# Section 2: Body Plan and Functional Anatomy

**General Body Plan**

Cnidarians exhibit two primary body forms, **polyp** and **medusa**, each adapted to distinct ecological roles and lifestyles. Both forms are characterized by **radial symmetry**, allowing interaction with the environment from all directions.

The **polyp** (polypus, Greek: “many-footed”) is a sessile, cylindrical structure that attaches to a substrate, with its mouth and tentacles oriented upward to capture prey. This body form is commonly seen in sea anemones and corals, where it plays key roles in asexual reproduction and habitat formation. In contrast, the **medusa** (medousa, Greek: “guardian”), is a free-swimming, umbrella-shaped structure with tentacles extending downward. Medusae dominate the life cycles of many Scyphozoa and Cubozoa species and are well adapted for sexual reproduction and locomotion in open water.

The body wall in both forms is composed of three layers:

* **Epidermis** (epi, Greek: “on top” + derma, Greek: “skin”): The outermost layer, containing protective cells and specialized structures such as cnidocytes.
* **Gastrodermis** (gaster, Greek: “stomach” + derma, Greek: “skin”): The innermost layer, responsible for digestion and nutrient absorption.
* **Mesoglea** (meso, Greek: “middle” + gloios, Greek: “glue”): A gelatinous, non-living layer between the epidermis and gastrodermis that provides buoyancy and structural support.

The **mesoglea** plays a critical role in medusae, acting as an elastic matrix that recoils after bell contractions during locomotion. Although it is acellular, the mesoglea can contain amoeboid cells and structural proteins in some species, enhancing flexibility and providing additional support. In polyps, the mesoglea primarily helps maintain the organism's shape and stability.

Cnidarians are classified as **acoelomate** animals, meaning they lack a true coelom or body cavity entirely. Unlike coelomates, which have a mesoderm-lined cavity separating the digestive tract from the outer body wall, cnidarians possess only two germ layers: the **epidermis** and **gastrodermis**, with a non-living, gelatinous **mesoglea** in between. This diploblastic arrangement is sufficient for their relatively simple body plan, as the gastrovascular cavity functions as both a digestive and circulatory system. The absence of a coelom does not hinder their ability to capture prey, digest nutrients, or distribute resources, as these functions are effectively carried out by diffusion and the flow of water through their gastrovascular cavity.

### Species Profile: Deepstaria enigmatica (The Ghost Jellyfish)

The **ghost jellyfish**, Deepstaria enigmatica, is a deep-sea scyphozoan with a highly unusual and almost alien body plan. Unlike most medusae, its bell forms an enormous, translucent, and flexible sheet-like structure, resembling a billowing parachute. Found in the depths of the Atlantic and Pacific Oceans, this jellyfish lacks the typical pulsating motion of other medusae. Instead, it drifts passively through the water, capturing prey such as crustaceans by enveloping them in its expansive bell. The ghost jellyfish's unique body plan challenges the conventional structure of medusae, emphasizing the vast morphological diversity within cnidarians.

**Cnidocytes and Nematocysts: Specialized Cells for Predation and Defense**

Cnidocytes (knide, Greek: “nettle” + cyte, Greek: “cell”) are specialized stinging cells unique to cnidarians, enabling them to capture prey and defend against predators. Inside each cnidocyte is a **nematocyst** (nema, Greek: “thread” + kystis, Greek: “bladder”), a stinging organelle that executes one of the most explosive and rapid biological processes known.

The nematocyst is stored under immense osmotic pressure, generating forces exceeding **7,000 pounds per square inch** and ejecting its thread at speeds up to **2 meters per second**. This extraordinary power is activated when the **cnidocil** (knidion, Greek: “little nettle” + cil, Latin: “hair”) detects external stimuli such as prey movement or chemical cues.

The structure of a cnidocyte is intricate. It consists of a capsule housing the nematocyst’s coiled **tubule**, sealed by a lid-like **operculum** (operire, Latin: “to cover”). When triggered, the operculum bursts open, releasing the tubule in an explosive discharge. The tubule is armed with **stylets** (styletus, Latin: “small pointed tool”) and **barbs**, which penetrate and anchor into the prey, delivering venom or ensnaring the target.

Mechanism of Action:

* The **cnidocil** senses mechanical or chemical stimuli and triggers the nematocyst.
* The **operculum** opens, releasing the coiled tubule.
* The **tubule** everts explosively, driven by high osmotic pressure.
* **Stylets** pierce the prey, while **barbs** secure the tubule and venom is delivered.

The diversity of nematocysts reflects their specialized roles:

* **Penetrant nematocysts** inject venom to immobilize prey.
* **Adherent nematocysts** release sticky threads for anchoring or ensnaring.
* **Volvent nematocysts** deploy coiled threads to entangle prey.

### Species Profile: Chironex fleckeri (The Sea Wasp)

The **sea wasp**, Chironex fleckeri, is a box jellyfish from the class Cubozoa, renowned for its extreme venom. Found in the waters of northern Australia, its tentacles contain some of the most potent penetrant nematocysts in the animal kingdom, capable of causing cardiac arrest in humans within minutes. The sea wasp is also an exceptional swimmer, using its advanced **pulsatile swimming** to actively hunt small fish. With its ability to see shapes and movement using its **complex eyes**, the sea wasp combines extreme venom, sensory adaptations, and active predation, making it one of the ocean’s most dangerous and efficient predators.

**Feeding and Digestion**

Cnidarians are primarily carnivorous, relying on their tentacles and nematocysts to capture prey, which is transported to the **mouth**. From the mouth, food passes into the **pharynx**, a tubular structure that leads to the gastrovascular cavity. The pharynx is lined with cilia, which help transport food inward.

In polyps such as sea anemones, the vertical organization of body structures supports efficient feeding and digestion. The **mouth** and pharynx are located at the apex of the body, leading into the central **gastrovascular cavity**, where extracellular digestion begins. Enzymes secreted by the gastrodermal cells break down prey into smaller particles, which are then absorbed for intracellular digestion. At the base of the polyp lies the **basal disc**, or "foot," which anchors the organism to a substrate and can aid in slow, creeping movements.

The gastrovascular cavity serves as a multifunctional organ, acting as both a digestive and circulatory system. Once nutrients are absorbed, they are distributed throughout the body via the cavity’s branching channels. Waste material is expelled through the mouth, as cnidarians lack an anus, underscoring the simplicity of their body plan.

**Movement and Locomotion**

Cnidarians display a range of locomotor abilities driven by their unique muscular adaptations.

In polyps, movement is limited but effective for their sessile lifestyle. **Longitudinal muscles** within the body wall contract to produce bending or creeping movements, while the **basal disc** secretes adhesive substances to secure the polyp in place. Some polyps, such as sea anemones, detach and relocate by sliding along their substrate.

Medusae employ **pulsatile swimming**, a rhythmic contraction and relaxation of the bell that propels them forward. **Circular muscles** in the bell margin contract to expel water from the gastrovascular cavity, generating thrust. The **mesoglea** acts as an elastic spring, recoiling the bell to its original shape after each contraction. This energy-efficient movement allows medusae to travel significant distances while conserving energy.

The coordination of muscle contractions in medusae allows for precise control of movement, enabling them to navigate through the water column and adjust their position for feeding or reproduction. Longitudinal muscles in tentacles and oral arms enhance their ability to manipulate prey and respond to environmental changes.

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