

# CHAPTER 29 INTRODUCTION TO INVERTEBRATES

## Chapter Outline

### 29.1 Evolution of Animals

#### A. Animal History

1. The fossil record is more complete for hard-shelled animals than for animals lacking a shell.
2. Possible evolutionary relationships are primarily worked out by using anatomical criteria.
3. There are over 30 animal phyla; we consider the major invertebrate phyla and the chordates.

#### B. Criteria for Classification

##### 1. Levels of Organization

- a. Animals may have the cellular, tissue, or organ level of organization.
- b. **Germ layers** refer to the number of layers of tissues.
- c. Most animals are made of three **tissue layers**: endoderm, ectoderm and mesoderm.
- d. Animals with only ectoderm and endoderm are limited to a **tissue level of organization**.
- e. Animals with three tissue layers develop an **organ level of organization**.

##### 2. Type of Body Plan

- a. Animals with a sac plan have an incomplete digestive system with only one opening used for both entrance and exit of food.
- b. Animal with the tube-within-a-tube plan have a complete digestive system with separate entrance and exit to the digestive system; this allows specialization zones along the digestive tract.

##### 3. Types of Symmetry

- a. **Asymmetry** means there is no particular symmetry.
- b. **Radial symmetry** describes body parts arranged around an axis, like spokes of a wheel.
  - 1) Radially symmetrical animals may be **sessile** (i.e., attached to a substrate or less motile).
  - 2) This symmetry enables an animal to reach out in all directions from one center.
- c. **Bilateral symmetry** describes a body having a right and left, or complementary halves.
  - 1) Only one longitudinal cut down the center produces mirror halves.
  - 2) Bilaterally symmetrical animals tend to be active and to move forward at an anterior end.
  - 3) The development of a head to localize the brain and sensory organs is called **cephalization**.

##### 4. Type of Coelom

- a. **True coelomates** possess a body cavity or **coelom** completely lined with mesoderm.
- b. **Acoelomates** lack a body cavity or coelom although they have mesoderm.
- c. **Pseudocoelomates** possess a **pseudocoelom**; the body cavity is incompletely lined by mesoderm because the cavity develops between the mesoderm and endoderm.
- d. Coelomates are either protostomes or deuterostomes.
- e. **Protostomes** have an embryonic development where the first embryonic opening becomes the mouth.
- f. **Deuterostomes** develop with the second opening becoming the mouth.

##### 5. Segmentation is repetition of body parts along the length of the body.

- a. Among coelomates, molluscs and echinoderms are non-segmented.
- b. Annelids, arthropods, and chordates are segmented.
- c. Segmentation leads to specialization of parts as they differentiate for specific purposes.

### 29.2 Multicellularity

#### A. About 5,000 species of **sponges** are in the phylum **Porifera**.

1. Sponges have no symmetry and no tissues; they are to the side from the mainstream of animal evolution.
2. Sponges remain at a cellular level of evolution, having evolved separately from protozoan ancestors.
3. Sponges are aquatic, largely marine animals, that vary greatly in size, shape, and color.
4. Their saclike bodies are perforated by many pores; Porifera means “pore-bearing.”
5. Their cell organization is demonstrated by fragmenting a sponge; cells survive and reorganize into a sponge.
6. Several types of cells are found in a sponge.

- a. The outer layer of their wall contains flattened epidermal cells; some have contractile fibers.
  - b. Middle layer is a semifluid matrix with wandering amoeboid cells and spicules.
  - c. Inner layer is composed of **collar cells** (choanocytes).
  - d. There are no nerve cells or means of coordination between cells.
7. Beating collar cells produce currents through pores in wall into a central cavity and out through osculum.
  8. Simple sponges 10 cm tall can filter as much as 100 liters of water a day.
  9. Sponges are **sessile filter feeders**; they stay in one place and filter food from the water.
    - a. Collar cells engulf and digest food particles in food vacuoles, or pass them to amoeboid cells.
    - b. Amoeboid cells transport nutrients from cell to cell, and they also produce gametes and spicules.
  10. Sponges reproduce asexually by budding, which can produce quite large colonies.
  11. Fragmentation occurs when sponges are chopped up; each piece can start a complete sponge.
  12. Sponges reproduce sexually when eggs and sperm are released into a central cavity; the zygote develops into a ciliated larva.
  13. Sponge classification is partly based on the chemistry of its skeleton composed of spicules.
    - a. **Spicules** are tiny needle-shaped structures with one to six rays, depending on chemical structure.
    - b. Chalk sponges have spicules composed of calcium carbonate.
    - c. Glass sponges have spicules of silica.
  14. **Spongin** is a protein made of modified collagen, it gives a sponge its flexibility.

### 29.3 Two Tissue Layers

- A. About 90 species of **comb jellies** are in the phylum **Ctenophora**.
  1. Comb jellies develop only ectoderm and endoderm (are diploblasts), and are radially symmetrical.
  2. Comb jellies are transparent and often luminescent; their eight plates of fused cilia resemble long combs.
  3. Most of their body is a jellylike packing material called **mesoglea**.
  4. They are the largest animals to be propelled by beating cilia.
  5. Long tentacles covered with sticky filaments—or an entire body covered by sticky mucus—captures prey.
- B. Cnidarians
  1. About 9,000 species of cnidarians are in the phylum **Cnidaria**.
  2. Cnidaria also develop only ectoderm and endoderm and are tubular or bell-shaped.
  3. They mostly live in coastal waters but there are oceanic jellyfish and freshwater hydras.
  4. Cnidaria have **cnidocytes**, a specialized cell that contains a **nematocyst**.
    - a. The **nematocyst** is a fluid-filled capsule, which contains a long, spirally coiled hollow thread.
    - b. When the trigger of the cnidocyte is touched, the nematocyst is discharged.
    - c. Some threads merely trap prey or predators; others have spines that penetrate and inject paralyzing toxins.
  5. A cnidarian body is a two-layered sac with the epidermis derived from ectoderm.
  6. The inner tissue layer derived from the endoderm secretes digestive juices into the **gastrovascular cavity**.
  7. The gastrovascular cavity digests food and circulates nutrients.
  8. There are muscle fibers at the base of the epidermal and gastrodermal cells.
  9. Nerve cells located below the epidermis near the mesoglea interconnect and form a **nerve net**.
    - a. Unlike highly organized nervous systems, this nerve net transmits impulses in several directions at once, which results in multiple firings of nematocysts in parts not directly stimulated.
    - b. Having both muscle fibers and nerve fibers, these animals are capable of directional movement, the body can contract or extend, and tentacles that ring the mouth can extend to grasp prey.
  10. Cnidaria have two basic body plans.
    - a. A **polyp** is vase-shaped and the mouth is directed upward.
    - b. A **medusa** is bell-shaped and the mouth is directed downward.
    - c. A medusa has more mesoglea than a polyp; tentacles are concentrated on the margin of the bell.
    - d. Both body forms may have been a part of life cycle of early cnidaria.

- e. When both stages are present, the animal is dimorphic and the polyp stage is sessile and produces the medusae.
  - f. The medusa stage is motile and produces the egg and sperm, dispersing the species.
- C. Cnidarian Diversity
1. Sea anemones and corals are in the class **Anthozoa**.
    - a. Sea anemones are solitary polyps 5–100 mm in height and 5–200 mm in diameter or larger.
    - b. Many are brightly colored and resemble flowers.
    - c. A thick, heavy body supports a mouth that is surrounded by hollow tentacles.
    - d. Sea anemones feed on invertebrates and fish.
    - e. They attach to rocks, timbers, etc., or may be mutualistic and attach to a hermit crab's shell.
    - f. Corals may be solitary; most are colonial.
    - g. Most corals live in shallow waters; the accumulation of their calcium-carbonate remains builds **reefs**.
  2. Class **Hydrozoa** includes hydras and Portuguese man-of-war (*Physalia*).
    - a. The polypoid stage is dominant.
    - b. The Portuguese man-of-war is a colony of polyps; the original polyp becomes a gas-filled float.
    - c. Other polyps bud to specialize for feeding or reproduction.
    - d. It can cause serious injury to swimmers with a tentacle having numerous nematocysts; each tentacle arises from the base of each feeding polyp.
  3. The class **Scyphozoa** includes the true jellyfishes (e.g., *Aurelia*).
    - a. The medusa stage is dominant in jellyfish; the polyp remains small.
    - b. Jellyfishes are an important part of the zooplankton, the food for larger marine animals.
- D. *Hydra* and *Obelia*
1. *Hydra* are solitary, freshwater hydrozoan polyps.
    - a. The hydra body is a small tube about one-quarter inch in length.
    - b. Four to six tentacles containing nematocysts surround the mouth, the only opening at one end.
    - c. *Hydra* move by gliding or somersaulting.
    - d. Hydras have both muscular and nerve fibers, and respond to touch.
  2. *Hydra* Anatomy
    - a. Epidermal cells are termed **epitheliomuscular cells** and contain muscle fibers.
    - b. Cnidocytes and sensory cells are in the epidermis.
    - c. Interstitial cells can produce an ovary or testis, and may assist regeneration.
    - d. **Gland cells** secrete digestive juices into a gastrovascular cavity; the tentacles capture and stuff in prey.
    - e. Digestion is completed within food vacuoles of **nutritive-muscular cells**.
    - f. Nutrients then diffuse to the rest of the cells in the body.
  3. *Hydra* Reproduction
    - a. *Hydra* reproduces asexually by budding.
    - b. In sexual reproduction, sperm from a testis swim to an egg within an ovary; after early development within an ovary, a protective shell allows the egg to survive until conditions are optimum for it to emerge.
  4. *Obelia* is a colony of polyps enclosed in a hard, chitinous covering.
    - a. **Feeding polyps** have nematocysts and extend beyond the covering to capture tiny worms, etc.
    - b. Polyps are connected and partially digested food is distributed through the colony.
    - c. A colony increases in size by asexually budding new polyps.
    - d. **Reproductive polyps** bud off the medusae stage which is free-living or attached to the colony.
    - e. *Obelia* medusae tentacles have nematocysts; the gastrovascular cavity extends into tentacles.
    - f. A nerve net runs in two rings around the bell margin; it has statocysts for balance and ocelli to detect light.
    - g. Sperm and egg from medusae unite; the resulting zygote develops into a ciliated planula larva that settles down to develop into a polyp colony.
  5. Evolutionary History of Cnidaria
    - a. Some biologists propose that a planuloid-type organism gave rise to both the cnidaria and the flatworms.
    - b. Cnidaria have two tissues and are radially symmetrical; flatworms have three germ layers and bilateral symmetry.

## 29.4 Bilateral Symmetry

- A. Triploblasts
  1. All animals beyond this point are **triploblasts** with three germ layers.
  2. Flatworms have a **sac body plan** while ribbon worms have a tube-within-a-tube body plan.
  3. The **tube-within-a-tube plan** allows specialization of parts along the tube.
- B. About 650 species of marine ribbon worms are in phylum **Nemertea**.
  1. Ribbon worms have a distinctive eversible **proboscis** stored in a rhynchocoel.
  2. When walls of the rhynchocoel are contracted, the proboscis is everted.
  3. The proboscis is a long, hollow tube that is shot outward through a pore located just above the mouth.
  4. The proboscis is used for prey capture, defense, locomotion, and burrowing.
- C. Flatworms
  1. 13,000 species of flatworms belong to phylum **Platyhelminthes**.
  2. Classification
    - a. Planaria and relatives are freshwater animals in the class **Turbellaria**.
    - b. Flukes are external or internal parasites in the class **Trematoda**.
    - c. Tapeworms are internal parasites in the class **Cestoda**.
  3. In addition to endoderm and ectoderm, a mesoderm layer gives rise to muscles and reproductive organs.
  4. There is no coelom; they are acoelomates.
  5. A branched gastrovascular cavity is the site of extracellular digestion and it distributes nutrients about the body.
  6. The flat, thin body allows gas exchange to occur by diffusion.
  7. An excretory system functions as an osmotic-regulating system.
  8. Flatworms are bilaterally symmetrical; free-living forms exhibit **cephalization**, the development of a head region.
  9. Flatworms have a **ladder-type nervous system**.
    - a. Paired ganglia form a brain.
    - b. Sensory cells are in the body wall.
- D. Free-living Flatworms
  1. Turbellaria include freshwater planaria such as the planaria *Dugesia*.
  2. Planaria live in lakes, ponds, and streams and feed on small living or dead organisms.
  3. The head is bluntly arrow-shaped; side extensions (auricles) are sensory organs to detect food and enemies.
  4. The two light-sensitive eyespots have pigmentation that makes them look cross-eyed.
  5. Three muscle layers—an outer circular, an inner longitudinal, and a diagonal—allow for varied movement.
  6. In larger forms, locomotion is accomplished by movement of cilia on ventral and lateral surfaces.
  7. Numerous gland cells secrete a mucous material upon which the animal moves.
  8. Digestion
    - a. It captures food by wrapping itself around prey, entangling it in slime, and pinning it down.
    - b. The **pharynx** is a muscular tube that extends through the mouth and through which food is ingested.
    - c. In a three-branched gastrovascular cavity, digestion is both extracellular and intracellular.
  9. Excretion
    - a. The **flame-cell system** consists of a series of interconnecting canals that run length of the body on either side of the longitudinal axis and side branches of the canals.
    - b. A **flame cell** is a bulb-shaped cell containing a tuft of cilia inside the hollow interior of the bulb; cilia move back and forth, bringing water into canals that empty through pores at the surface.
    - c. It functions in both water excretion and osmotic regulation.
  10. Planaria can reproduce both sexually and asexually.
    - a. They constrict beneath the pharynx; each half will grow into a whole animal—regeneration.
    - b. Planaria are **hermaphroditic**, possessing both male and female sex organs.
    - c. Planaria cross-fertilize each other.
    - d. Fertilized eggs are enclosed in a cocoon and hatch in two to three weeks into tiny worms.

## E. Parasitic Flatworms

1. As parasites, flukes and tapeworms have characteristic modifications.
  - a. Loss of predation allows a lack of cephalization; the head carries hooks and suckers to attach to a host.
  - b. There is extensive development of reproductive system with loss of other systems.
  - c. Well-developed nervous and gastrovascular systems are not needed; it does not seek out or digest prey.
  - d. Flukes and tapeworms are covered by a **tegument** that protects them from host digestive juices.
2. Two Hosts
  - a. Flukes and tapeworms use a secondary (intermediate) host to travel from primary host to primary host.
  - b. A primary host is infected with sexually mature adults; the secondary host contains the larval stage(s).

## F. Flukes

1. The class **Trematoda** includes the flukes.
2. Blood, liver, and lung flukes inhabit those organs.
3. Fluke bodies are generally oval and elongate.
4. At the “head,” an oral sucker is surrounded by sensory papillae; another sucker also helps attach.
5. Flukes have reduced digestive, nervous, and excretory systems.
6. The reproductive system is well developed and they are usually hermaphroditic.
7. The blood fluke causes **schistosomiasis**.
  - a. Schistosomiasis disease is found predominantly in tropical Africa and South America where about 800,000 infected persons die each year.
  - b. Blood flukes are male or female; the female fluke deposits eggs in blood vessels around the intestines.
  - c. The eggs migrate to the intestine and are passed out with feces.
  - d. Tiny larvae hatch in water and swim until they detect and enter a particular species of snail.
  - e. The larvae reproduce asexually inside the snail and eventually leave the snail.
  - f. If the larvae penetrate the skin of the human body, they begin to mature in the liver and implant in the small intestine blood vessels.
  - g. A weakened person is more likely to die from secondary diseases.
8. The Chinese liver fluke requires two intermediate hosts (a snail and a fish).
  - a. Humans become infected when they eat uncooked fish.
  - b. Adults live in the liver and deposit eggs in the bile duct, which carries eggs to the intestine.
  - c. Larval flukes must then pass through two intermediate hosts, a snail and a fish.

## G. Tapeworms

1. A tapeworm head or **scolex** contains hooks and suckers for attachment to intestinal wall of host.
2. Behind this head is a short neck and then a long string of **proglottids**.
3. Each proglottid segment contains a full set of both male and female sex organs and little else.
4. There are excretory canals but no digestive system and only rudiments of nerves.
5. After fertilization, proglottids become a bag of eggs; mature proglottids break off and pass out with feces.
6. If eggs of tapeworms are ingested by pigs or cattle, larvae become encysted in the muscle of hosts.
7. The covering of ingested eggs is digested away and larvae burrow through intestinal wall and travel by bloodstream to lodge and encyst in muscle.
8. A cyst is a hard-walled structure sheltering a larval worm.
9. If humans eat the meat of infected pigs or cattle and fail to cook the meat properly, they too become infected.

## 29.5 A Pseudocoelom

### A. Roundworms

1. The pseudocoelom is a body cavity that is incompletely lined with mesoderm.
2. Body support is provided by the hydrostatic pressure of fluid in the pseudocoelom pressing against a tough cuticle.
3. Perhaps 90,000 species of roundworms are in the phylum **Nematoda**.
4. These worms are unsegmented and have a smooth outside wall.
5. Nematode worms are found almost everywhere: sea, fresh water, soil, etc.

6. Many are scavengers or parasites; some are predators.
7. *Ascaris*
  - a. Males are smaller than females and their posterior end curves to a point.
  - b. These worms move by whiplike motions because only longitudinal muscles lie next to the body wall.
  - c. Mating produces eggs that mature in the soil; therefore, most are limited to warmer climates.
  - d. When eggs are swallowed, larvae burrow through intestinal wall to the liver, heart and/or lungs.
  - e. In the lungs, the larvae molt; after 10 days they migrate up the windpipe to the throat and are swallowed.
  - f. Back in the intestine, mature worms mate and the female deposits eggs that are lost with feces.
  - g. Feces must reach mouth of the next host to complete a life cycle; therefore proper sanitation easily prevents infection.
8. **Trichinosis** is a serious infection.
  - a. Humans contract *Trichinella* eating raw pork with encysted larvae.
  - b. After maturation, female adult burrows into the wall of the small intestine and produces living offspring that are carried by bloodstream to skeletal muscles where they encyst.
9. Filarial worms cause various diseases.
  - a. *Dirofilaria* is the heartworm parasite of dogs and is a common filarial worm of temperate zones.
  - b. **Elephantiasis** occurs in tropical Africa.
    - 1) It is caused by a filarial worm that utilizes the mosquito as a secondary host.
    - 2) Adult worms reside in and block the lymphatic vessels; ultimately this results in the limbs of an infected individual swelling to monstrous size.
    - 3) It is treatable only in the early stages but not after scar tissue has blocked the lymphatic vessels.

#### A. Rotifers

1. About 2,000 species of rotifers belong to phylum **Rotifera**.
2. Rotifers are abundant in freshwater.
3. Although microscopic and easily confused with protozoans, rotifers are multicellular with a pseudocoelom and organs.
4. A crown of cilia (corona) causes a rotating motion; this organ of locomotion also directs food to mouth.