Phylum Cnidaria

The name Cnidaria comes from the Greek word "cnidos," which means stinging nettle. Phylum Cnidaria includes animals that exhibit radial or biradial symmetry and are diploblastic, meaning that they develop from two embryonic layers, ectoderm and endoderm. Nearly all (about 99 percent) cnidarians are marine species. Many thousands of cnidarian species live in the world's oceans, from the tropics to the poles, from the surface to the bottom. Some even burrow. A smaller number of species are found in rivers and fresh water lakes.

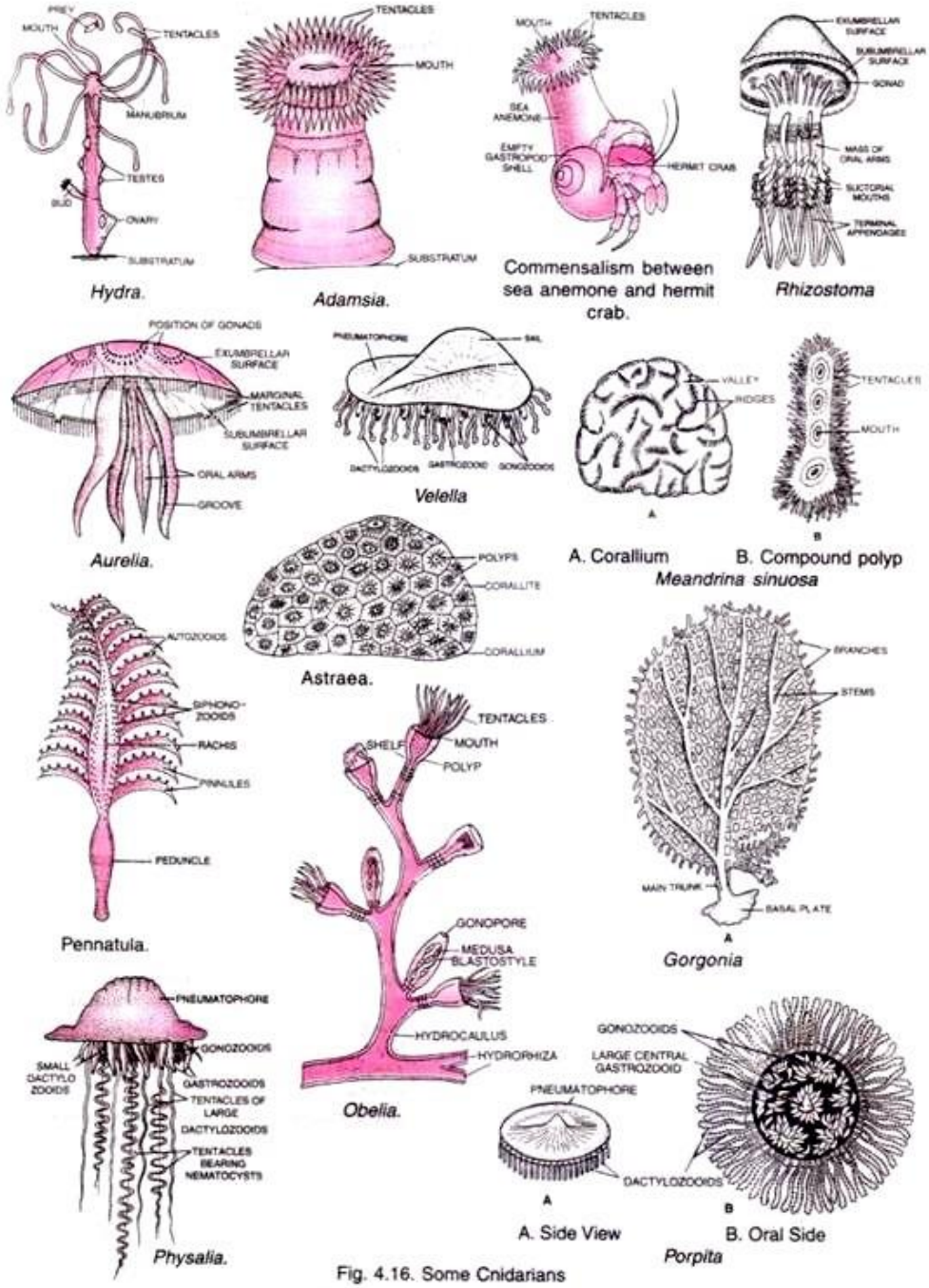
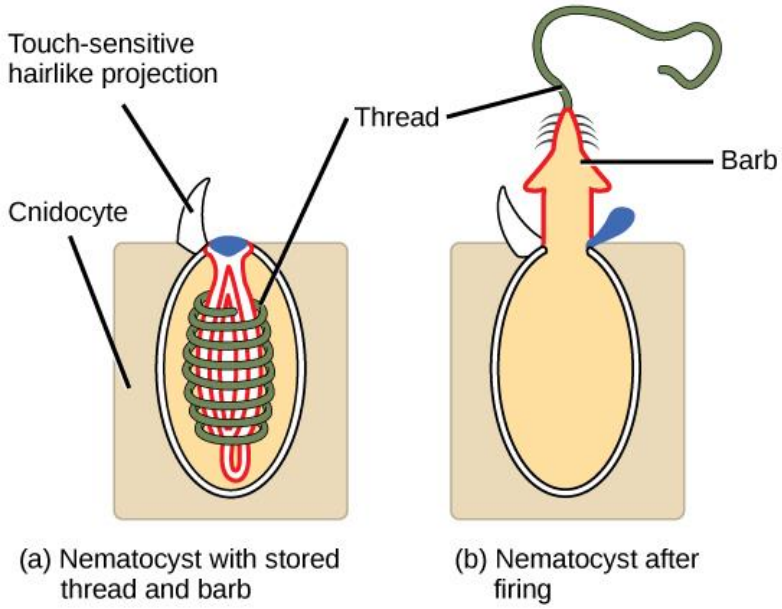


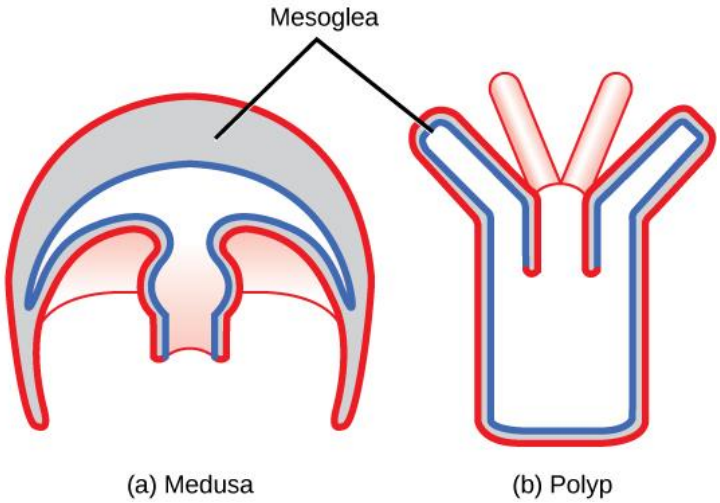
Fig. 4.16. Some Cnidarians

Whereas the defining cell type for the sponges is the choanocyte, the defining cell type for the cnidarians is the cnidocyte, or stinging cell. These cells are located around the mouth and on the tentacles, and serve to capture prey or repel predators. Cnidocytes have large stinging organelles called nematocysts, which usually contain barbs at the base of a long coiled thread. The outer wall of the cell has a hairlike projection called a cnidocil, which is sensitive to tactile stimulation. If the cnidocils are touched, the hollow threads evert with enormous acceleration, approaching 40,000 times that of gravity. The microscopic threads then either entangle the prey or instantly penetrate the flesh of the prey or predator, releasing toxins (including neurotoxins and pore-forming toxins that can lead to cell lysis) into the target, thereby immobilizing it or paralyzing it



Animals in this phylum display two distinct morphological body plans: polyp or “stalk” and medusa or “bell”. An example of the polyp form is Hydra spp.; perhaps the most well-known medusoid animals are the jellies (jellyfish). Polyp forms are sessile as adults, with a single opening to the digestive system (the mouth) facing up with tentacles surrounding it. Medusa forms are motile, with the mouth and tentacles hanging down from an umbrella-shaped bell.

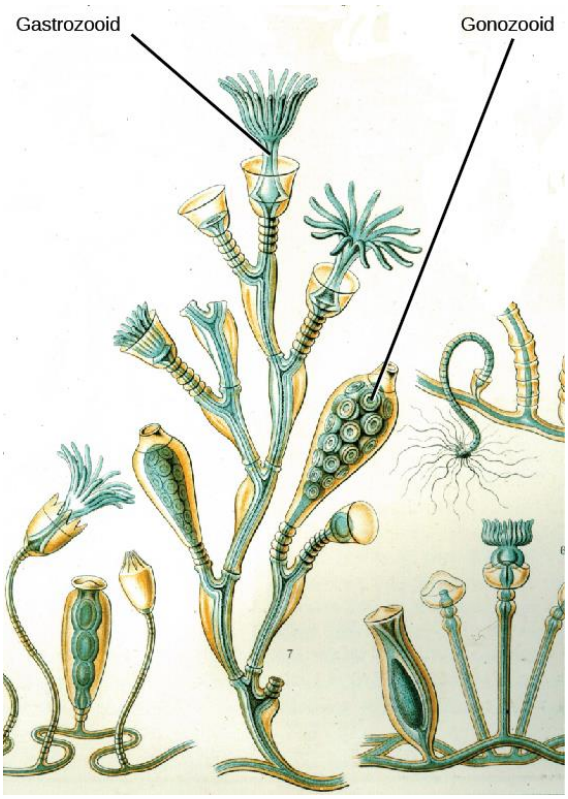
Some cnidarians are polymorphic, having two body plans during their life cycle. An example is the colonial hydroid called an Obelia. The sessile polyp form has, in fact, two types of polyps. The first is the gastrozooid, which is adapted for capturing prey and feeding; the other type of polyp is the gonozooid, adapted for the asexual budding of medusa. When the reproductive buds mature, they break off and become free-swimming medusa, which are either male or female (dioecious). The male medusa makes sperm, whereas the female medusa makes eggs. After fertilization, the zygote develops into a blastula and then into a planula larva. The larva is free swimming for a while, but eventually attaches and a new colonial reproductive polyp is formed.



Cnidarian morphology: Cnidarians have two distinct body plans, the medusa (a) and the polyp (b). All cnidarians have two membrane layers, with a jelly-like mesoglea between them

Some cnidarians are dimorphic, that is, they exhibit both body plans during their life cycle. In these species, the polyp serves as the asexual phase, while the medusa serves as the sexual stage and produces gametes. However, both body forms are diploid.

An example of cnidarian dimorphism can be seen in the colonial hydroid *Obelia*. The sessile asexual colony has two types of polyps. The first is the *gastrozooid*, which is adapted for capturing prey and feeding. In *Obelia*, all polyps are connected through a common digestive cavity called a *coenosarc*. The other type of polyp is the *gonozooid*, adapted for the asexual budding and the production of sexual medusae. The reproductive buds from the gonozooid break off and mature into free-swimming medusae, which are either male or female (dioecious). Each medusa has either several testes or several ovaries in which meiosis occurs to produce sperm or egg cells. Interestingly, the gamete-producing cells do not arise within the gonad itself, but migrate into it from the tissues in the gonozooid. This separate origin of gonad and gametes is common throughout the eumetazoa. The gametes are released into the surrounding water, and after fertilization, the zygote develops into a blastula, which soon develops into a ciliated, bilaterally symmetrical planula larva. The planula swims freely for a while, but eventually attaches to a substrate and becomes a single polyp, from which a new colony of polyps is formed by budding.



Types of polyps in *Obelia*: The sessile form of *Obelia geniculate* has two types of polyps: gastrozooids, which are adapted for capturing prey, and gonozooids, which bud to produce medusae asexually.

All cnidarians are diploblastic and thus have two "epithelial" layers in the body that are derived from the endoderm and ectoderm of the embryo. The outer layer (from ectoderm) is called the *epidermis* and lines the outside of the animal, whereas the inner layer (from endoderm) is called the *gastrodermis* and lines the digestive cavity. In the planula larva, a layer of ectoderm surrounds a solid mass of endoderm, but as the polyp develops, the digestive or gastrovascular cavity opens within the endoderm. A non-living, jelly-like mesoglea lies between these two epithelial layers. In terms of cellular complexity, cnidarians show the presence of differentiated cell types in each tissue layer, such as nerve cells, contractile epithelial cells, enzyme-secreting cells, and nutrient-absorbing cells, as well as the presence of intercellular connections. However, with a few notable exceptions such as *statocysts* and *rhopalia*, the development of organs or organ systems is not advanced in this phylum.

The nervous system is primitive, with nerve cells scattered across the body. This nerve net may show the presence of groups of cells in the form of nerve plexi (singular: plexus) or nerve cords. The nerve cells show mixed characteristics of motor as well as sensory neurons. The predominant signaling molecules in these primitive nervous systems are chemical peptides, which perform both excitatory and inhibitory functions. Despite the simplicity of the nervous system, it coordinates the movement of tentacles, the drawing of captured prey to the mouth, the digestion of food, and the expulsion of waste.

The cnidarians perform extracellular digestion in which the food is taken into the gastrovascular cavity, enzymes are secreted into the cavity, and the cells lining the cavity absorb nutrients. The gastrovascular cavity has only one opening that serves as both a mouth and an anus; this is termed an incomplete digestive system. Cnidarian cells exchange oxygen and carbon dioxide by diffusion between cells in the epidermis with water in the environment, and between cells in the gastrodermis with water in the gastrovascular cavity. The lack of a circulatory system to move dissolved gases limits the thickness of the body wall, necessitating a non-living mesoglea between the layers. There is no excretory system or organs; nitrogenous wastes simply diffuse from the cells into the water outside the animal or in the gastrovascular cavity. There is also no circulatory system, so nutrients must move from the cells that absorb them in the lining of the gastrovascular cavity through the mesoglea to other cells.

The phylum Cnidaria contains about 10,000 described species divided into four classes: Anthozoa, Scyphozoa, Cubozoa, and Hydrozoa. The anthozoans, the sea anemones and corals, are all sessile species, whereas the scyphozoans (jellyfish) and cubozoans (box jellies) are swimming forms. The hydrozoans contain sessile forms and swimming colonial forms like the "Portuguese Man of War".

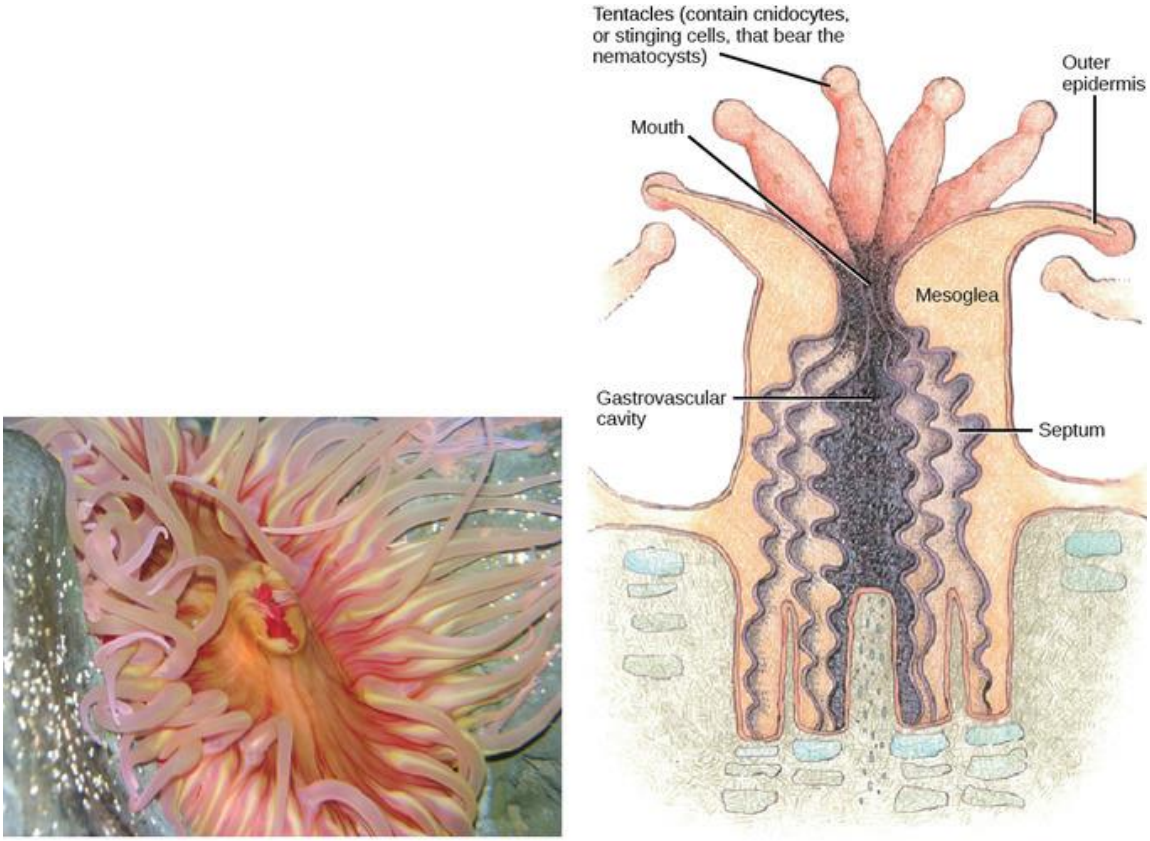
Class Anthozoa

The class Anthozoa includes all cnidarians that exhibit a polyp body plan only; in other words, there is no medusa stage within their life cycle. Examples include sea anemones, sea pens, and corals, with an estimated number of 6,100 described species. Sea anemones are usually brightly colored and can attain a size of 1.8 to 10 cm in diameter. These animals are usually cylindrical in shape and are attached to a substrate. The mouth of a sea anemone is surrounded by tentacles that bear cnidocytes. They have slit-like mouth openings and a pharynx, which is the muscular part of the digestive system that serves to ingest as well as egest food. It may extend for up to two-thirds the length of the body before opening into the gastrovascular cavity. This cavity is divided into several chambers by longitudinal septa called mesenteries. Each mesentery consists of one ectodermal and one endodermal cell layer with the mesoglea sandwiched in between. Mesenteries do not divide the gastrovascular cavity completely; the smaller cavities coalesce at the pharyngeal opening. The adaptive benefit of the mesenteries appears to be an increase in surface area for absorption of nutrients and gas exchange.

Sea anemones feed on small fish and shrimp, usually by immobilizing their prey using the cnidocytes. Some sea anemones establish a mutualistic relationship with hermit crabs by attaching to the crab's shell. In this relationship, the anemone gets food particles from prey caught by the crab, while the crab is protected from the predators by the stinging cells of the anemone. Anemone fish, or clownfish, are able to live in the anemone since they are immune to the toxins contained within the nematocysts. Another type of anthozoan that forms an important mutualistic relationship is reef building coral. These hermatypic corals rely on a symbiotic relationship with zooxanthellae. The coral gains photosynthetic capability, while the zooxanthellae benefit by using nitrogenous waste and carbon dioxide produced by the cnidarian host.

Anthozoans remain polypoid throughout their lives. They can reproduce asexually by budding or fragmentation, or sexually by producing gametes. Both gametes are produced by the polyp,

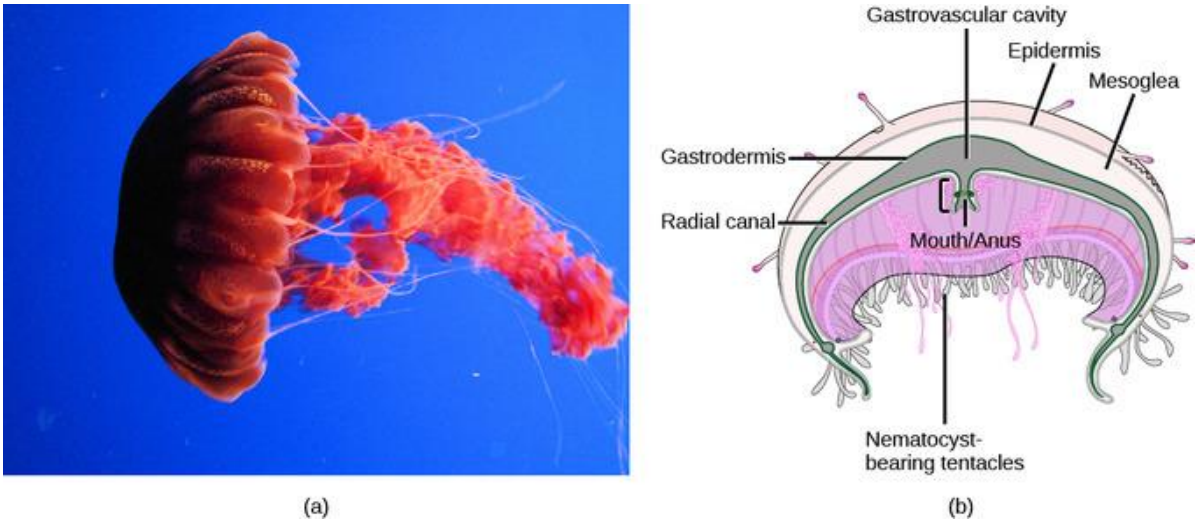
which can fuse to give rise to a free-swimming planula larva. The larva settles on a suitable substratum and develops into a sessile polyp.



Anthozoans: The sea anemone (a), like all anthozoans, has only a polyp body plan (b).

Class Scyphozoa

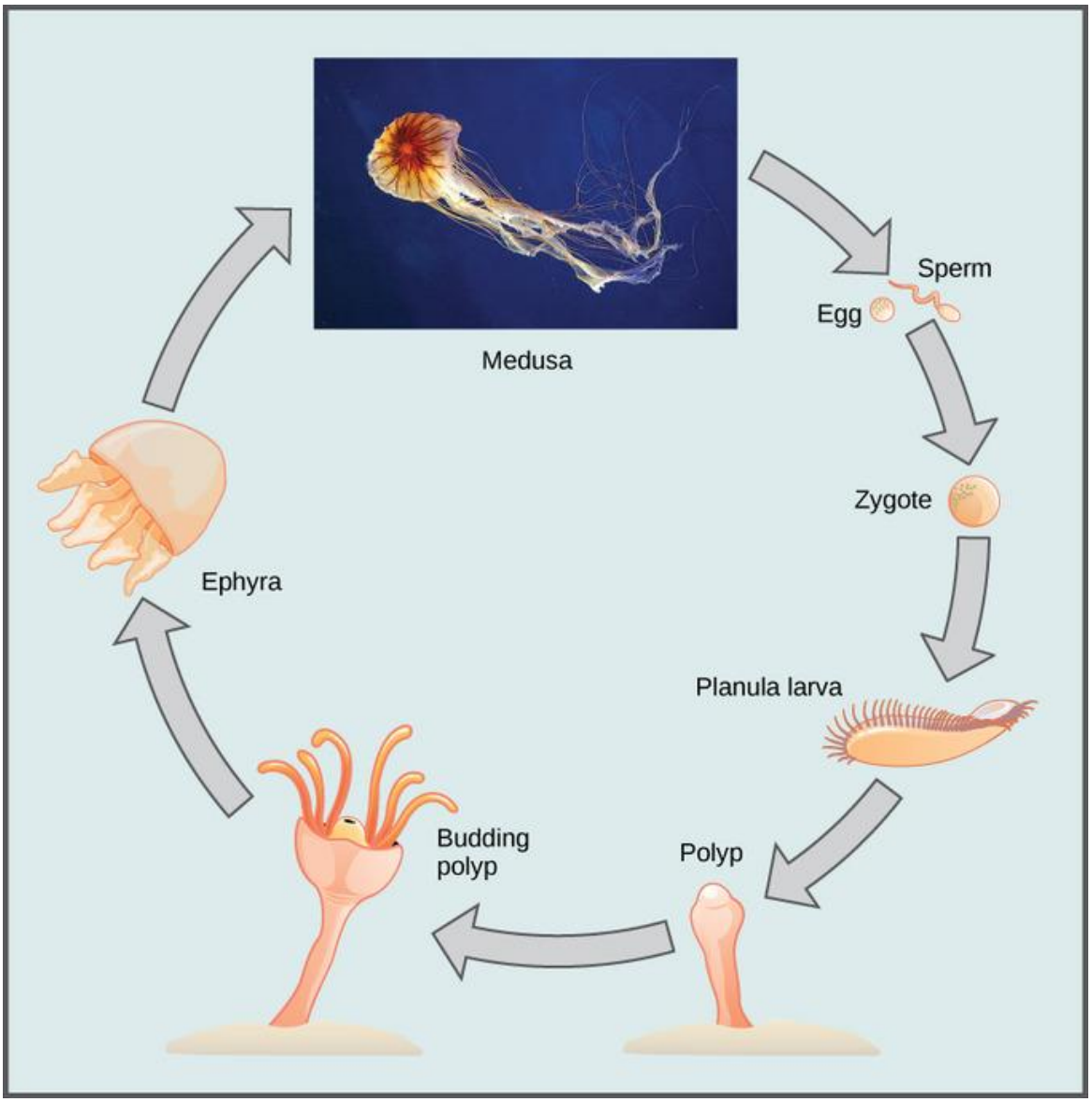
Class Scyphozoa, an exclusively marine class of animals with about 200 known species, includes all the jellies. The defining characteristic of this class is that the medusa is the prominent stage in the life cycle, although there is a polyp stage present. Members of this species range from 2 to 40 cm in length, but the largest scyphozoan species, *Cyanea capillata*, can reach a size of 2 m across. Scyphozoans display a characteristic bell-like morphology.



Scyphozoans: For jellyfish (a), and all other scyphozoans, the medusa (b) is the most prominent of the two life stages.

In the jellyfish, a mouth opening, surrounded by tentacles bearing nematocysts, is present on the underside of the animal. Scyphozoans live most of their life cycle as free-swimming, solitary carnivores. The mouth leads to the gastrovascular cavity, which may be sectioned into four interconnected sacs, called diverticuli. In some species, the digestive system may be further branched into radial canals. Like the septa in anthozoans, the branched gastrovascular cells serves to increase the surface area for nutrient absorption and diffusion; thus, more cells are in direct contact with the nutrients in the gastrovascular cavity.

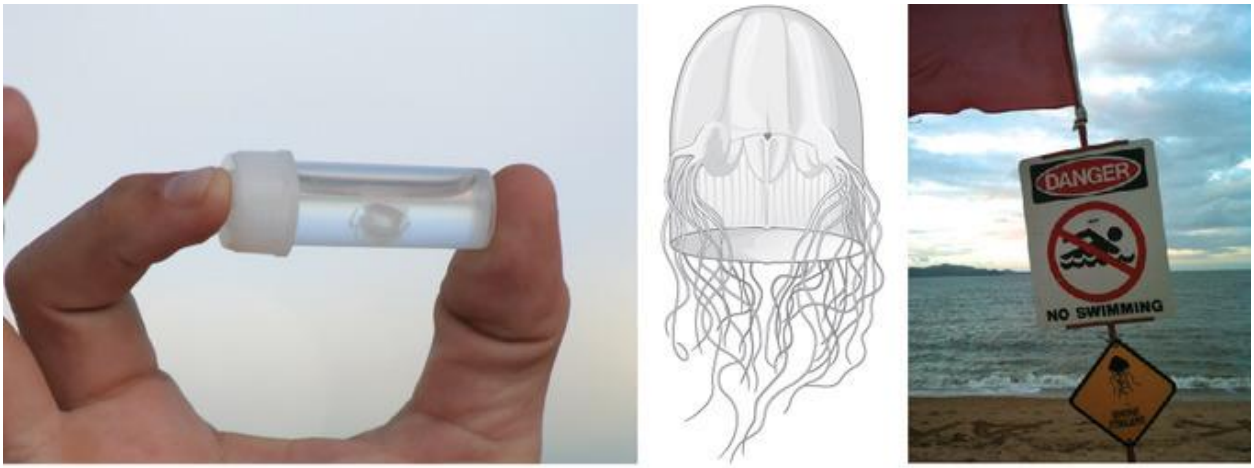
In scyphozoans, nerve cells are scattered over the entire body. Neurons may even be present in clusters called rhopalia. These animals possess a ring of muscles lining the dome of the body, which provides the contractile force required to swim through water. Scyphozoans are dioecious animals, having separate sexes. The gonads are formed from the gastrodermis with gametes expelled through the mouth. Planula larvae are formed by external fertilization; they settle on a substratum in a polypoid form known as scyphistoma. These forms may produce additional polyps by budding or may transform into the medusoid form. The life cycle of these animals can be described as polymorphic because they exhibit both a medusal and polypoid body plan at some point.



Lifecycle of a jellyfish: The lifecycle of a jellyfish includes two stages: the medusa stage and the polyp stage. The polyp reproduces asexually by budding, while the medusa reproduces sexually.

Class Cubozoa

Class Cubozoa includes jellies that have a box-shaped medusa: a bell that is square in cross-section; hence, they are colloquially known as “box jellyfish.” These species may achieve sizes of 15–25 cm. Cubozoans display overall morphological and anatomical characteristics that are similar to those of the scyphozoans. A prominent difference between the two classes is the arrangement of tentacles. This is the most venomous group of all the cnidarians.



Cubozoans: The (a) tiny cubazoan jelly *Malo kingi* is thimble shaped and, like all cubozoan jellies, (b) has four muscular pedalia to which the tentacles attach. *M. kingi* is one of two species of jellies known to cause Irukandji syndrome, a condition characterized by excruciating muscle pain, vomiting, increased heart rate, and psychological symptoms. Two people in Australia, where Irukandji jellies are most-commonly found, are believed to have died from Irukandji stings. (c) A sign on a beach in northern Australia warns swimmers of the danger.

The cubozoans contain muscular pads called pedalia at the corners of the square bell canopy, with one or more tentacles attached to each pedalium. These animals are further classified into orders based on the presence of single or multiple tentacles per pedalium. In some cases, the digestive system may extend into the pedalia. Nematocysts may be arranged in a spiral configuration along the tentacles; this arrangement helps to effectively subdue and capture prey. Cubozoans exist in a polypoid form that develops from a planula larva. These polyps show limited mobility along the substratum. As with scyphozoans, they may bud to form more polyps to colonize a habitat. Polyp forms then transform into the medusoid forms.

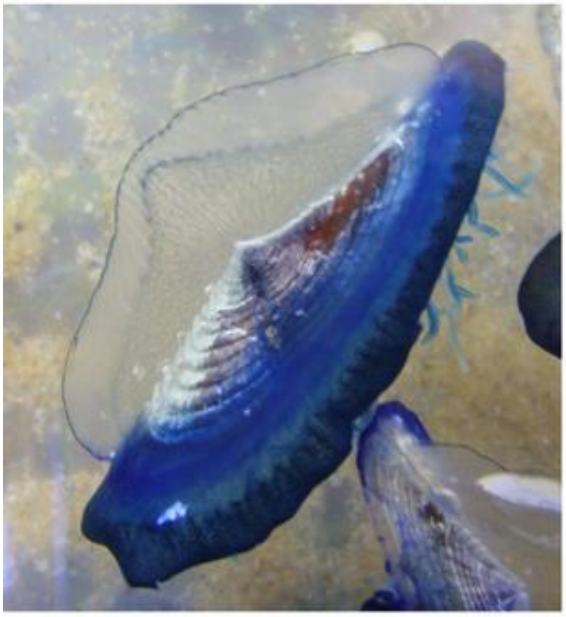
Class Hydrozoa

Hydrozoa includes nearly 3,200 species; most are marine, although some freshwater species are known. Animals in this class are polymorphs: most exhibit both polypoid and medusoid forms in their lifecycle, although this is variable.

The polyp form in these animals often shows a cylindrical morphology with a central gastrovascular cavity lined by the gastrodermis. The gastrodermis and epidermis have a simple layer of mesoglea sandwiched between them. A mouth opening, surrounded by tentacles, is present at the oral end of the animal. Many hydrozoans form colonies that are composed of a branched colony of specialized polyps that share a gastrovascular cavity, such as in the colonial hydroid *Obelia*. Colonies may also be free-floating and contain medusoid and polypoid individuals in the colony as in *Physalia* (the Portuguese Man O' War) or *Velella* (By-the-wind sailor). Other species are solitary polyps (*Hydra*) or solitary medusae (*Gonionemus*). The true characteristic shared by all these diverse species is that their gonads for sexual reproduction are derived from epidermal tissue, whereas in all other cnidarians they are derived from gastrodermal tissue.

(a) *Obelia*

(b) *Physalia physalis* (Portuguese Man O' War)



(c) *Velella bae*

(d) *Hydra*

Hydrozoans: (a) *Obelia*, (b) *Physalia physalis*, known as the Portuguese Man O‘ War, (c) *Velella bae*, and (d) *Hydra* have different body shapes, but all belong to the family Hydrozoa.

Key Points

Cnidarians have two distinct morphological body plans known as polyp, which are sessile as adults, and medusa, which are mobile; some species exhibit both body plans in their lifecycle.

All cnidarians have two membrane layers in the body: the epidermis and the gastrodermis; between both layers they have the mesoglea, which is a connective layer.

Cnidarians carry out extracellular digestion, where enzymes break down the food particles and cells lining the gastrovascular cavity absorb the nutrients.

Cnidarians have an incomplete digestive system with only one opening; the gastrovascular cavity serves as both a mouth and an anus.

The nervous system of cnidarians, responsible for tentacle movement, drawing of captured prey to the mouth, digestion of food, and expulsion of waste, is composed of nerve cells scattered across the body.

Anthozoa, Scyphozoa, Cubozoa, and Hydrozoa make up the four different classes of Cnidarians.

Anthozoans include sea anemones, sea pens, and corals.

The pharynx of anthozoans (ingesting as well as egesting food) leads to the gastrovascular cavity, which is divided by mesenteries.

In Anthozoans, gametes are produced by the polyp; if they fuse, they will give rise to a free-swimming planula larva, which will become sessile once it finds an optimal substrate.

Sea anemonies and coral are examples of anthozoans that form unique mutualistic relationships with other animal species; both sea anemonies and coral benefit from food availability provided by their partners.

Scyphozoans have a ring of muscles that lines the dome of their bodies; these structures provide them with the contractile force they need to swim through water.

Scyphozoans have separate sexes and form planula larvae through external fertilization.

Jellies exhibit the polyp form, known as a scyphistoma, after their larvae settle on a substrate; these forms will later bud-off and transform into their more prominenent medusa forms.

Cubozoans differ from Scyphozoans in their arrangement of tentacles; they are also known for their box-shaped medusa.

Out of all cnidarians, cubozoans are the most venomous.

Hydrozoans are polymorphs, existing as solitary polyps, solitary medusae, or as colonies.

Hydrozoans are unique from all other cnidarians in that their gonads are derived from epidermal tissue.

Key Terms

Mesentery: in invertebrates, it describes any tissue that divides the body cavity into partitions

Cnidocyte: a capsule, in certain cnidarians, containing a barbed, threadlike tube that delivers a paralyzing sting

Hermatypic: of a coral that is a species that builds coral reefs

Diploblastic: having two embryonic germ layers (the ectoderm and the endoderm)

Cnidocyte: a capsule, in certain cnidarians, containing a barbed, threadlike tube that delivers a paralyzing sting

Dioecious: having the male and female reproductive organs on separate parts (of the same species)

Rhopalia: small sensory structures found within Scyphozoa that are characterized by clusters of neurons that can be used to sense light

Scyphistoma: the polypoid form of scyphozoans

Nematocyst: a capsule, in certain cnidarians, containing a barbed, threadlike tube that delivers a paralyzing sting

Hydroid: any of many colonial coelenterates that exist mainly as a polyp; a hydrozoan