have. Compare the external surface contour of the epidermis with the internal surface contour of the gastrodermis.

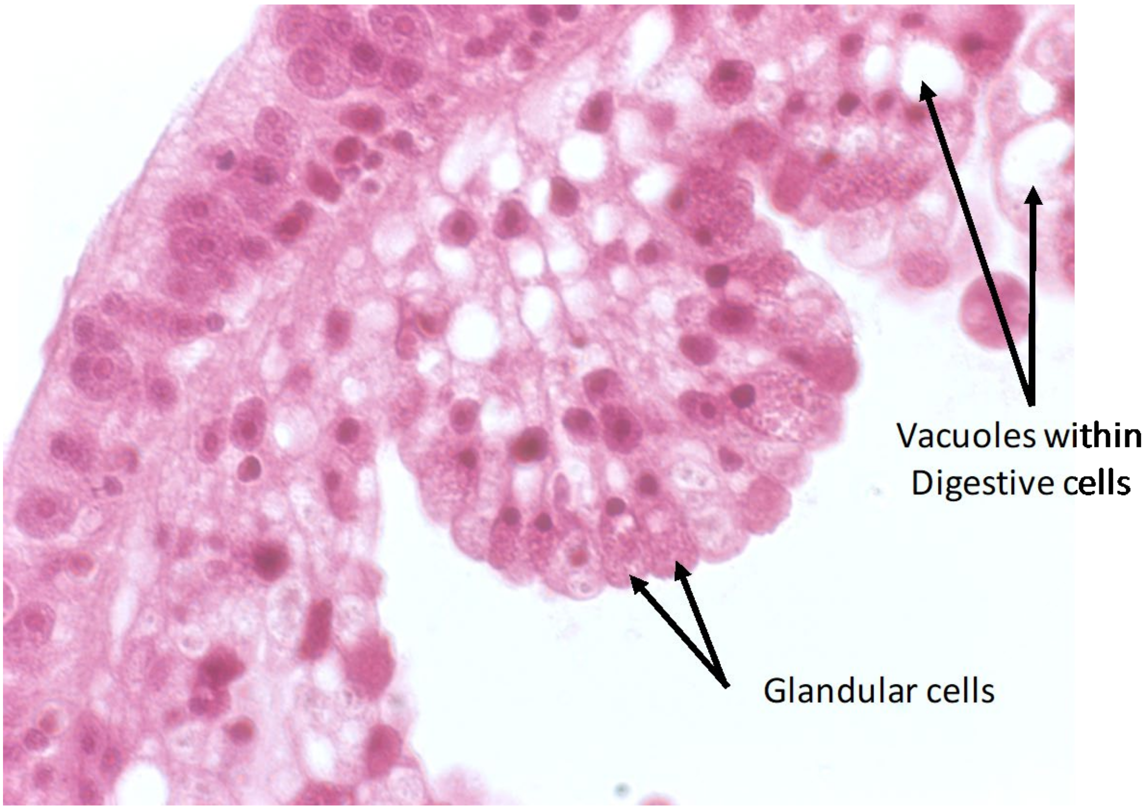

Figure 2.4. Micrograph of a cross-section of a Hydra, with cells and organelles in the gastrodermis indicated.

<u>Classes of Cnidarians</u>

Hydrozoa: ***Hydra, Obelia, Physalia***
Scyphozoa: ***Aurelia***
Anthozoa: ***Metridium***

Class Hydrozoa

Hydra, the organism that you have been investigating, is a member of the Class Hydrozoa. However, it does not exhibit the features that are distinctive for this class. Most hydrozoans are **colonial**, reproduce sexually in the **medusa** stage of their life cycle, and are marine. Hydra is **solitary**, undergoes sexual reproduction as a polyp, and lives in freshwater. Thus, to investigate the features of the organisms in Class Hydrozoa, we are going to switch our focus to ***Obelia*.**

Polyp/Hydroid stage

Look at a slide of the *Obelia* hydroid (Figs. 2.5, 2.6, 2.7, and 2.8). The stalk consists of a nonliving outer layer called the **perisarc,** which is secreted by and protects the inner living layer, the **coenosarc** (Fig. 2.5). Two types of zooids (functional polyps) arise from the stalk by **budding** (asexual reproduction). The **hydranth** (Figs. 2.5, 2.6, and 2.8) is the feeding polyp, and it resembles *Hydra*.

The other zooid is reproductive and is called the **gonangium** (Figs. 2.5, 2.7, and 2.8). On its stalk (**blastostyle**), there are many red rosette structures. These structures are **medusa buds**, which are produced asexually. They will eventually leave the gonangium through its **gonopore** and become free-swimming jellyfish.

In *Obelia*, the perisarc extends from the stalk to the zooids and creates a protective cup around each of them. The hydranth is surrounded by the **hydrotheca**, while the gonangium is surrounded by the **gonotheca**. The perisarc, hydrotheca, and gonotheca may be difficult to see on your specimen, because they tend to be clear. If you cannot see these layers, adjust the light level on your microscope by closing the diaphragm, which is controlled by a lever found below the stage.

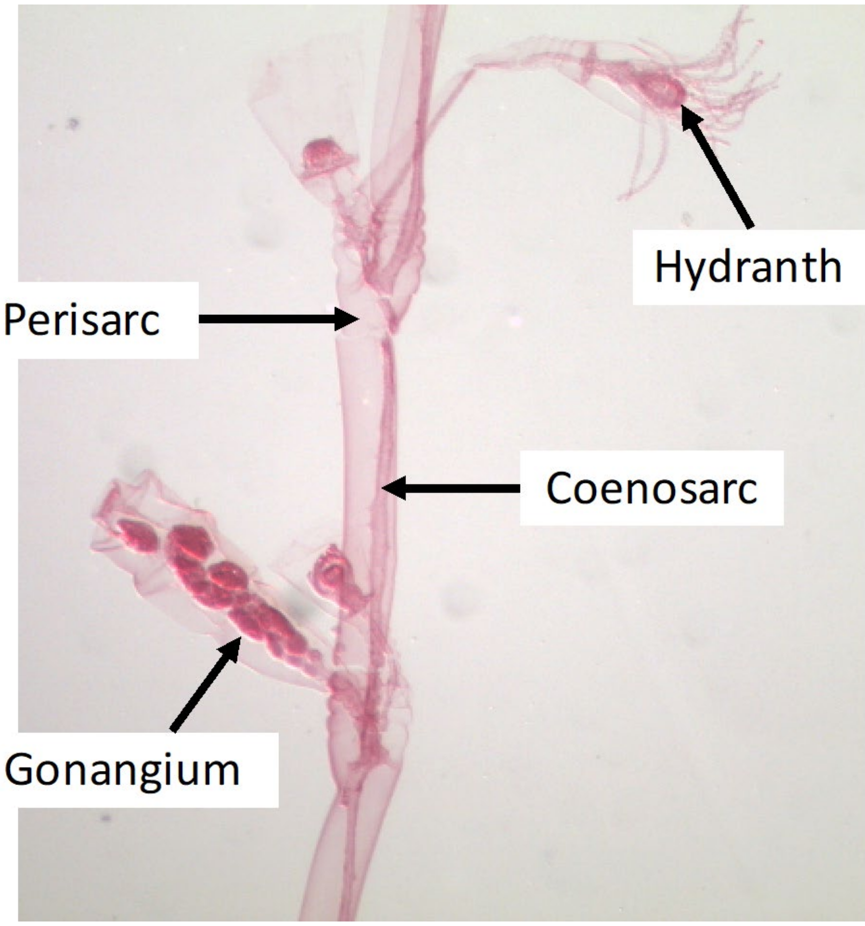

Figure 2.5. Labeled micrograph of a whole mount of an *Obelia* colony.

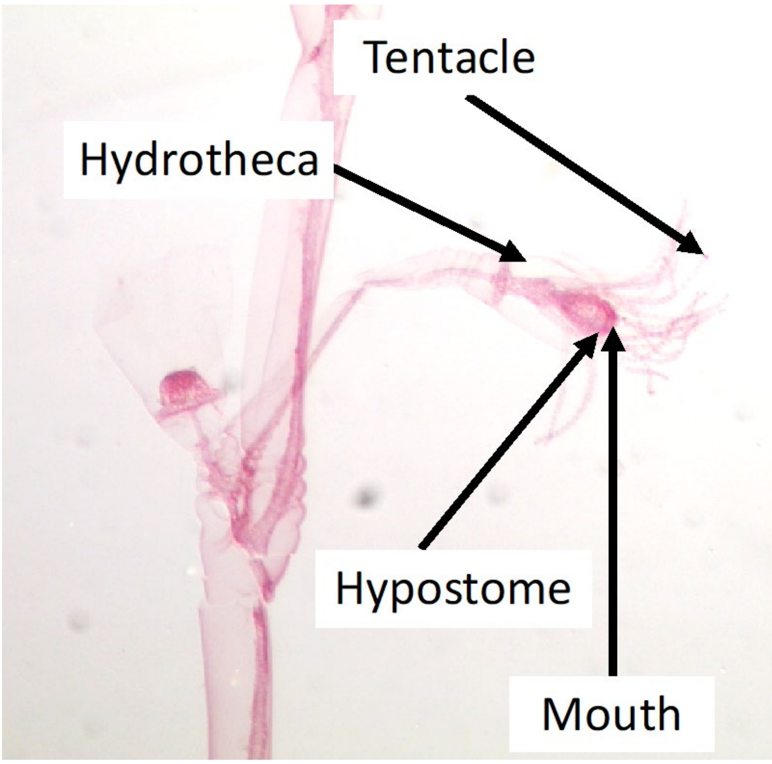

Figure 2.6. Labeled micrograph of a whole mount of an *Obelia* hydranth.

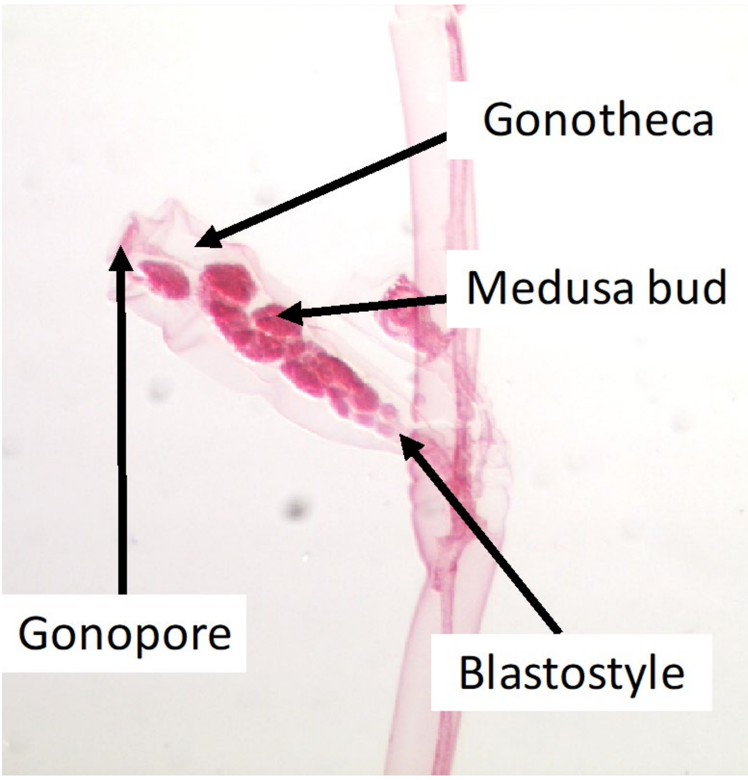

Figure 2.7. Labeled micrograph of a whole mount of an *Obelia* gonangium.

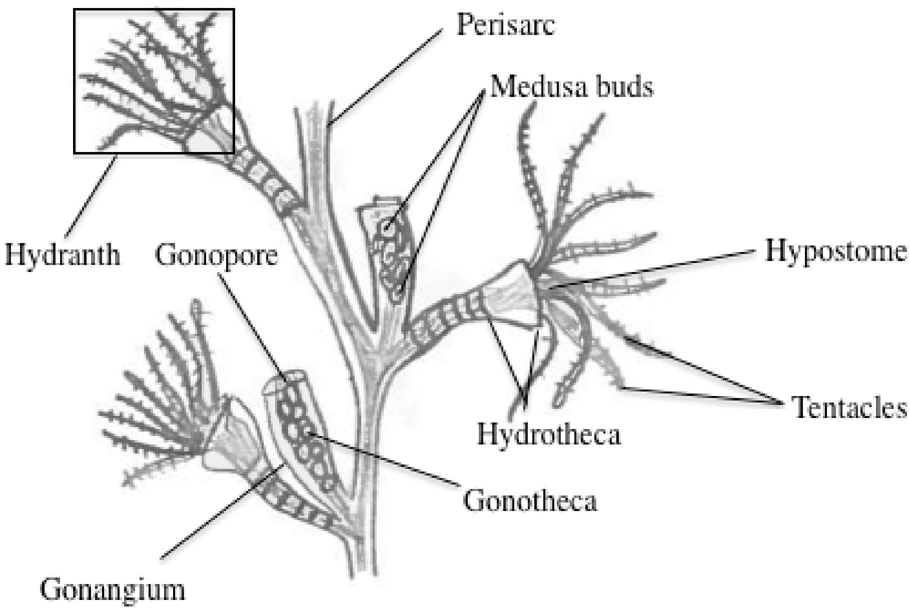

Figure 2.8. Diagram of an *Obelia* colony with important structures labeled.

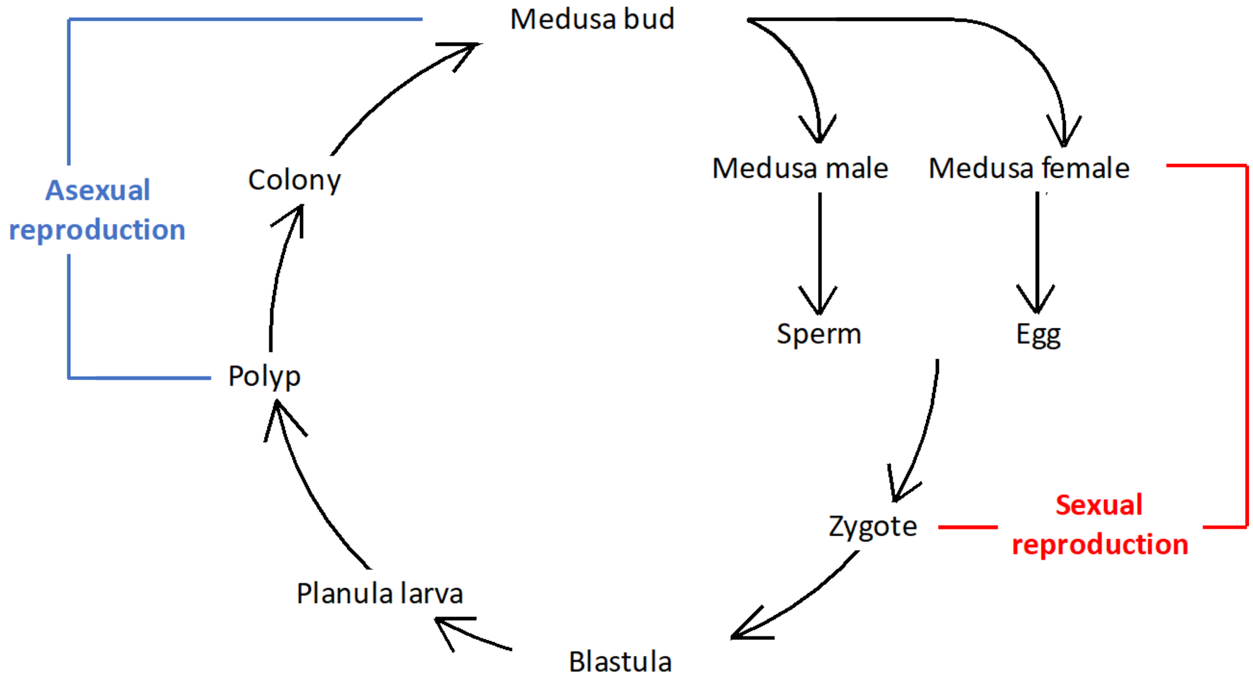

Figure 2.9. Word diagram of the life cycle of *Obelia*.

<u>Medusoid stage</u>

As mentioned above, most hydrozoans undergo sexual reproduction in the medusa stage of their life cycle (Fig. 2.9), and *Obelia* is no exception. The medusoid, or jellyfish, stage is topologically identical to the hydroid stage. The medusa differs from the hydroid in that it has more tentacles, is free swimming, and has a much thicker mesoglea.

Look at the slide of the *Obelia* medusoid (Figs. 2.10, 2.11, and 2.12). This species has a very small medusoid, but it shows the convex surface (**exumbrella**) and **subumbrella** (concave) surface. The projection from the middle of the subumbrella surface is called the **manubrium,** and like the hypostome of the hydroid, contains the **mouth** at its apex. Frequently, fixation of the specimen causes it to invert, making the manubrium project atypically from the convex surface like a handle (Fig. 2.10).

In an **oral** or **aboral** view, four canals can be seen radiating out from the central stomach. These structures are the **radial canals,** which connect the central **stomach** to a **ring canal** at the base of the tentacles. The radial canals, stomach, and ring canal are all part of the **gastrovascular cavity**. Single spherical objects are associated with each radial canal. These objects are the **gonads** (Figs. 2.10 and 2.11).

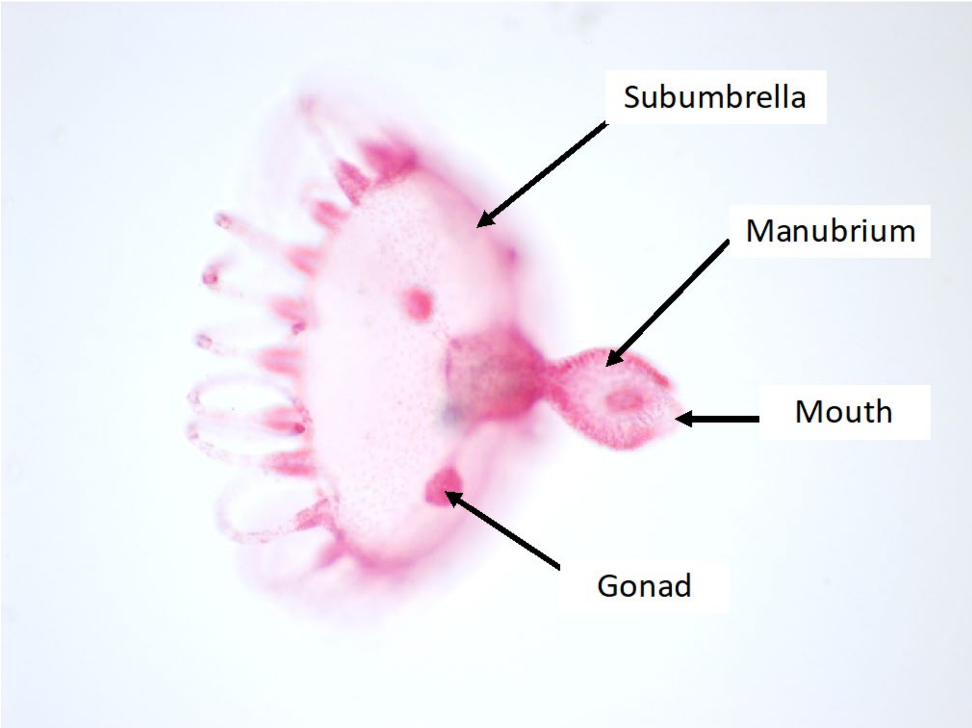

Figure 2.10. Labeled micrograph of a whole mount of an *Obelia* medusa (oral view).

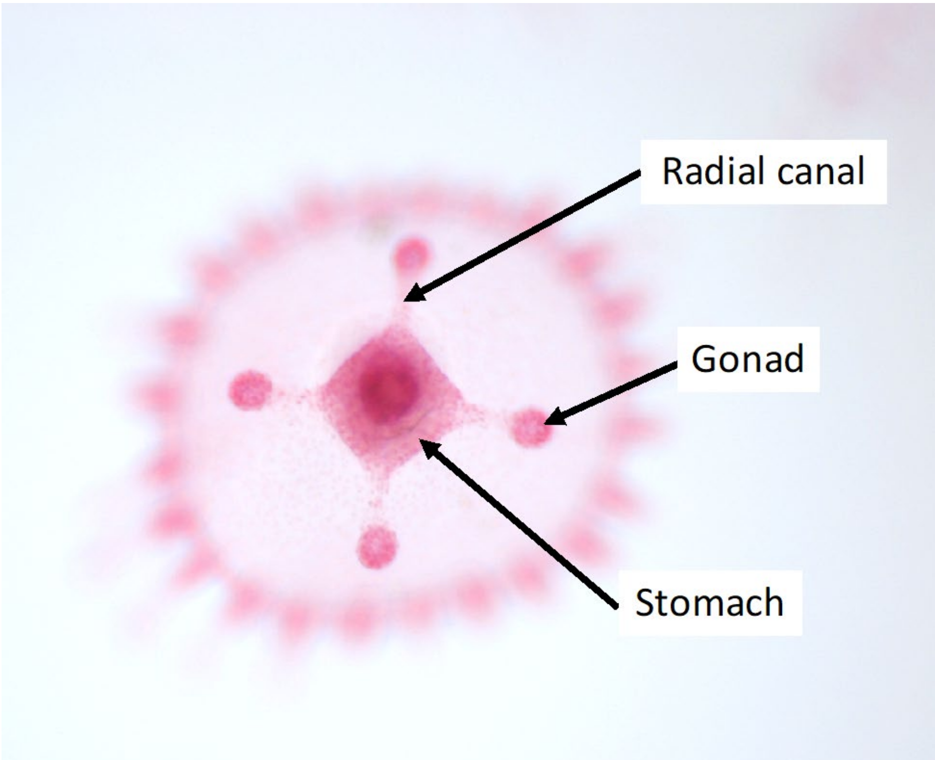

Figure 2.11. Labeled micrograph of a whole mount of an *Obelia* medusa (oral view).

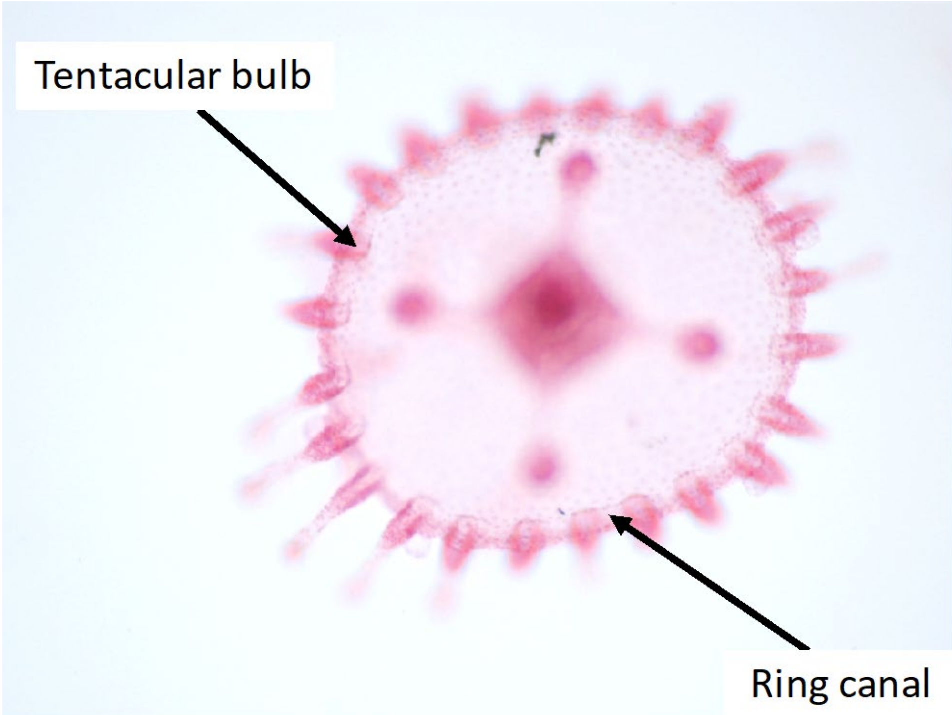

Figure 2.12. Labeled micrograph of a whole mount of an *Obelia* medusa (oral view).

To assist you with your study of hydrozoan jellyfish, a labeled diagram of *Gonionemus*, another member of Class Hydrozoa, has also been included (Fig. 2.13), and on it, you will notice another distinctive feature of these organisms that is difficult to see in our specimens. It is a membranous, shelf-like structure called a **velum**, which projects in (towards the manubrium) from the inner edge of the ring canal region.

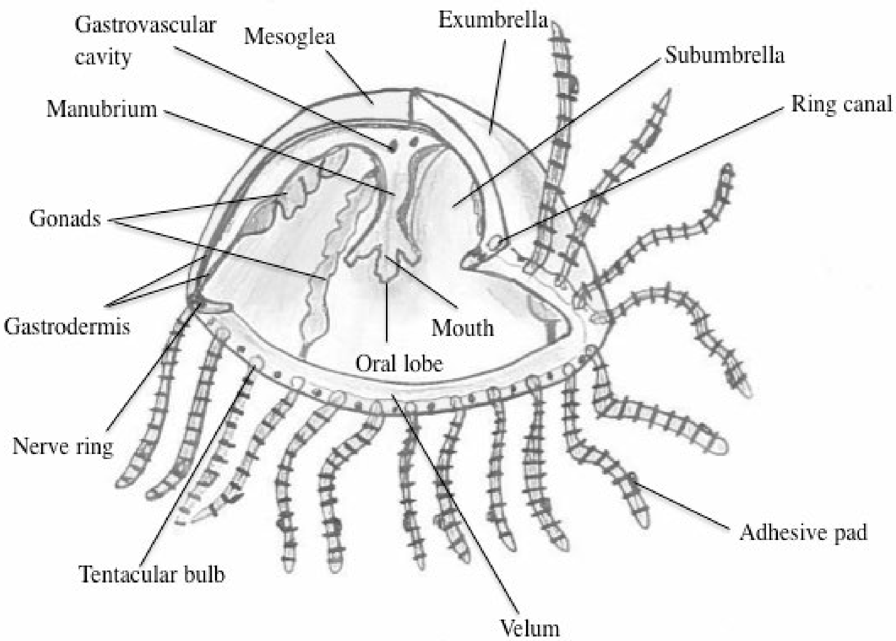

Figure 2.13. Diagram of *Gonionemus*, an example of a hydrozoan jellyfish.

<u>Class Hydrozoa</u>

<u>Siphonophore</u>

Although the Portuguese man-of-war (***Physalia***) appears to be a medusa, it is actually a colonial form, similar to *Obelia*. It has an air bladder (**pneumatophore**), which the colony uses to control its position within the water column. The long tentacles hanging from the base of the bladder are supplied with cnidocytes containing nematocysts. These tentacles are called **dactylozooids** and have the function of paralyzing prey. Immediately under the bladder are **gastrozooids**, which digest the prey and are numerous. **Gonophores** (reproductive zooids) and jelly zooids are also present. Thus, *Physalia* is a mixture of a hydroid and medusoid generation. Observe the specimens on display.

<u>Class Scyphozoa</u>

<u>Scyphozoan Jellyfish</u>

Anthozoans have no jellyfish stage. The large jellyfish, therefore, belong to the class Scyphozoa. In comparison to hydrozoan jellyfish, they do not have a velum, their gonads are positioned internally, and on average, they are much larger. ***Aurelia*** is an example of this class (Figs. 2.14, 2.15, 2.16, 2.17, and 2.18).

The tentacles of *Aurelia* are short (Fig. 2.14), and are arranged around the periphery of its bell, as in other medusae. However, short tentacles are not a distinctive feature of organisms in Class Scyphozoa. The manubrium is very short and perhaps absent. From the mouth region, there extend four long lobes called **oral arms,** which reach to the bell margin (Fig. 2.14).

The mouth leads into the stomach, which opens into four large cavities called **gastric pouches** (Fig. 2.15). When these structures are viewed together, they resemble a four-leaf clover. From these cavities, as well as from the stomach, **radial canals** extend to the **ring canal** at the bell margin. Thus, there are many radial canals, not just four, as with the hydrozoan medusa.

On the oral surface of the gastric pouches are dark staining, horseshoe-shaped, **gonads** (2.16). Also on the oral surface of the gastric pouches are small projections called **gastric filaments**, which house cnidocytes containing nematocysts.

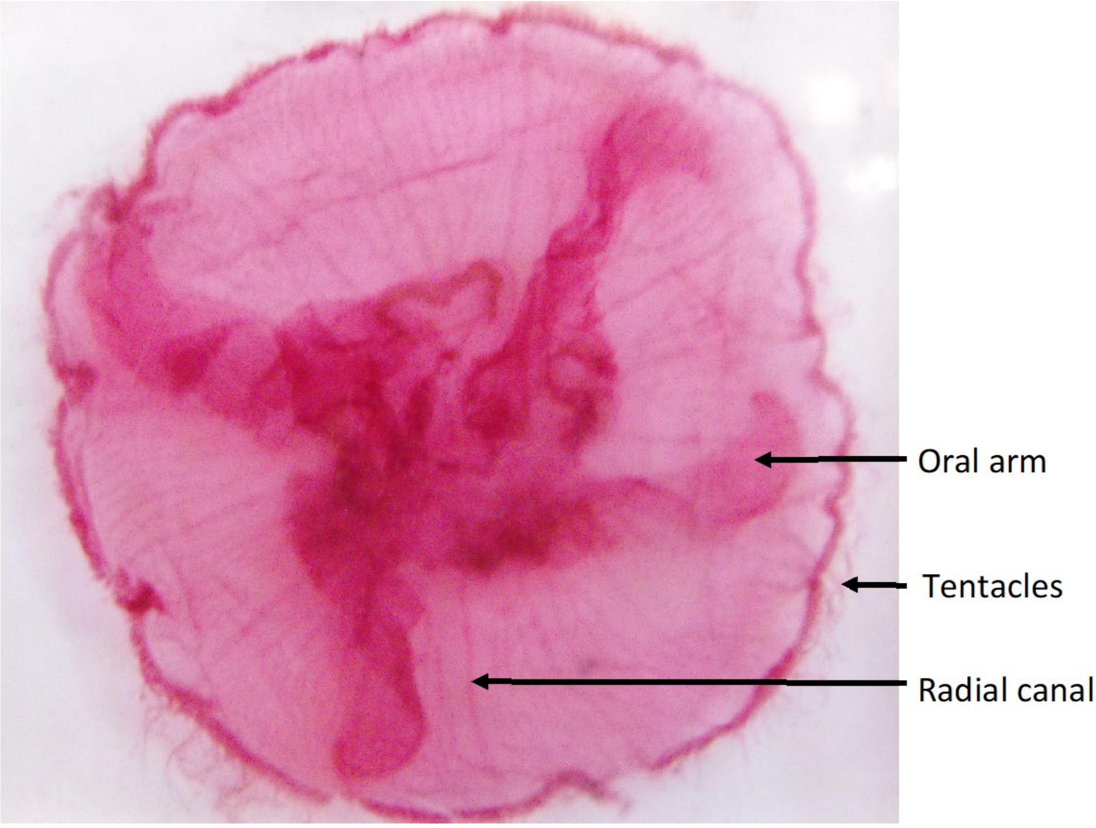

Figure 2.14. Photo of an adult *Aurelia* specimen with some important structures indicated.

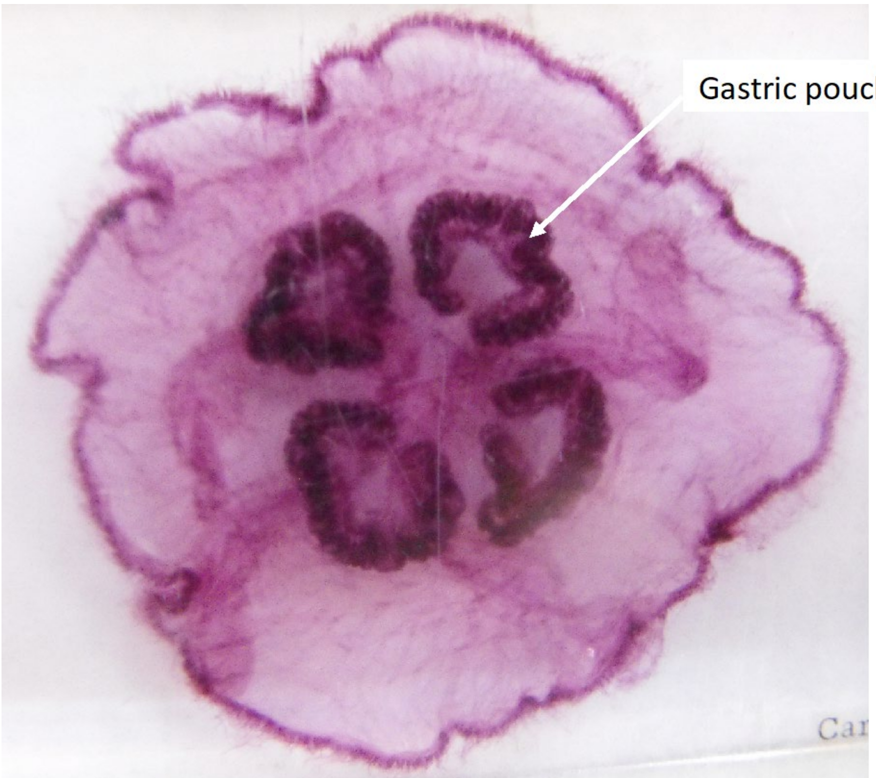

Figure 2.15 Photo of an adult *Aurelia* specimen with one important structure indicated.

Class Hydrozoa

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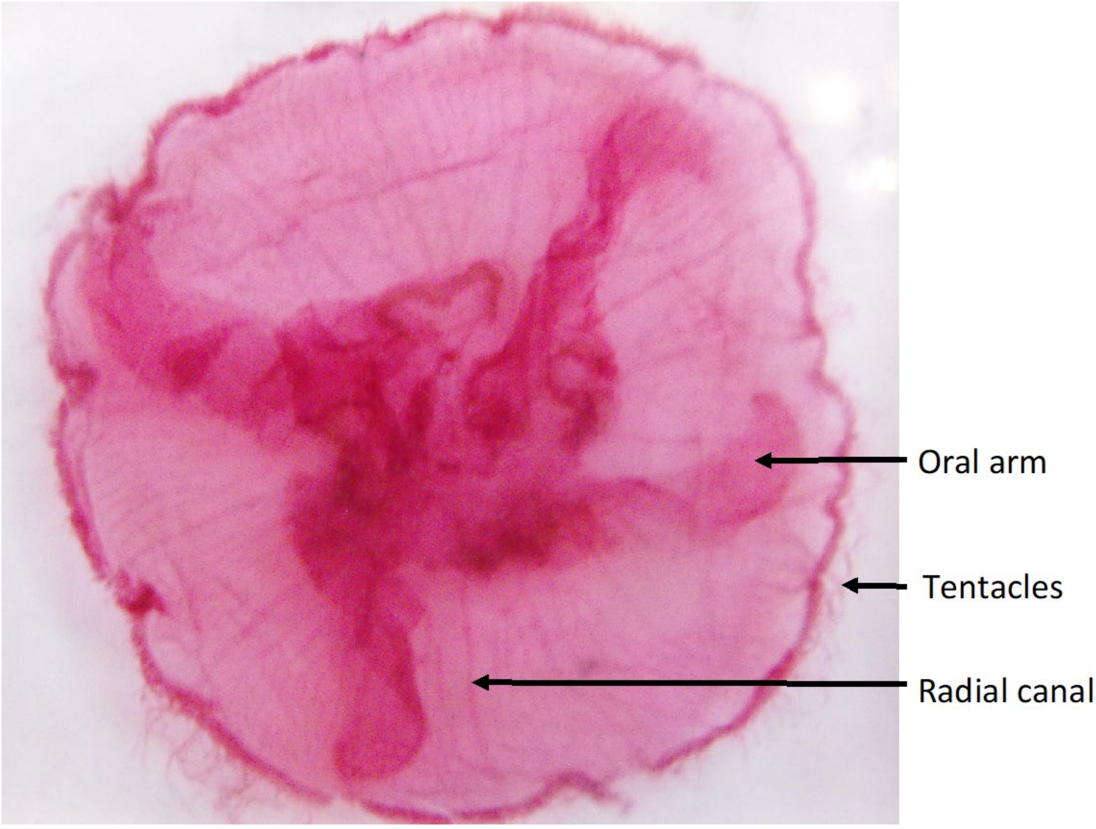

Figure 2.14. Photo of an adult *Aurelia* specimen with some important structures indicated.

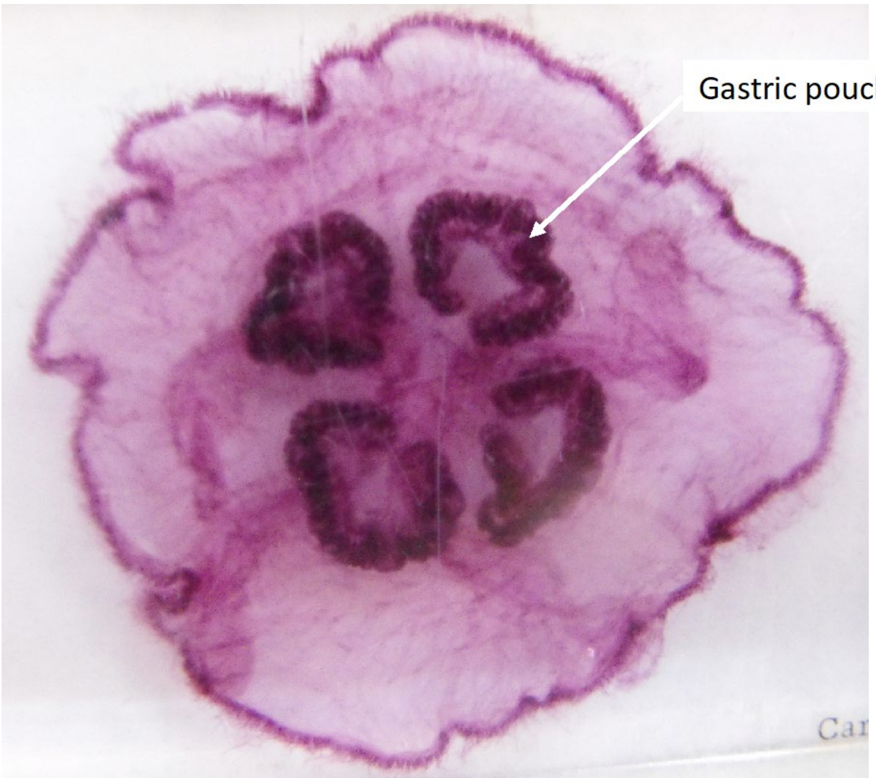

Figure 2.15 Photo of an adult *Aurelia* specimen with one important structure indicated.

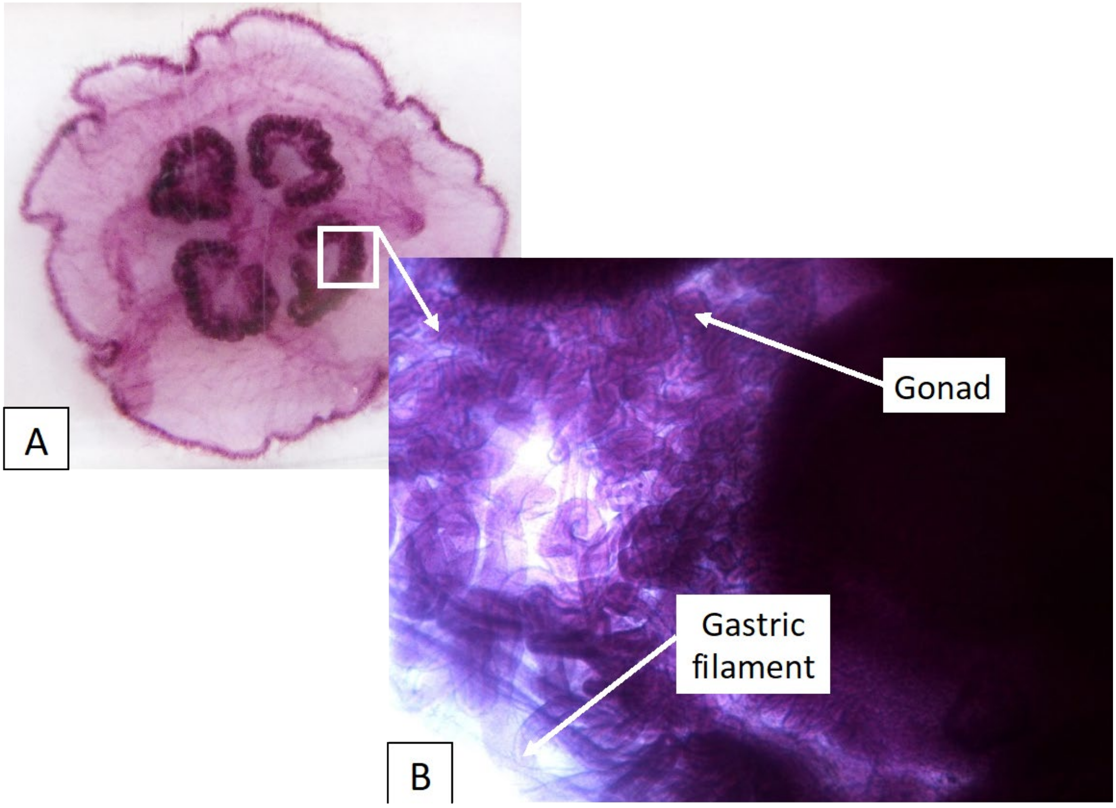

Figure 2.16. A. Photo of an adult *Aurelia* specimen. **B.** Labeled micrograph depicting the region indicated by the box on A.

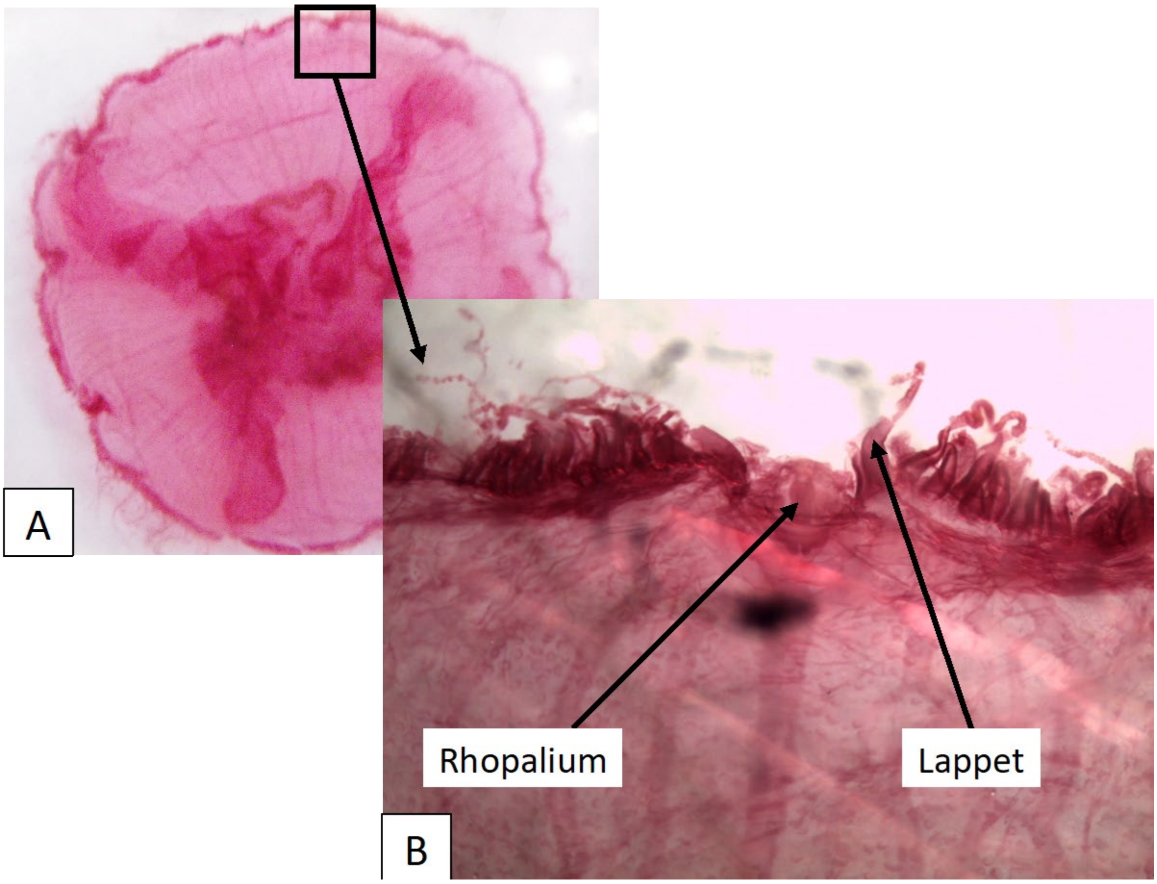

Figure. 2.17. A. Photo of an adult *Aurelia* specimen. **B.** Labeled micrograph depicting the region indicated by the box on A.

Around the bell margin are periodic indentations. Lobes called **lappets** (Fig. 2.17) flank these indentations. Between each pair of lappets are structures called **rhopalia**, which house a **statocyst**, or organ of balance, a **photoreceptor (ocellus)**, and a **chemoreceptor**.

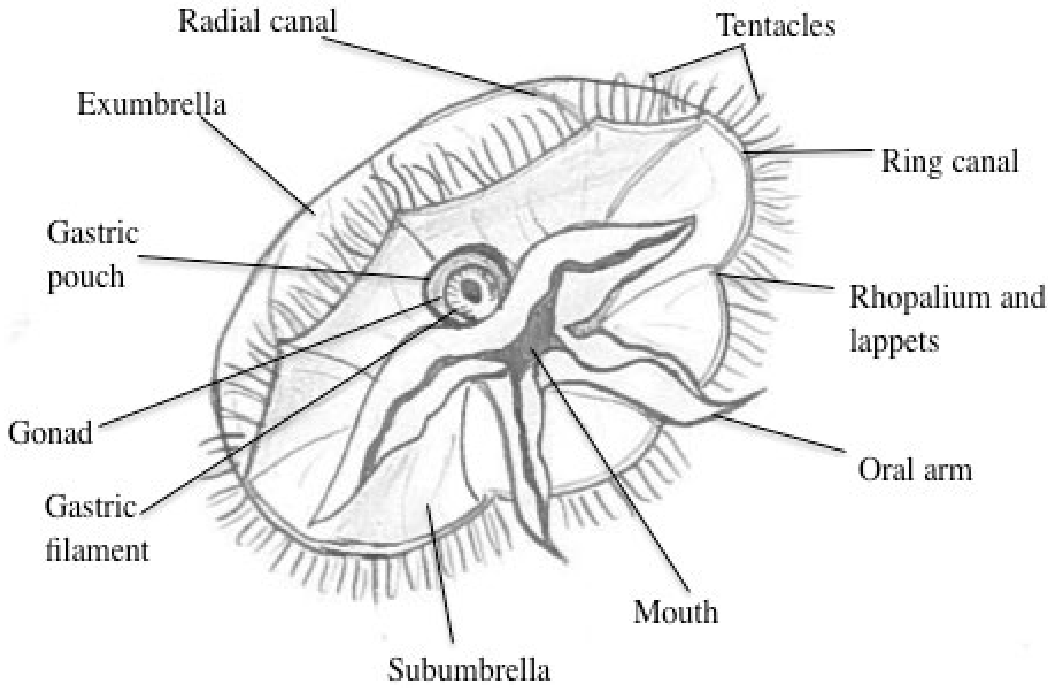

Figure 2.18. Labeled diagram of *Aurelia*, an example of a scyphozoan jellyfish.

From your study of *Aurelia*, it should be clear that scyphozoans reproduce sexually in the medusoid stage. Male and female medusa produce sperm and eggs respectively, and fertilization of the eggs produces a zygote that develops into a blastula and finally a gastrula, which in ALL cnidarians, is called a **planula larva** (Figs. 2.19 and 2.20).

The planula larva undergoes further development and becomes a polyp. The polyp of scyphozoans is called a **scyphistoma** (Fig. 2.21). The scyphistoma undergoes a unique form of budding which results in a distinctive life stage known as a **strobila** (Fig. 2.22). Each of the buds eventually leaves the strobila and becomes a young jellyfish called an **ephyra** (Fig. 2.23). The ephyra grows larger and develops gonads, and at this point, is considered an adult medusa (Figs. 2.14-2.18).

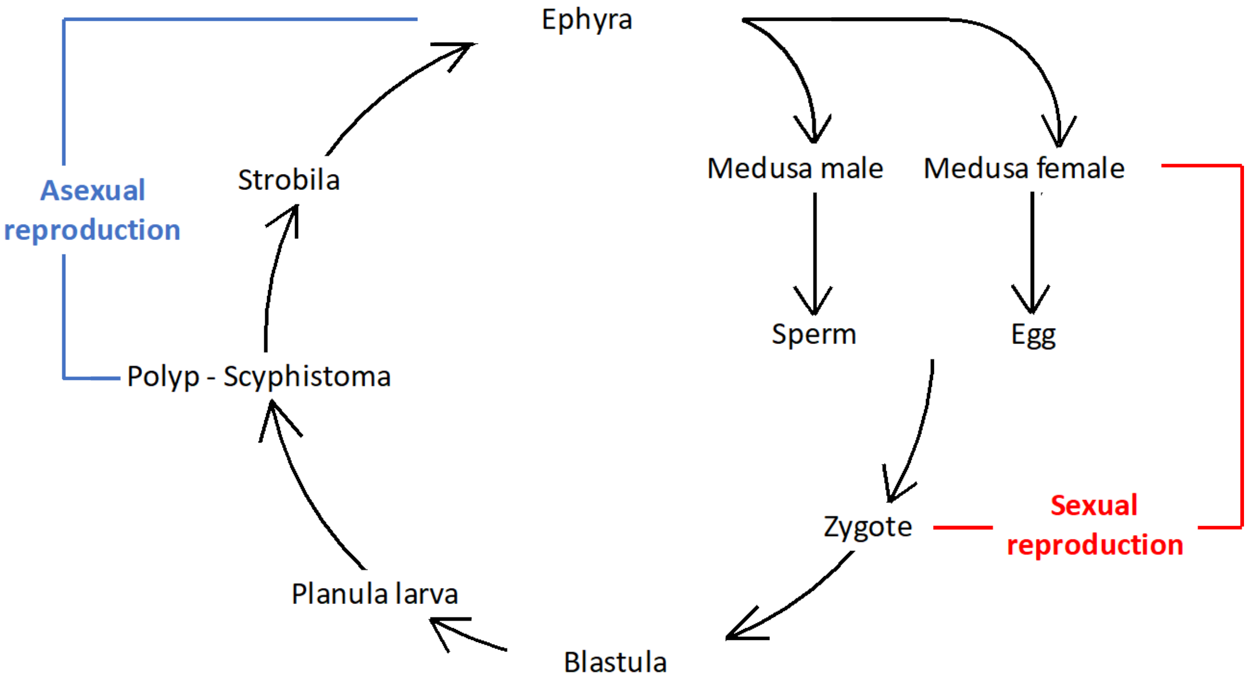

Figure 2.19. Word diagram of the life cycle of *Aurelia*.

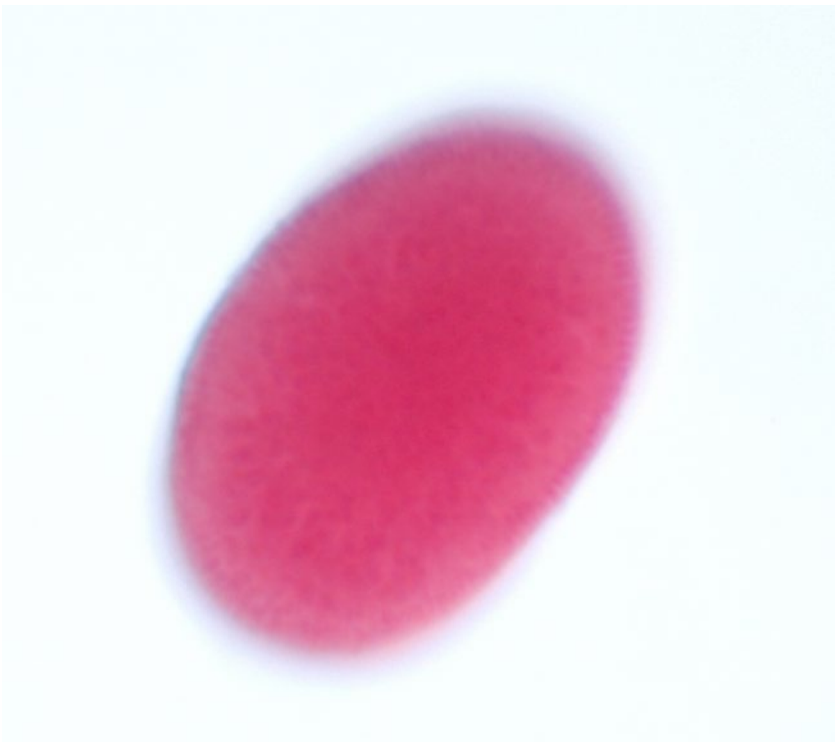

Figure 2.20. Micrograph of a whole mount of an *Aurelia* planula larva.

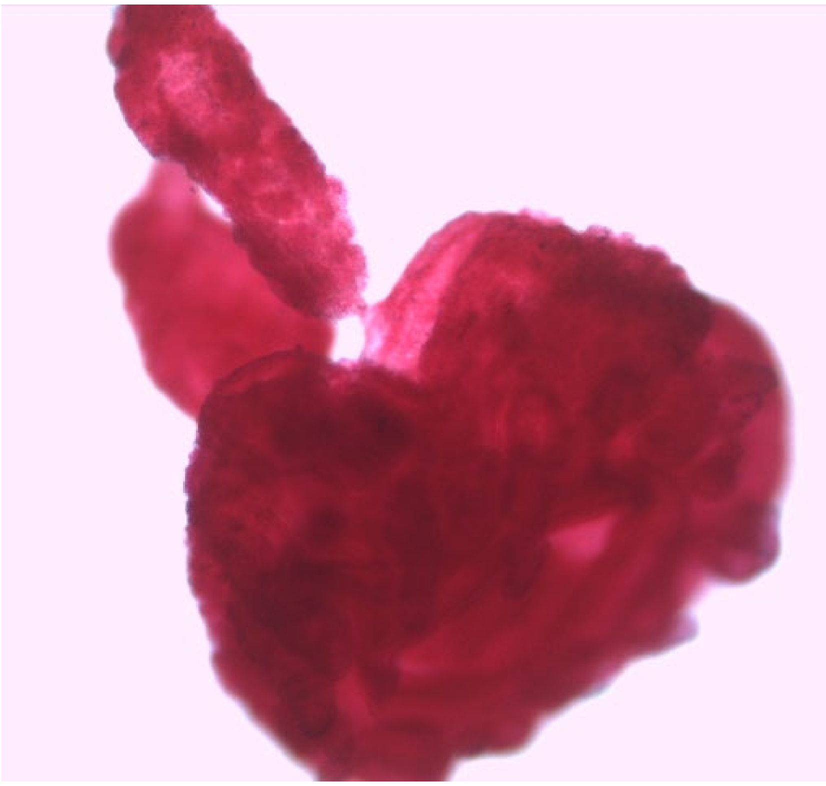

Figure 2.21. Micrograph of a whole mount of an *Aurelia* scyphistoma.

Figure 2.22. Micrograph of a whole mount of an *Aurelia* strobila.

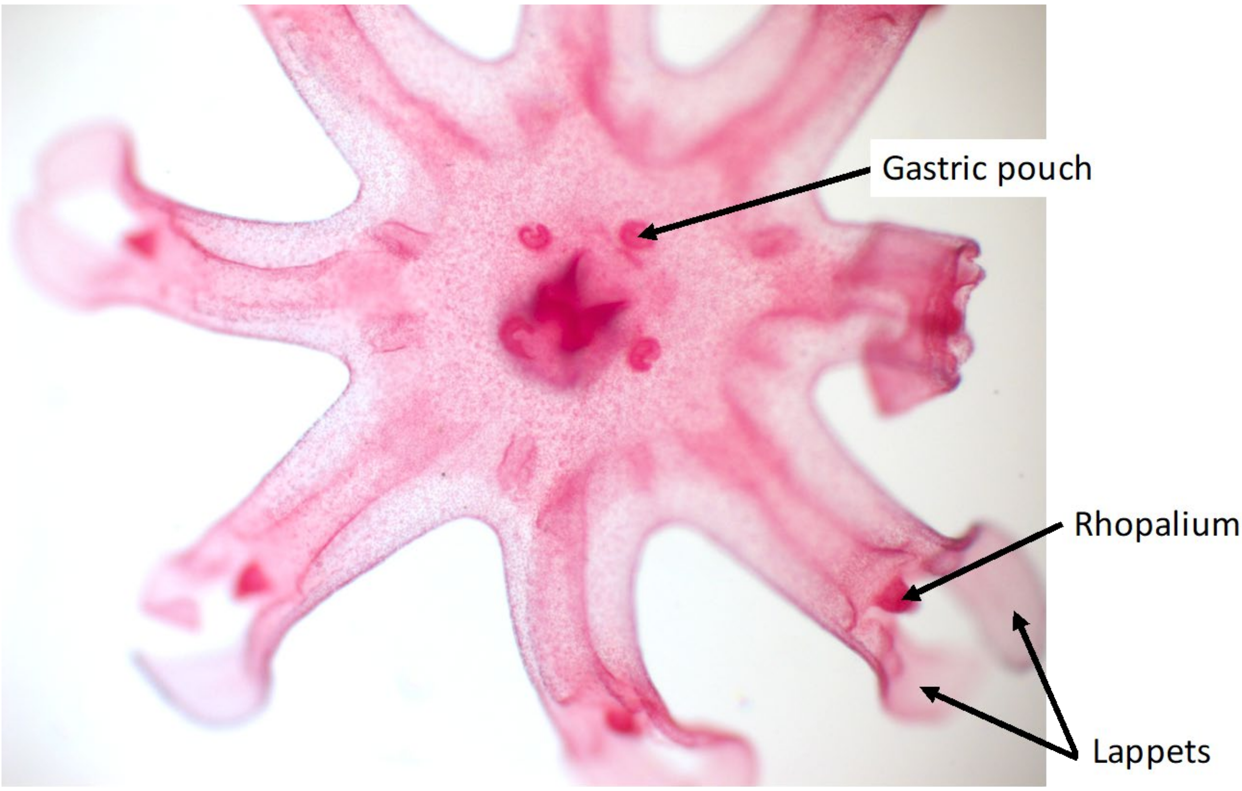

Figure 2.23. Micrograph of a whole mount of an *Aurelia* ephyra with a few structures indicated.

Class Anthozoa

Members of this class only exist as polyps. There is no medusa stage in their life cycle. Thus, these organisms share features with *Hydra*, including the ability to undergo sexual reproduction in the polyp stage.

To study this group of organisms, we are going to examine a species of sea anemone (***Metridium***). *Metridium* is a member of Subclass Hexacorallia and therefore exhibits the distinctive features of this subclass. However, it is also an excellent example of an anthozoan.

Metridium (Sea anemone)

Anthozoan features

Look at a cross-section of *Metridium*. In a cross-section, many distinctions can be made with similar cross-sections of *Hydra* and these differences serve to separate Classes Anthozoa and Hydrozoa. The gastrovascular cavity of the anemone is much larger (Fig. 2.24) than this cavity in *Hydra*.

In addition, the anemone's cavity is divided into chambers by partitions called **septa** (also called mesenteries) (Figs. 2.24, 2.25, and 2.26). Some of the separations are complete and are called **primary septa**. In comparison, some of the partitions may only extend a short distance into the cavity, and these partitions are called **secondary** and **tertiary septa**. These septa can also be seen on the clay model of *Metridium*.

The mesoglea is also greater in extent in *Metridium* (Fig. 2.25) than in *Hydra*. However, just like in other cnidarians, the mesoglea of the anemone is bordered by the epidermis and gastrodermis. And, the gastrodermis (epithelial layer) lines all surfaces within the gastrovascular cavity. However, in anthozoans, striated muscle is found in association with the gastrodermis. You can see these **muscles** in association with the primary and secondary septa (Fig. 2.26).

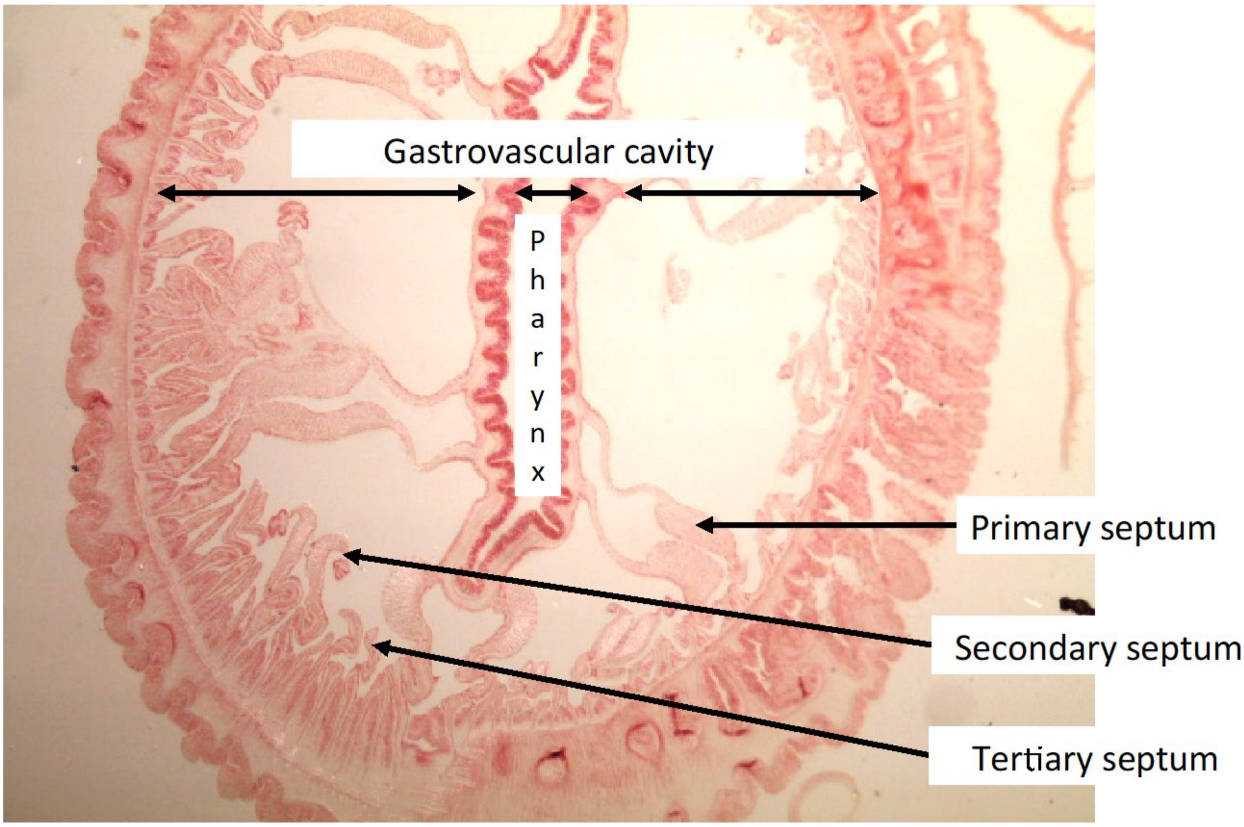

Figure 2.24. Labeled micrograph of a cross-section of *Metridium*.

Water enters the gastrovascular cavity of an anemone through its **mouth**, which is at the center of the **oral disc**, and then travels into its **pharynx** (Figs. 2.24, 2.27A, and clay model). In order for water to circulate throughout its gastrovascular cavity, there must be connections between the chambers created by the septa. These connections are created by holes in the primary septa called **septal perforations**, which can be seen on the clay model and on the diagram (Fig. 2.27A).

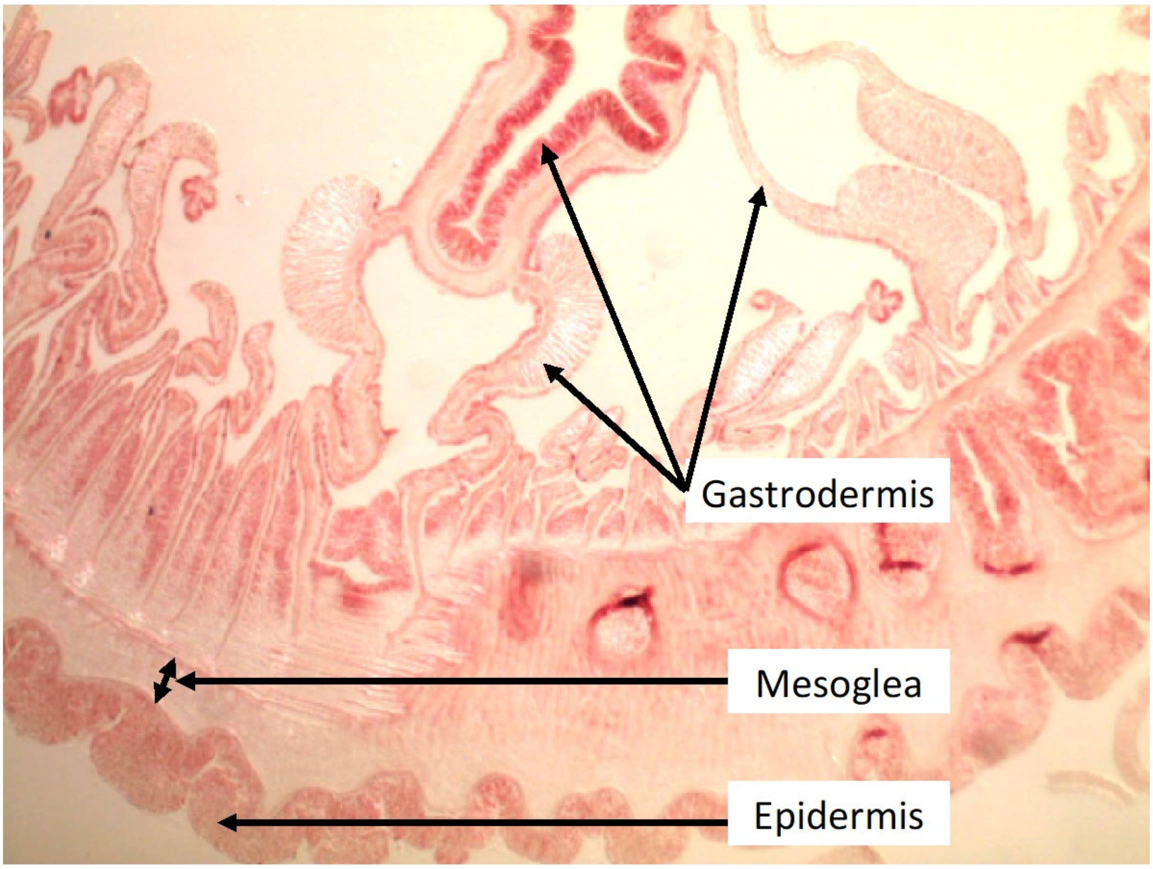

Figure 2.25. Labeled micrograph of a cross-section of *Metridium*.

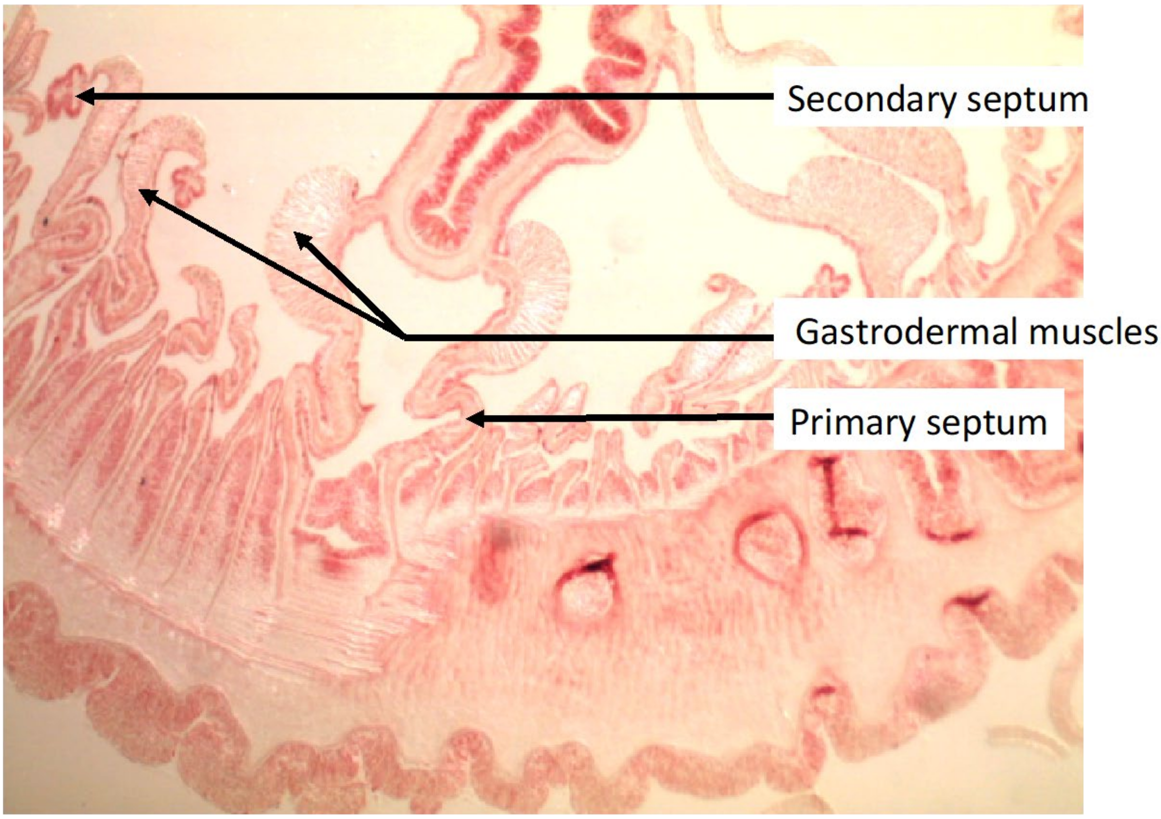

Figure 2.26. Labeled micrograph of a cross-section of *Metridium*.

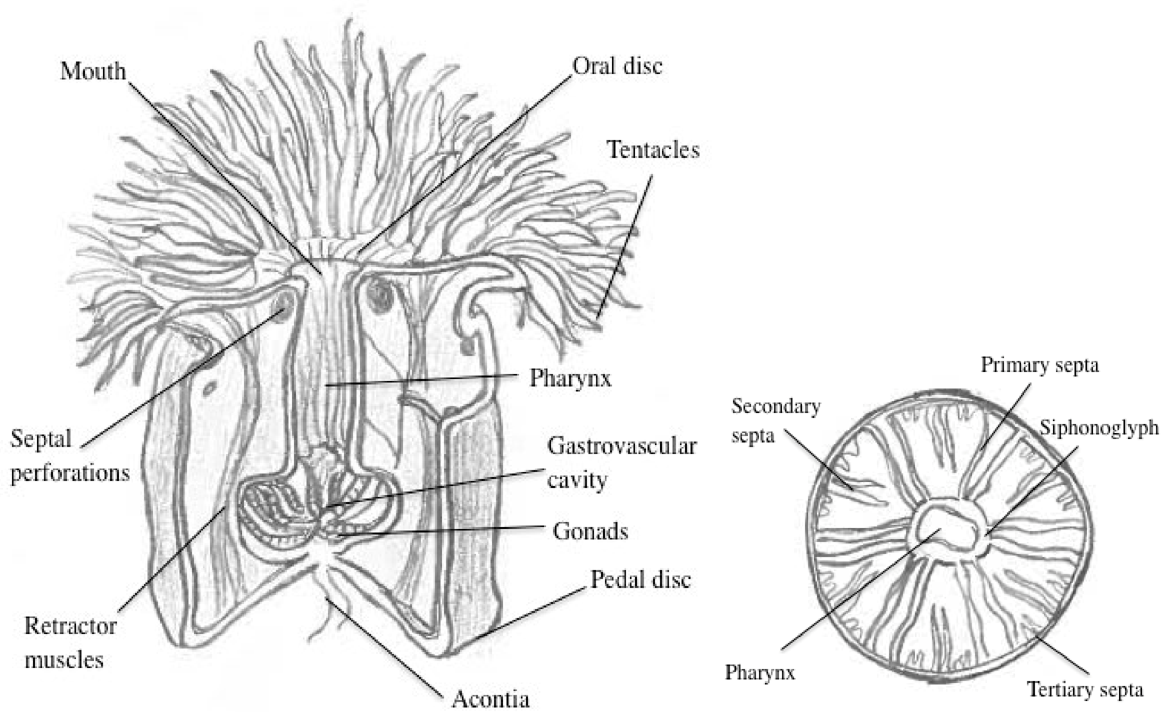

Figure 2.27. A. Diagram of a sea anemone. **B.** Cross-section through an anemone.

Hexacorallian features

Metridium is also a member of **Subclass Hexacorallia**, and one of the distinctive features of these organisms is that they possess **hexamerous symmetry**. Thus, certain features appear in sixes or multiples of six. In *Metridium*, this characteristic is most clearly seen in the **primary septa**, because there are **six pairs** of them (Fig. 2.28). The presence of **pairs of septa** (primary, secondary, and tertiary) is also distinctive to members of this subclass.

Actiniarian features

Finally, *Metridium* is an example of the **Order Actiniaria**. A feature that is distinctive for this group is the presence of a ciliated groove at one or both ends of their mouths that extends into the pharynx. This groove is called a **siphonoglyph** (Fig. 2.27B and Fig. 2.28), and the movement of the cilia in this groove moves water into the pharynx.

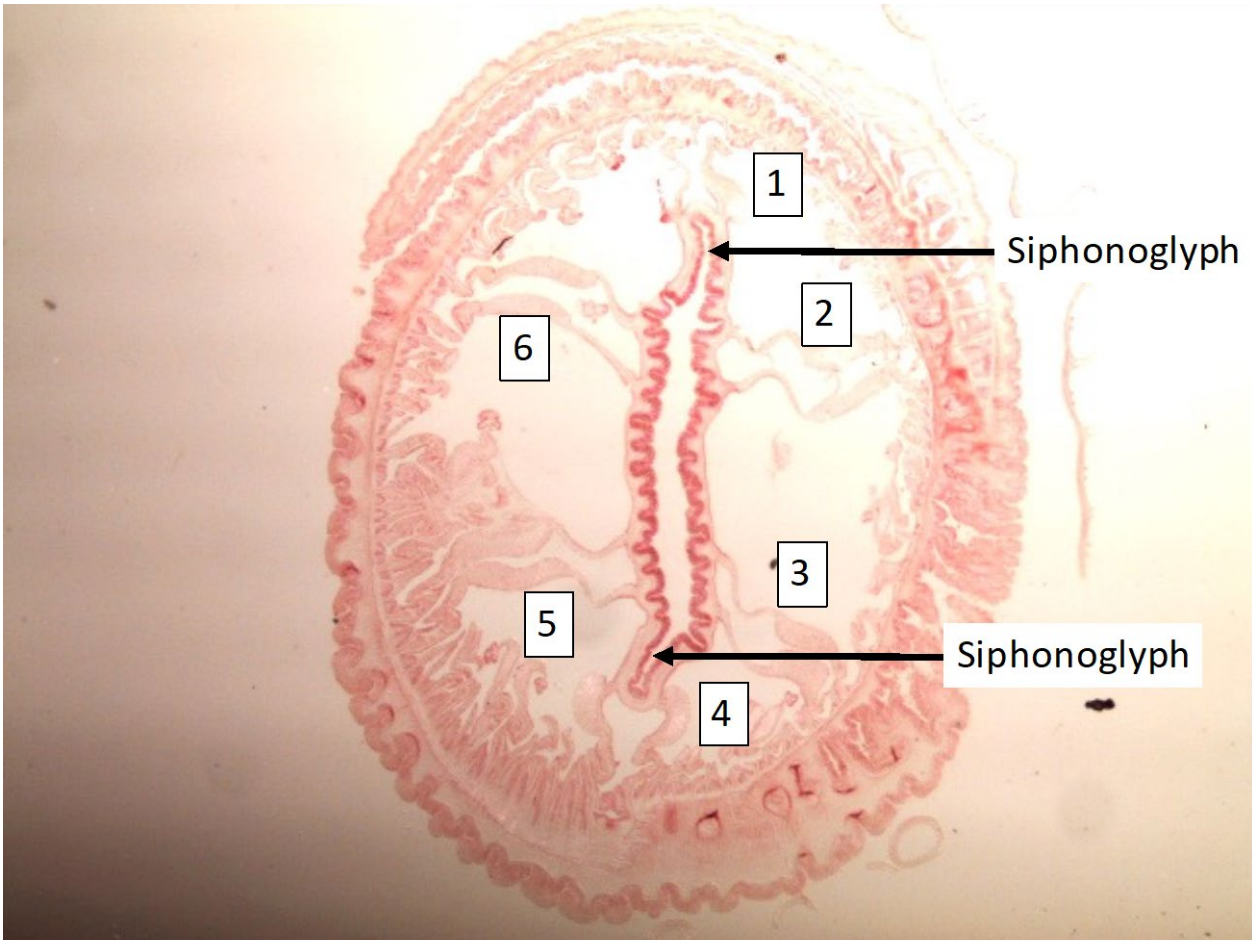

Figure 2.28. Micrograph of a cross-section of *Metridium*. Pairs of primary septa are numbered, and the siphonoglyphs is indicated.

Order Scleractinia

The other members of the **Subclass Hexacorallia** are hard corals, and they are in the **Order Scleractinia**. The distinctive feature of these organisms is the calcium carbonate cup that is secreted by each polyp. These cups are called **corallites** (Fig. 2.29).

Figure 2.29. Photograph of corallites.

Subclass Ceriantipitharia

The Class Anthozoa contains two other subclasses, in addition to Hexacorallia. Members of the **Subclass Ceriantipitharia** include tube anemones and thorny corals. Unlike the hexacorallians, these organisms possess **unpaired septa**. However, we do not have cross-sections of these organisms for you to examine. You will just study the skeletons of these animals that are on display in the lab.

Subclass Octocorallia

The last anthozoan subclass that we will be studying is **Octocorallia**. These organisms include sea fans, sea pens, sea whips, and sea pansies. The features that they share are **eight complete, unpaired septa** and octamerous symmetry. Again, we only have the skeletons of these animals for you to study.

Radial Symmetry

Throughout this exercise there has been no use of the orientation terms used with organisms possessing bilateral symmetry. It is not meaningful to speak of the dorsal or ventral surface of a hydroid or a medusoid. This is because the organisms are **radially symmetrical**. Several planes can be passed through the organism, which will divide it into mirror image halves.

Replacing the terms used in bilaterally symmetrical animals are the terms **oral surface**, the surface on which the mouth is found, and **aboral** surface, the surface opposite to the one on which the mouth is found. The main axis is the oral-aboral axis. Movement away from this axis is peripheral. In this course, you will study three phyla that have radial symmetry.

<u>Phylum Review</u>

Phylum Cnidaria (means "nettle-bearing")

- sac-like body
- gastrovascular cavity
  - lined by gastrodermis
  - used for extracellular digestion
- single orifice for mouth and anus
- most have tentacles around oral end
- nerve net; no central nervous system
- polymorphism; polyps and medusoid stages
- radial symmetry
- nematocysts in cnidocytes

  - **Class Hydrozoa** (means "water serpent animal")
    - *Hydra*, *Obelia*, *Physalia*
    - solitary or colonial
    - asexual polyps and sexual medusae--some may have either polyp or medusa stage reduced or absent
    - hydranths without mesentaries
    - medusae with a velum
    - aseptate gastrovascular cavity
    - ectodermal gonads (when present)

  - **Class Scyphozoa** (means "cup animal")
    - *Aurelia*
    - includes most large jellyfish
    - solitary
    - polyp stage reduced or absent
    - bell-shaped medusae without velum
    - microscopic septa divide gastrovascular cavity
    - tetramerous radial symmetry
    - endodermal gonads
    - mesoglea enlarged

  - **Class Anthozoa** (means "flower animal")
    - *Metridium* (sea anemone)
    - corals (both soft corals and hard corals)
    - solitary or colonial
    - only polyp forms; medusa stage absent
    - gastrovascular cavity subdivided by mesentaries (septa) bearing nematocysts
    - usually either hexamerous or octomerous radial symmetry

- endodermal gonads
- mesoglea enlarged to form collenchyma (true mesoderm)

- **Subclass Hexacorallia** (means “divided into six”)
    - sea anemones and hard corals
    - hexamerous
    - mesenteries in pairs

    - **Order Actiniaria**
        - sea anemones
        - well-developed pharynx and siphonoglyph

    - **Order Scleractinia** (means “hard”)
        - hard corals
        - calcareous exoskeletons - corallites

- **Subclass Ceriantipatharia**
    - tube anemones and thorny corals
    - mesenteries unpaired

- **Subclass Octocorallia** (means “divided into eight”)
    - sea fans, soft corals, sea pansies
    - octamerous symmetry
    - solenia

Phylum Ctenophora

Ctenophores are structurally similar to Cnidarians in that they have two embryonic germ layers and radial symmetry. They contain rows of comb-like plates used for locomotion. Many are also luminescent and glow a bright green color when disturbed. A jarred specimen is available for you to examine.