CHAPTER 7 STUDY GUIDE RADIATE ANIMALS

7.1 Introduction

A. A Fearsome Tiny Weapon

1. More highly organized than sponges; most are sessile.
2. Many are effective predators.
3. Nematocysts are deadly weapons requiring only a small stimulus to fire.
4. Can kill even very large prey.

B. Cnidarian Life History

1. Over 9,000 species are in the phylum **Cnidaria**.
2. Cnidaria have specialized cells (**cnidocytes**) that contain a specialized stinging organelle, the **nematocyst**.
3. Nematocysts are only formed and used only by Cnidarians.
4. Cnidarians originated close to the base of the metazoan lineage.
5. Fossil cnidarian specimens are dated to over 700 million years ago.
6. Today, they are most common in shallow marine environments, some are fresh water but none are terrestrial.
7. Hydroids, sea anemones, jellyfishes, and corals are cnidarians.
8. Some live symbiotically; algae in reef-building corals are critical to coral reef formation.
9. The four classes of Cnidaria are Hydrozoa, Scyphozoa, Cubozoa and Anthozoa.

7.2 Position and Contributions

A. Position of radiates in Animal Kingdom

1. Both phyla Cnidaria and Ctenophora make up the radiate animals.
2. Biradial symmetry is radial symmetry limited to two planes that create mirror images.
3. Other eumetazoans have bilateral symmetry or their radial symmetry is derived from a bilateral ancestor.
4. Neither Cnidaria nor Ctenophora have advanced beyond tissue level of organization although a few organs are seen.

B. Biological Contributions

1. Both phyla have two well-defined germ layers: ectoderm and endoderm; mesoderm may be derived from ectoderm.
2. There is an internal body cavity: the gastrovascular cavity.
3. Extracellular digestion occurs in the gastrovascular cavity; gastrodermal cells accomplish cellular digestion.
4. Most have tentacles, which are extensible projections for food capture.
5. Radiates are the simplest animals with nerve cells; there is no central nervous system.
6. Radiates are the simplest animals with sense organs: statocysts and ocelli.
7. Locomotion is by muscular contraction or ciliary comb plates.
8. Unique features include nematocysts, colloblasts and ciliary comb plates.

C. Characteristics of Cnidaria (Figure 7.1)

1. All are aquatic and mostly marine.
2. Radial or biradial symmetry forms oral and aboral ends.
3. The polyp and medusa forms allow wider ecological possibilities.
4. The two body types are the free-swimming medusae and the polyps.
5. Some have an exoskeleton or endoskeleton of chitinous, calcareous or protein components.
6. They have a diploblastic body, with two layers: epidermis and gastrodermis; some are triploblastic with an **ectomesoderm**.
7. The gastrovascular cavity has a single opening serving as both mouth and anus.
8. Nematocysts are in epidermis or gastrodermis and abundant on tentacles.
9. The nerve net may include some sensory organs.
10. The muscular system has an outer layer of longitudinal fibers and an inner layer of circular fibers.
11. Reproduction is either asexual or sexual; a planula larva may be present.
12. There is no excretory or respiratory system.
13. There is no coelomic cavity.

D. Ecological Relationships

1. Cnidarians are most abundant in shallow marine habitats.
2. Colonial hydroids are attached to underwater structures.
3. The Portugese man-of-war and *Velella* have floats or sails.
4. Ctenophores, mollusks, and flatworms eat hydroids with nematocysts.
5. Molluscs and fishes feed on cnidarians.
6. Certain hydroids and sea anemeones live commensally on shells.

7. Reef-building corals provide habitat for fish that humans consume.
8. Planktonic medusae may be an important food source for fish; the reverse is also true.

E. Form and Function

1. Dimorphism and polymorphism in Cnidarians: Cnidaria have two basic body plans (Figure 7.3).
2. A **polyp** is a hydroid form.
   a. Polyps are an adaptation to a sedentary life.
   b. The body is tubular with the mouth directed upward and surrounded by tentacles.
   c. The aboral end is attached to substrate by a pedal disc.
   d. Polyps may reproduce asexually by budding, fission, or pedal laceration.
   e. In budding, a knob of tissue breaks off from the parent's body and becomes its clone.
   f. Fission clones are produced when one-half of a polyp pulls away from the other.
   g. Pedal laceration may result in a new polyp developing from a torn pedal disc.
   d. In colonial forms, the polyps may be specialized for feeding, reproduction or defense.
   e. Sea anemones and corals are all polyps with no medusa stage.
3. A **medusa** is bell or umbrella-shaped adapted for floating or swimming.
   a. The mouth is directed downward; tentacles may extend down from the rim of the umbrella.
   b. In tetramerous symmetry, body parts are arranged in fours.
4. Both stages have retained the sac-like body plan typical of the phylum.
5. Both have three body layers; medusa has a much thicker mesoglea than do polyps.

F. Locomotion:

1. Hydras can move about freely, but colonial polyps are permanently attached.
2. Sea anemones can move on their basal discs; hydras can move by a "measuring worm" motion, or float to the surface on a gas bubble.
3. Most medusae move freely, or swim by contracting the bell, expelling water from the concave oral side.
4. Cubozoans are strong swimmers.

G. Life Cycles

1. A zygote develops into a free-swimming planula that settles and metamorphoses into a polyp.
2. Hydrozoa and Scyphozoa polyps eventually make medusae.
3. Medusae are dioecious and will reproduce sexually.
4. Sea anemones are all polyps with asexual and sexual reproduction.
5. True jellyfishes (Scyphozoa) have a conspicuous medusoid form.
6. Colonial hydroids (Hydrozoa) have both a polyp and medusa stage.

H. Feeding and Digestion

1. Mouth opens into **gastrovascular cavity;** mouth may be surrounded by an elevated **manubrium** or **oral lobes**
2. Cnidarians prey on a variety of organisms, often larger than themselves.
3. Digestion is **extracellular digestion**, but nutritionally, is **intracellular digestion.**

I. Body Wall

1. **Body Wall:** consists of outer **epidermis**; inner **gastrodermis**, with **mesoglea** between them.
2. **Mesoglea** is gelatinous, has no fibers, and lies between the epidermis and gastrodermis.
3. **Gastrodermis:** contains **nutritive-muscular cells** (tall columnar cells with laterally extended bases to form a primitive form of a circular muscular layer.
4. Water in the **gastrovascular cavity** serves as a **hydrostatic skeleton.**
5. Gastrodermal cells of green hydras bear green algae **(zoochlorellae)**, but marine cnidarians bear the dinoflagellate **zooxanthellae.**
6. **Epidermis: contains epitheliomuscular, interstitial, gland, cnidocyte**, **sensory cells,** and **nerve cells.**
7. **Epitheliomuscular cells** cover the epithelium and are used for muscular contraction (Figure 7.5).
8. Their bases contain myofibrils that form a longitudinal muscle layer.
9. **Interstitial cells** are undifferentiated stem cells that give rise to cnidoblasts, sex cells, buds, and nerve cells.
10. **Gland cells** secrete mucus around the mouth or pedal disc.
11. The **cnidocyte** is the cell that produces the nematocyst; it develops from a **cnidoblast**.
12. Over 20 different types of cnidae have been described; they are important in taxonomy.
13. **Nematocysts** are tiny capsules made of chitin-like material and containing a coiled filament (Figure 7.6).

14 A little lid or **operculum** covers the end of the capsule.

15 The inside of the thread may have tiny barbs or spines.

16 Except in Anthozoa, a modified cilium called a **cnidocil** functions as a trigger.

17 Both small organic molecules and vibrations sensitize anthozoan cnidocytes.
18 After a nematocyte is discharged, its cnidocyte is absorbed and another develops.
19 Hydras have three types of nematocysts (Figure 7.4).
    1) **Penetrants** penetrate prey and inject poison.
    2) **Volvents** recoil and entangle prey.
    3) **Glutinants** secrete an adhesive for locomotion and attachment.
20. Mechanism of Nematocyst Discharge
    a. The cell can generate a high osmotic pressure of 140 atmospheres within the cnidocyte.
    b. The osmotic pressure falls as the hydrostatic pressure increases.
    c. When stimulated, the high internal osmotic pressure causes water to rush into the capsule.
    d. The operculum opens and rapidly releases the increased hydrostatic pressure launching the thread.
    e. At the everting end of the thread, the barbs point backward to anchor.
    f. Poison may be injected when it penetrates the prey.
21. Only a few jellyfish and the Portuguese man-of-war can seriously harm humans.
22. Sensory cells among epidermal cells bear a flagellum for chemical and tactile stimuli and synapse with nerve cells.
23. Epidermal nerve cells are generally multipolar with both one-way and two-way synapses.

J. Nerve Net

1. Two nerve nets, one at the base of epidermis and one at the base of gastrodermis, interconnect.
2. Nerve impulses move across synapses by neurotransmitters.
3. Unlike higher animals, cnidarian nerves have neurotransmitters on both sides of the synapses allowing transmission either direction.
4. Cnidarian nerves lack the myelin sheath on axons.
5. There is no central nervous system, but ring nerves serve as marginal sense organs of medusae.
6. In Scyphozoa: a fast network coordinates swimming movements; a slower one coordinates tentacles.
7. Nerves synapse with both slender sensory cells and epitheliomuscular cells forming a **neuromuscular system**.
8. The nerve net pattern is also found in annelid, human and other digestive systems.

7.4. Class Hydrozoa

A. Characteristics

1. Most Hydrozoa are marine and colonial with both polyp and medusa forms; some freshwater hydra lack a medusa stage.
2. Some marine hydroids lack free medusae; some hydrozoans are only medusae and lack polyps
3. Hydra is not typical but is easy to study; the colonial *Obelia* is more exemplary.

4. Hydra: A Freshwater Hydrozoan

a. Hydra are solitary polyps found in fresh water.
b. Hydra are found worldwide, with 16 species in North America.
c. The body is a cylindrical tube; the aboral end has a basal or pedal disc for attachment.
d. The mouth at the oral end is on a conical elevation called the **hypostome**.
e. A ring of 6-10 hollow tentacles encircles the mouth.
f. The mouth opens to a **gastrovascular cavity**.
g. Hydra feed on small crustaceans, insect larvae, and annelid worms using nematocysts in tentacles (Figure 7.9).
h. Glutathione, released from prey wounds, causes the mouth to open.
g. Buds may project from the side and develop into young hydras that separate from the parent.
h. Testes or ovaries are rounded projections on the body surface (Figure 7.8).
i. Hydra survive the winter as cysts, they hatch in favorable spring weather.
k. Undifferentiated interstitial cells can develop into cnidoblasts, sex cells, buds, or nerve cells, but not epitheliomuscular cells.
l. Gland cells on the adhesive disc secrete an adhesive and sometimes a gas bubble for floating.
r. Hydra can glide on the basal disc or use tentacles to slowly tumble.

B. Hydroid Colonies: *Obelia* is an example of hydroid colonies with a base, a stalk, and one or more terminal polyps or zooids (Figure 7.10).

1. **Gastrozooids** are feeding polyps with a terminal mouth and circulate of tentacles.
2. **Dactylozooids** are polyps specialized for defense.
3. **Gonophores** are sacs containing ovaries or testes.
4. Hydranths capture crustaceans, worms, and larvae providing food for the entire colony.
5. Circulation is a function of the ciliated gastrodermis and body pulsations.
6. Buds do not detach from the parent thereby increasing colony size.
7. Medusa are produced by budding in reproductive polyps named **gonangia**.

8. Medusa produce gametes that unite forming a ciliated planula larva.
9. Hydroids are small, 2 mm to several centimeters in diameter (Figure 7.10).
10. The margin of the bell that projects inward is the **velum** (Figure 7.12).
11. Muscular pulsations fill and empty the bell causing propulsion.
12 The mouth opens into a suspended manubrium that leads to the stomach and four radial canals.
13. The nerve net is concentrated into two nerve rings at the base of the velum.
14. The bell contains statocysts for equilibrium and ocelli for light sensing.

C. Other Hydrozoans

1. *Physalia physalis* (Portuguese man-of-war)are colonial hydrozoans with specialized medusa and polyp types integrated into a single "superorganism" individual (Figure 7.13).
2. It has an air sac with secreted gas that is blown by the wind and carries new individuals.
3. Calcareous skeletons of hydrozoans resembling true corals are **hydrocorals** (Figure 7.14).

7.5 Class Scyphozoa

A. Characteristics

1. Most of the larger jellyfishes belong to this class (Figures 7.15, 7.16).
2. Nearly all float in open sea but one order is sessile, attached to seaweeds by a stalk.
3. Bells vary in shape and size.
5. Scyphozoans lack the shelf-like **velum** found in hydrozoan medusae
6. The margin of the umbrella has indentations, each bearing a pair of lappets.
7. Between lappets is a sense organ, the club-shaped **rhopalium** bearing a hollow statocyst functioning in equilibrium.
8. The mouth is beneath the umbrella.
9. A **manubrium** forms four oral lobes to capture and ingest prey.
10. Tentacles, manubrium, members of and the entire body may have nematocysts.
11. *Aurelia* has short tentacles; plankton caught in mucus of the umbrella are carried to food pockets.
12. Extending from the stomach are four gastric pouches with gastric filaments covered with nematocysts.
13. A complex system of radial canals branches out from pockets to a ring canal in the margin.
14. Sexes are separate and fertilization is internal in the gastric pouch of the female.
15. A zygote develops into a ciliated planula larva; this attaches and develops into a **scyphistoma**.
16. The scyphistoma undergoes **strobilation** to form buds, known as **ephyrae**, that break loose to form jellyfish medusae.
17. Life cycle of *Aurelia* (Figures 7.16, 7.17).

7.6 Class Staurozoa (Figure 7.18) stalked jellyfish (no medusa)

7.7 Class Cubozoa (Figure 7.19)

A. Characteristics

1. These were formerly considered an order of Scyphozoa.
2. The medusoid form is dominant; the polyp is inconspicuous or unknown.
3. The umbrella is square; one or more tentacles extend from each corner.
4. At the base of each tentacle is a flat blade called a pedalium.
5. The umbrella edge turns inward to form a velarium, increasing swimming efficiency.
6. They are strong swimmers and feed mostly on fish.

7.8 Class Anthozoa (Figure 7.20 and 7.21)

A. Characteristics

1. Anthozoans lack a medusa stage.
2. All anthozoans are marine, found in both deep and shallow water, and vary in size.
3. There are three subclasses: **Zoantharia, Ceriantipatharia** and **Alcyonaria.**
4. Zoantharia and Cerianthpatharia are hexamerous; Alcyonaria are octomerous (Figure 7.21).
5. Gastrovascular Cavity
   a. The cavity is large and partitioned by septa or mesenteries, inward extensions of body wall.
   b. Septa may be coupled or paired (Figure 7.22).
6. **Sea Anemones (Figure 7.24).**
   a. Actinaria polyps are larger and heavier than hydrozoan polyps.
   b. They attach to shells, rocks, timber, etc., by pedal discs; some burrow in mud or sand.
   c. A crown of tentacles surrounds the flat oral disc.
   d. A slit-shaped mouth leads into a pharynx.
   e. The **siphonoglyph** is a ciliated groove that creates the water current into the pharynx.
   f. Currents carry in oxygen and remove wastes, and maintain fluid pressure for a hydrostatic skeleton.
   g. The gastrovascular cavity is divided into six pairs of primary septa or mesenteries.

h. **Acontia threads** at lower ends of septal filaments may protrude through the mouth to help secure prey.
i. When in danger, water is rapidly expelled through pores as the anemone contracts to a small size.
j. Most harbor symbiotic algae; some have a mutualistic relationship with hermit crabs.
k. Some anemone fishes shelter in sea anemones and have a skin mucus that protects them from triggering nematocysts.
l. Reproduction
   1) Some have separate sexes and some are hermaphroditic.
   3) Gonads are on the margins of septa; fertilization is external or in the gastrovascular cavity.
   4) The zygote becomes a ciliated larva.
   5) In pedal laceration, small pieces of the pedal disc break off and regenerate a small anemone.
   6) Transverse fission occurs as well as budding.

7. **Zoantharian Corals**
   a. Members of the order Scleractinia are also known as true or stony corals.
   b. They are miniature sea anemones that live in calcareous cups they have secreted (Figure 7.25).
   c. Their gastrovascular cavity is hexamerous but there is no siphonoglyph.
   d. Instead of a pedal disc, they secrete a limey skeletal cup with sclerosepta projecting up into the polyp.
   e. A sheet of living tissue forms over the coral surface, connecting all gastrovascular cavities.
   f. Calcareous cup exoskeleton (Figure 7.25); example of Anthozoan (Figure 7.26).
8. **Octocorallian Corals**
   a. All have octomerous symmetry, eight pinnate tentacles and eight unpaired complete septa.
   b. All are colonial and gastrovascular cavities communicate through tubes called **solenia** (Figure 7.26).
   c. Solenia runs through an extensive mesoglea (coenenchyme).
   d. Alcyonarian corals show great variation. (Figure 7.28).
9. **Coral Reefs**
   a. Coral reefs have great productivity, rivaled only by tropical rainforests.
   b. Living plants and animals are limited to the top layer above the calcium carbonate deposits.
   c. **Reef-building corals** and **coralline algae** form most coral reefs.
   d. These corals require full salinity of seawater and warmth and light, limiting them to waters between 30 degrees north and south, optimal conditions for zooxanthellae.
   e. Microscopic zooanthellae are photosynthetic algae that live in coral tissues.
   f. They fix carbon dioxide for the coral as food source and recycle phosphorus and nitrogenous wastes.
   g. Coralline algae help build reefs with calcium carbonate.
   h. Nutrients from fertilizer and sewage threaten coral reefs with excessive algal growth.
   i. Coral reefs are suffering from global warming and high concentrations of carbon dioxide.
10. **Classification of Cnidaria**
    Class Hydrozoa
    Class Scyphozoa
    Class Staurozoa
    Class Cubozoa
    Class Anthozoa
      Subclass Zoantharia
      Subclass Ceriantipatharia
      Subclass Alcyonaria

7.8 Phylum Ctenophora

A. Ctenophore Life History

1. This phylum has fewer than 100 species.
2. All are marine species; most prefer warm waters.
3. Ctenophores have eight rows of comblike plates for locomotion (Figure 7.28).
4. Like cnidarians, they have primary radial symmetry.
5. Except for one species, they do not have nematocysts; the one species with nematocysts lacks colloblasts and apparently takes nematocysts from cnidarians it eats.
6. Nearly all are free-swimming; only a few creep or are sessile.
7. They use the ciliated combs to propel themselves forward (Figures 7.29 & 7.30).
8. Many are bioluminescent.

B. Form and Function

1. Comb Plates

a. Eight equally spaced bands called **comb rows** extend from the aboral to oral pole.
b. Each band is made of transverse plates of long fused cilia called **comb plates** (Figure 7.31).
c. The beat in each row begins at the aboral end and moves along combs to the oral end.
d. All eight rows beat in unison; this drives the animal forward mouth-first.

2. Tentacles
   a. The two tentacles are long, solid and extensible.
   b. They retract into a pair of tentacle sheaths.
   c. The surface bears **colloblasts** or glue cells that secrete sticky material to hold animals.
3. Digestion occurs in the pharynx.
4. Nervous System
   a. Their system resembles cnidarians; there is no central control.
   b. A subepidermal plexus is concentrated under each comb plate.
   c. The **statocyst** is a bell-like chamber; tufts of cilia sense changes in pressure from a **statolith** as the animal changes position.
   d. The epidermis bears sensory cells sensitive to chemical and other stimuli.
   e. When contacting an unfavorable stimulus, the cilia reverse their beat and it moves backward.
   f. Comb plates are sensitive to touch; they withdraw into the jelly when touched.
5. Reproduction and Development
   a. Ctenophores are monoecious.
   b. Fertilized eggs are discharged through epidermis into the water.
   c. A few species brood eggs.
   d. The larva are free swimming.

C. Classification of Ctenophora

Class Tentaculata
Class Nuda

7.9 Phylogeny and Adaptive Radiation

A. Phylogeny (Figure 7.1)

1. The most likely theory is that cnidaria and ctenophores arose from a radially symmetrical, planula-like ancestor.
2. Perhaps the trachyline **medusae** of Hydrozoa came first as they resemble the ancestral cnidaria and develop directly from planula and actinula larvae to medusa.
3. The alternative is the **anthozoan or polyp** life cycle was ancestral, the medusa form was added later.
4. Molecular evidence supports a common anthozoan ancestor of hydrozoans, scyphozoans, and cubozoans.
5. Molecular evidence also suggests ctenophores branched off the metazoan line after sponges but before the evolution of cnidarians.

B. Adaptive Radiation

1. Evolution in both phyla has remained close to the basic plan.
2. Cnidarians have diversified greatly for colonial life.