CHAPTER 8 STUDY GUIDE

8.1 Getting Ahead

A. Cephalization

1. Sessile animals survive well with radial symmetry.
2. Concentrating the sense organs on the head is an advantage to active animals that seek food; this provides an anterior and posterior end and **bilateral symmetry.**
3. Phyla are Platyhelminthes (flatworms), Nemertea (ribbon worms), and Gnathostomulida (jaw worms).

B. Position in Animal Kingdom and Biological Contributions

1. These are the simplest animals with primary bilateral symmetry.
2. They have a solid body without a coelom; they are the **acoelomate bilateria.**
3. Specialization of organs provides the **organ-system level** of organization.
4. They are **protostomes** with **spiral cleavage**; flatworms and nemerteans have **determinate cleavage.**
5. The mesoderm is well-defined; they are **triploblastic** with all three germ layers (Figure 8.1).
6. Along with cephalization, this is the beginning of a ladder-type of **nervous system.**
7. The simplest excretory or **osmoregulatory systems** appear.
8. Nemerteans have the **simplest circulatory system** and a one-way alimentary canal with both mouth and anus.

8.2 Phylum Platyhelminthes

A. Characteristics of Phylum Platyhelminthes

1. The generic term "worm" has since been reclassified into distinct groups.
2. A cellular **mesodermal parenchyma** replaced the gelatinous mesoglea.
3. In some platyhelminths, parenchyma is made of more muscle cells and fibers then cnidarian mesoglea.
4. Flatworms vary from a millimeter to many meters in length.
5. Some flatworms are free-living (e.g., "planaria" Figure 8.3); others are parasitic.
   a. Turbellarians are mostly free-living in aquatic or moist terrestrial environments (Figure 8.2); some are symbiotic or parasitic.
   b. All flukes and tapeworms are parasitic.
   c. Parasitic flatworms may have several hosts in their life cycle; some larvae may be free-living.
6. Three germ layers **(triploblastic)** present.
7. **Bilateral symmetry** and dorsoventrally flattened body.
8. **Syncytial tegument** with **rhabdites.**
9. Complete digestive system, but no internal body space **(acoelomate).**
10. Nervous system and simple sense organs present.
11. Excretory system of **flame cells (protonephridia).**
12. Respiratory, circulatory, and skeletal system lacking.
13. Class Turbellaria mostly free-living; classes Monogenea, Trematoda, and Cestoda are entirely parasitic.

B. Ecological Relationships

1. Freeliving flatworm (class Turbellia) are bottom dwellers in marine, freshwater, and moist places.
2. A few turbellarians such as *Dugesia* live in freshwater and are used in laboratory courses.
3. Most monogeneans are ectoparasites; trematodes and cestodes are endoparasites.
4. Many species have indirect life cycles with more than one host.

C. Form and Function

1. **Tegument and Muscles**
   a. Most turbellarians have a cellular, ciliated epidermis on a basement membrane.
   b. Rod-shaped rhabdites swell and form a protective mucous sheath.
   c. Most turbellarians have dual-gland adhesive organs (Figure 8.4).
      1) **Viscid gland cells** fasten microvilli of **anchor cells** to the substrate.
      2) Secretions of **releasing gland cells** provide a quick chemical detachment.
   d. Under the basement membrane, muscle fibers run circularly, longitudinally and diagonally.
   e. Parenchyma cells fill spaces in body; they are noncontractile portions of muscle cells.
   f. Some turbellarians, and all other members of this phylum, have a syncytial tegument; nuclei are not separated by cell membranes.
   g. The non-turbellarians lack cilia and have a tegument (Figure 8.5).
   h. A few turbellarions have a syncytial "in sunk" epidermis with cells located beneath the basement membrane.
2. **Nutrition and Digestion**

a. Cestodes have no digestive system; others (e.g., "planaria") have a mouth, pharynx and an intestine (Figure 8.6).
b. In planarians, the pharynx can extend through the mouth that is mid-ventrally located.
c. The intestine may be simple or branched.
d. This **gastrovascular cavity** is lined with columnar epithelium.
e. The mouth of flukes opens near the anterior end.
g. Monogeneans and trematodes feed on host cells, cellular debris and body fluids.
h. Proteolytic enzymes from the intestine are secreted for extracellular digestion.
i. Phagocytic cells in the gastrodermis complete digestion at intracellular level.
j. Undigested food is egested back out the pharynx.
k. Cestodes rely on the host's digestive tract and they absorb digested molecules.

3. **Excretion and Osmoregulation**
   a. Except in some turbellarians, flatworms have **protonephridia** with **flame cells** (Figure 8.6).
   b. Beating flagella drive fluids down collecting ducts, forming a negative pressure that draws fluids through a network or weir.
   c. The wall of the duct beyond the flame cell bears folds or microvilli to resorb certain ions and molecules.
   d. Collecting ducts empty to the outside by pores.
   e. Metabolic wastes are removed largely by diffusion through the body wall.
4. **Nervous System and Sense Organs**
   a. Flatworms are cephalized.
   a. The subepidermal nerve plexus resembles the nerve net of cnidarians.
   b. One to five pairs of longitudinal nerve cords lie under the muscle layer.
   d. Freshwater planarians have one ventral pair of nerve cords forming a ladder-type pattern; the brain is a bilobed ganglion anterior to the ventral nerve cords.
   e. Except in simpler turbellarians, nerves are now sensory, motor and association-types.
   f. Active locomotion favored cephalization and evolution of sense organs.
   g. **Ocelli** are light-sensitive eyespots in turbellarians, monogeneans and larval trematodes.
   h. Tactile and chemoreceptive cells are abundant, especially in the ear-shaped auricles.
   i. Some have statocysts for equilibrium and **rheoreceptors** for sensing direction of water currents.
5. **Reproduction and Regeneration**
   a. Fission
      1) Many turbellarians constrict behind the pharynx and separate into two animals.
      2) Each half regenerates the missing parts; this provides for rapid population growth.
      3) Some do not separate immediately, creating chains of zooids.
   b. Some asexual reproduction occurs in intermediate hosts; see life cycles to follow.
   c. Nearly all are monoecious but cross-fertilize.
   d. **Endolecithal** eggs are typical and ancestral.
   e. In endolecithal eggs, yolk for the developing embryo is contained within the shell.
   e. Some turbellarians and all other groups have female gametes with little yolk; it is contributed by separate organs, **yolk glands**.
      1) Yolk cells surround the zygote in **ectolecithal** eggs.
   f. Development may be direct or indirect.
   g. Embryo and larval stages are present in some flatworms.

D. Class Turbellaria

1. Turbellarians are mostly free-living and range from 5 mm to 50 cm long (Figure 8.7).
2. This class is distinguished by gut form and pharynx type.
3. The mouth is located on the ventral side and leads to a gut.
4. Most turbellarians with endolecithal eggs have no guts or have simple (unbranched) guts.
5. Polyclades have a folded pharynx, branched gut, and large size.
6. Very small planaria swim by cilia.
   a. Adults move by cilia and gliding over a slime track secreted by marginal adhesive glands.
   b. Rhythmical muscular waves pass backward from the head.
7. Turbellarians have a simple life style with no larva.
8. Some planarians attach by stalks to plants or stones after hatching.
9. The ciliated larva in marine turbellarians is similar to a trochophore.
10. The order Acoela is ancestral; their bodies were small with mouths but no gastrovascular cavity.
    a. Molecular evidence suggests acoels are a sister taxon to all other Bilateria.
    b. Acoels and some turbellarians now form a group called acoelomorphs.

c. Platyhelminthes is not monophyletic within acoelomorphs.
d. Turbellarians form a paraphyletic group.
e. Ectolecithal turbellarians form a clade with trematodes, monogeneans and cestodes.
f. A dual-gland adhesive system in some endolecithal turbellarians forms a clade with ectolecithal flatworms.

D. Class Trematoda

1. All trematodes are parasitic flukes.
2. Most adults are endoparasites of vertebrates.
3. They resemble ectolecithal turbellaria but the tegument lacks cilia in adults.
4. Adaptations for parasitism include:
   a. penetration glands,
   b. glands to produce cyst material,
   c. hooks and suckers for adhesion, and
   d. increased reproductive capacity.
5. Some trematodes retain ancestral turbellarian characteristics of alimentary canal and reproductive, excretory and nervous systems.
6. Sense organs are poorly developed.
7. **Subclass Digenea (medically and economically important)**
   a. Nearly all have an indirect life cycle with the **first intermediate host** being a mollusc.
   b. The **definitive** or **final host** where sexual reproduction occurs is a vertebrate.
   c. A second or third intermediate host may be required in the life cycle.
   d. They parasitize a wide range of hosts and most parts of most systems in hosts.
   e. **General Digenean Life Cycle**
      1) The **egg** passes from the definitive host in excreta and must reach water.
      2) The egg then hatches into a free-swimming ciliated larva, the **miracidium**.
      3) The miracidium penetrates the tissues of a snail and transforms into a **sporocyst**.
      4) The sporocyst reproduces asexually into more sporocysts or many **rediae**.
      5) Rediae reproduce asexually into more rediae or into **cercariae** with tails.
      6) Cercariae emerge from the snail and penetrate a second intermediate host or encyst on objects to become metacercariae, or juvenile flukes.
      7) The adult grows from a **metacercaria** when it is eaten by the definitive host.
   f. Serious parasites of humans and domestic animals are digeneans (Table 8.1).
   g. Sheep Liver Fluke: *Fasciola hepatica* was the first digenean whose life cycle was described.
   h. ***Clonorchis* Life Cycle (Figure 8.8)**
      1) This is the most important human liver fluke; it is common in China, Japan and Southeast Asia.
      2) It also infects cats, dogs and pigs.
      1) Adults live in bile passageways of humans and other fish-eating mammals.
      2) Eggs containing a complete miracidium are shed into water with feces.
      3) The eggs hatch only when ingested by snails of specific genera.
      4) The miracidium enters snail tissue and transforms into a sporocyst.
      5) A sporocyst produces one generation of rediae, which begin differentiation.
      6) Rediae pass into the snail liver and develop into free-swimming cercariae.
      7) Cercariae escape into water and swim until they contact a fish in the family Cyprinidae.
      8) Cercariae bore into fish muscles or under scales, and encyst as metacercariae.
      9) A mammal eating raw fish dissolves the cyst and young flukes migrate up the bile duct.
      10) A heavy infection can destroy the liver and result in death.
   i. ***Schistosoma*: Blood Flukes**
      1) Over 200 million people have **schistosomiasis**, infection with blood flukes.
      2) It is common in Africa, South America, West Indies, and the Middle and Far East.
      3) Three species account for most human schistosomiasis: *S. mansoni* in venules of large intestine, *S. japonicum* in venules of small intestine, and *S. haemotobium* in venules of urinary bladder.
   j. ***Schistosoma* Life Cycle (Figure 8.9).**
      1) Eggs are discharged in human feces or urine.
      2) In water, eggs hatch as ciliated miracidia; they must contact a particular species of snail to survive.
      3) In the snail, they transform to sporocysts that produce more sporocysts.
      4) Daughter sporocysts produce cercaria directly; cercariae escape from the snail and swim until they contact bare human skin.

5) Cercariae pierce the skin and shed their tails; they reach a blood vessel and make their way to certain body regions.
6) After developing in the liver, they migrate to their appropriate site.
7) Eggs released by females are extruded through the gut or bladder lining and exit with feces or urine.
8) Eggs that remain internal become centers of inflammation.
9) Eggs of *S. mansoni* and *S. japonicum* can damage the intestinal wall; *S. haematobium* damages the bladder wall.
10) Schistosome dermatitis (swimmer's itch) occurs when cercariae penetrate an unsuitable host such as a human (Figure 8.10).

E. Class Monogenea

1. Monogenetic flukes were originally placed in Trematoda; cladistic analysis places them closer to Cestoda.
2. Monogeneans are external parasites of fish, especially gills, but a few are found in bladders of frogs and turtles.
3. Monogeneans have a direct life cycle in a single host.
4. Monogeneans clamp onto the surface of a fish with a hooked opisthaptor (Figure 8.11).
5. Some are serious economic problems in fish farming.

F. Class Cestoda

1. Tapeworms have a unique flattened and segmented shape compared to other flatworms.
2. The **scolex** is a holdfast head portion with suckers and hooks.
2. Each trailing segment is a **proglottid** containing a set of reproductive organs (Figure 8.12).
3. As with Monogenea and Trematoda, the tegument is syncytial and has no cilia.
4. The entire surface of cestodes is covered with projections similar to microvilli seen in the vertebrate small intestine; these **microtriches** increase the surface area for food absorption (Figure 8.13).
5. Nearly all are monoecious.
6. Muscles, excretory and nervous systems are similar to other flatworms, they lack a digestive system.
7. They lack sensory organs except for modified cilia (Figure 8.13).
9. Nearly all cestodes require two hosts; the adult is parasitic in the digestive tract of the vertebrate.
    c. The main body is a chain of proglottids is called a **strobila** (Figure 8.14).
    d. Proglottids originate in the **germinative zone** just behind the scolex.
    e. A proglottid is usually fertilized by another proglottid in the same or different strobila.
    f. Shelled embryos form in the uterus; they are either expelled or the whole proglottid is shed.
10. Proglottid formation is not "true" segmentation; replication of sex organs is not equivalent to metamerism in annelids, etc.
11. Over 4000 species of tapeworms are known, infecting almost all vertebrates.
12. Most tapeworms do little harm to the host. Table 8.2 lists common cestodes of humans.
13. ***Taenia saginata*: Beef Tapeworm**
    a. This tapeworm lives as an adult in the alimentary canal of humans; the juvenile form is found in intermuscular tissue of cattle.
    b. Mature adults can reach over 7 meters in length.
    c. Gravid proglottids (with shelled, infective larvae) pass in feces.
    d. Life Cycle (Figure 8.15).
        1) Cattle swallow shelled larvae that hatch and burrow into blood and lymph vessels.
        3) When they reach voluntary muscle, they **encyst** to become bladder worms (**cysticerci**).
        4) When the infected meat is eaten, the cyst wall dissolves and the scolex evaginates to attach to intestinal mucosa.
        5) New proglottids develop in 2-3 weeks
        6) Infected persons expel numerous proglottids daily.
    e. Infection can be avoided by eating only thoroughly cooked beef.
14. ***Taenia solium*: Pork Tapeworm**
    a. This tapeworm lives as an adult in the small intestine of humans; juveniles live in muscles of pigs.
    b. If eggs or proglottids are ingested, the embryos migrate to organs and form **cysticerci**.
    c. **Cysticercosis** commonly occurs in eyes or the brain causing expected symptoms or death (Figure 8.16).

G. Classification of Phylum Platyhelminthes

Class Turbellaria

Class Trematoda
Class Monogenea
Class Cestoda

8.3 Phylum Nemertea (Rhynchocoela)

A. Characteristics

1. Nemerteans are often called ribbon worms; an alternative phylum name is Rhynchocoela.
2. They have a long muscular tube, the proboscis.
3. There are over 1000 species; most are less than 20 cm long (Figure 8.17) though some are several meters long (Figure 8.19).
4. Their general body plan is similar to that of turbellarians.
5. The epidermis is ciliated and has many gland cells.
6. The excretory system has flame cells; several have rhabdites.
7. The ciliated larva in marine forms resembles the trochophore larvae of annelids and molluscs.

B. Form and Function (Figure 8.18).

1. Slender and fragile, longer ones are difficult to study in the laboratory.
   a. *Amphiporus* is a common example; it is 20-80 mm long.
   b. It is dorsoventrally flattened with rounded ends.
   c. The body wall is ciliated columnar cells and layers of circular and longitudinal muscles.
   d. The adult has an anus, producing a complete digestive system that is more efficient.
   e. The anterior end has ocelli, a mouth and a separate opening of the proboscis.
   f. The proboscis is an eversible organ protruded from a rhynchocoel for defense and catching prey.
   g. The proboscis is everted by fluid pressure and retracted by muscles; it has a sharp-pointed stylet at the tip.
   h. Movement is by both musculature and cilia.
   i. Some glide on the substrate.
2. Nemerteans are carnivorous and eat dead or living prey.
   a. The slime-covered proboscis wraps around prey and the stylet pierces and holds prey until it is thrust into the mouth.
3. There is no heart; blood is moved by muscular walls of blood vessels.
4. Protonephridia are so closely associated with circulatory system that they are truly excretory rather than simply osmoregulatory in function as in flatworms.
5. The nervous system consists of paired ganglia, longitudinal nerves, and transverse nerves.
6. Most nermertans are dioecious, some reproduce by fragmentation and regeneration.

8.4 Phylum Gnathostomulida

A. Characteristics (Figure 8.20)

1. Over 80 species of jaw worms in 18 genera have been described.
2. They are delicate worm-like animals, 0.5 to 1 mm long.
3. They live in crevices of sediment and silt and endure low oxygen; they are often very common.
4. They lack a pseudocoel, circulatory system and anus and were formerly grouped with turbellarians.
5. Their parenchyma is poorly developed; the pharynx is similar to a rotifer mastax.
6. The pharynx has lateral jaws to scrape fungi and bacteria from the substrate.
7. The epidermis is ciliated but with only one cilium per cell.
8. Because of pharynx and jaw similarities, a new clade is proposed – Gnathifera.
9. This clade unites Ritifera, Acanthocephala, Micrognathozoa, and Gnathostomulida.

8.5 Phylogeny and Adaptive Radiation

A. Phylogeny (Figure 8.21)

1. A planuloid ancestor probably gave rise to sessile branch that was radial and another branch that became creeping and bilateral.
2. Bilateral symmetry provided cephalization, an advantage where sensory structures move to the head.
3. Ribosomal DNA, embryonic cleavage patterns and mesodermal origin indicate the acoels are outside the Platyhelminthes and a sister group of all other Bilateria.
4. Nemertea and Gnathostomulida belong to Lophotrochozoa along with the other flatworms but not the acoels.
5. Even excluding acoels, the taxon Turbellaria is paraphyletic but nevertheless convenient.
   a. Ectolecithal turbellarians are allied with trematodes, monogeneans and cestodes in a sister group to endolecithal turbellarians.

b. Ectolecithal turbellarians share characteristics with trematodes and cestodes as a group Cercomeria.
c. Trematodes, monogeneans and cestodes form a monophyletic group.

6. Jaw similarities suggest gnathostomulids and rotifers are closely related.

B. Adaptive Radiation

1. Their body shape and metabolic requirements were ideal for parasitic lifestyles.
2. Ribbon worms evolved beyond flatworms for a narrow predatory niche.
3. Jaw worms exploited the marine interstitial environment in low oxygen zones.