

# CHAPTER 45: MOLLUSKS AND ANNELIDS

## CHAPTER SYNOPSIS

Mollusks include a wide variety of animals: snails, slugs, clams, scallops, cuttlefish, octopuses, squids, and many others. All mollusks are bilaterally symmetrical, have a visceral mass, and a muscular foot. Digestive, reproductive, and excretory organs are located within the visceral mass. Respiratory organs, gills or lungs, are located within the mantle cavity. Many of them possess durable external shells, a product of the outer layer of the mantle; others have internal shells and a few possess no shell at all. Most mollusks exhibit a trochophore larval stage that may be followed by a second veliger larval stage. They are divided into seven classes, the ancestral form most closely resembling the chitons, class Polyplacophora. The gastropods, snails and slugs, have a distinct head with tentacles and glide on mucus secreted by the foot. Their visceral mass may be enclosed in a single spiral shell and is asymmetrical because of torsion during development. Bivalve mollusks possess two shells hinged together at the dorsal edge. They lack distinct heads and are generally filter feeders. Octopuses, squids, and nautilus comprise the class Cephalopoda. They have distinct heads and a series of tentacles evolved from the muscular foot. Cephalopods have highly developed nervous systems with elaborate eyes. They are the most intelligent and the largest invertebrate.

Annelids are segmented worms. Segmentation allows for more efficient locomotion as it increases overall flexibility. If an organ in one segment is damaged, duplicate organs in other segments continue to operate. Each segment is an

individual hydrostatic unit, capable of independent contraction, that possesses external chitinous bristles called setae. Annelids are constructed as a tube (the digestive tract) within a tube (the coelom). They have an organized nervous system with a well-developed brain and separate ganglia in each segment. Annelids possess a closed circulatory system with pulsating "hearts," but lack discrete respiratory organs. Gas exchange occurs across the surface of their skin, limiting their size and restricting them to moist environments. They are divided into three classes: Polychaeta (marine worms), Oligochaeta (earthworms), and Hirudinea (leeches). Marine worms are active predators and clearly ancestral to the other classes and related to mollusks by their trochophore larvae. Earthworms are represented by both terrestrial and aquatic forms, although the most common form is readily found in nearly everyone's backyard soil. Leeches are highly specialized, frequently parasitic worms that clearly evolved from the Oligochaetes.

Three phyla of animals share characteristics with and are intermediate between the protostomes and the deuterostomes. They include the phoronids, the ectoprocts, and the brachiopods, collectively called the lophophorate animals. They all exhibit a circular or U-shaped ridge around the mouth that functions in gas exchange and food collection. Their coelomic cavity lies within the lophophore. They vary most greatly in their developmental processes, either being protostome-like or deuterostome-like, but all possess clearly protostomic ribosomes.

## CHAPTER OBJECTIVES

- ä Understand the basic organization of a mollusk and the importance of the mantle.
- ä Describe the differences in body plan, reproduction, feeding, and respiration among the gastropods, bivalves, and cephalopods.
- ä Explain the advantages of segmentation in coelomic organisms and indicate the phyla that exhibit segmentation in either the adult or embryonic form.
- ä Understand the basic organization of annelids and how their organ systems compare to those of mollusks.
- ä Indicate how the annelids are more advanced than the mollusks.

- ä Understand how earthworms, polychaetes, and leeches differ from one another.
- ä Describe lophophorates and indicate their relationships to protostomes and deuterostomes.

## KEY TERMS

annelid worm  
bivalve mollusk  
clitellum  
foot  
gill  
gonad  
head

lophophore  
mantle  
nephridia  
nephrostome  
parapodia  
radula  
septa

seta (setae)  
torsion  
trochophore larva  
veliger larva  
visceral mass  
zoecium

## CHAPTER OUTLINE

### 45.0 Introduction

#### I. HIGHER INVERTEBRATES POSSESS A COELOM

- A. Mollusks and Annelids Are Two Major Coelomic Phyla fig 45.1
- B. Lophophorate Phyla Are Intermediate Between Protostomes and Deuterostomes

### 45.1 Mollusks were among the first coelomates

#### I. COELOMATES

##### A. Allows for Development of Complex Tissues and Organs

1. Repositions fluid in body
2. Evolution of a wide variety of body architectures
3. Enabled growth to great sizes

##### B. Mollusks

1. Include snails, slugs, clams, scallops, oysters, cuttlefish, octopuses fig 45.2
2. May possess durable shells
3. Characterized by a coelom fig 45.3
4. Widespread and abundant in marine, freshwater, and terrestrial habitats
5. Have successfully adapted to the land
  - a. Terrestrial forms occur in seasonally moist places
  - b. Surpassed by only arthropods in terms of success on land

##### C. Economic Importance

1. Sources of human food
2. Production of pearls and shell material
3. Have deleterious effects as well
  - a. Destructive to submerged timbers and planking
  - b. Zebra mussels have negatively impacted American aquatic ecosystems
  - c. Extensive crop and flower damage caused by snails and slugs
  - d. Serve as intermediate hosts for many serious parasitic diseases
4. Includes largest invertebrates
  - a. Giant squid exist in great numbers, but are rarely caught
  - b. Giant clam may reach 1.5 meters and 270 kilograms fig 45.4

## II. BODY PLAN OF THE MOLLUSKS

## A. Exhibit Distinct Bilateral Symmetry

fig 45.5

1. Possess a visceral mass covered with soft epithelium
2. Muscular foot is involved in locomotion
3. May have a well-defined head at the anterior end of the body
4. Folds from dorsal body wall form mantle
  - a. Mantle cavity may serve as lung or gills located within it
  - b. Gills are specialized portion of mantle
    - 1) Comprised of filamentous projections rich in blood vessels
    - 2) Highly efficient, extract 50% of oxygen from water
  - c. Outer surface of mantle may secrete protective shell
    - 1) Horny protein outer layer
    - 2) Calcium carbonate middle layer
    - 3) Pearly inner layer, thickens with age of animal
    - 4) Bivalve mollusks may produce pearls of shell material around foreign objects
5. Some forms can withdraw into shell
6. Continuous stream of water flows through mantle of aquatic mollusks
  - a. Water brings in oxygen and, in the bivalves, also food
  - b. Carries out wastes
  - c. May carry out gametes when they are formed
7. Muscular foot adapted for locomotion, attachment, food capture
  - a. Cephalopod foot divided into arms or tentacles
  - b. Foot of free-swimming, pelagic forms modified into fins
8. All mollusks except bivalves possess a rasping, tongue-like radula
  - a. Composed of dozens of rows of chitinous teeth
  - b. Some gastropods scrape algae with radula
  - c. Predatory gastropods use radula to drill holes in shells of their prey
9. Circulatory system consists of a heart and open flowing system
  - a. Three-chambered heart: Two collect from gills, third pumps to body
  - b. Coelom is primarily represented by small area around the heart
10. Excretory system is more efficient than that of lower invertebrates
  - a. Nitrogenous wastes removed by tubular nephridia
  - b. Funnel-shaped, cilia-lined nephrostome collects waste from coelom
  - c. Coiled tube from nephrostome connects to bladder
  - d. Bladder connected to excretory pore
  - e. Wastes collected from only coelom
  - f. Waste discharged into mantle cavity
  - g. Nutrients and salts reabsorbed to maintain osmotic balance
11. Advantages of a closed circulatory system
  - a. Coiled tubule of nephridium surrounded by capillary network
    - 1) Wastes extracted from circulatory system through capillaries
    - 2) Transferred to nephridium and discharged
    - 3) Salts, water, other materials reabsorbed from nephridium tubule
    - 4) Returned to capillary circulation
  - b. Far more efficient than flame cells of acoelomates
  - c. Flame cells pick up wastes only from body fluids
  - d. One of earliest lines to develop efficient circulatory system

fig 45.6

## B. Reproduction in Mollusks

1. Most have separate sexes, few hermaphroditic forms
  - a. Cross-fertilization is the rule, even in hermaphrodites
  - b. Some may change sex within one season
2. Fertilization is generally external, except in gastropods

- a. Many form free-swimming trochophore larvae fig 45.7a
- b. Resembles larval stage of marine annelids
- c. A second free-swimming veliger stage may precede adult form fig 45.7b
- d. Mollusks dispersed through larval forms

### III. THE CLASSES OF MOLLUSKS

#### A. Seven Classes of Mollusks

1. Four classes examined in detail
  - a. Polyplacophora: Chitons
  - b. Gastropoda: Snails, slugs, limpets
  - c. Bivalvia: Clams, oysters, scallops
  - d. Cephalopoda: Squids, octopuses, cuttlefishes, nautilus
2. Living and fossil mollusks provide information on evolutionary relationships
  - a. Probable ancestor was dorsoventrally flattened, worm-like, and unsegmented
  - b. May have chitinous cuticle and overlapping calcareous plates
  - c. Ancestor may have been segmented even though current forms are unsegmented

#### B. Class Polyplacophora: The Chitons

1. Have oval bodies with eight overlapping calcareous plates
2. Plates believed to be evidence of prior segmentation
3. Chitons creep along on broad, flat foot
  - a. Foot surrounded by groove or mantle cavity
  - b. Gills arranged within mantle cavity
4. Most chitons are shallow water grazing herbivores, some live in depths

#### C. Class Gastropoda: The Snails and Slugs

1. Basic features fig 45.8
  - a. Primarily marine, also freshwater and terrestrial forms
  - b. Possess single shell or are derived from shelled forms
  - c. Move via the foot, may be modified for swimming
  - d. Head possesses paired tentacles that may have terminal eyes
  - e. Mouth may have horny jaws and radula
2. Visceral mass asymmetrical because of torsion during development
  - a. Mantle cavity and anus moved from posterior to position near mouth
  - b. Lateral muscles of embryo grows disproportionately, 120° rotation
  - c. Twisting of shell, coiling, is a separate process
  - d. Associated with other anatomical changes, loss of right gill and nephridium
  - e. Visceral mass is bilaterally asymmetrical
3. Display varied feeding habits
  - a. Include predator, algae scrapers, and scavengers
  - b. Terrestrial herbivores are serious garden pests
  - c. Oyster drills bore into other mollusk shells, suck out insides
  - d. Cone shells are predators with harpoon-like radula
  - e. Some nudibranchs possess nematocysts obtained from cnidarian polyps
4. Terrestrial forms evolved a rudimentary lung under mantle
  - a. Animals live in environment with plenty of oxygen
  - b. More efficient than a gill would be under similar conditions

#### D. Class Bivalvia: The Bivalves

1. Includes clams, scallops, mussels, oysters
2. Basic features fig 45.9
  - a. Have two shells hinged together dorsally (left and right sides)
    - 1) Held together by a ligament

- 2) Close with contraction of adductor muscles
    - b. Mantle secretes shells and ligament, encloses internal organs within shells
      - 1) Mantle often forms incurrent and excurrent siphons
      - 2) Pair of complex, folded gills located under folds of the mantle
      - 3) Are sessile filter-feeders
    - c. Lack distinct heads and radulas fig 45.5
    - d. Wedge-shaped foot adapted for locomotion, burrowing, and anchoring
  - 3. Disperse from place to place in larval stage
  - 4. Scallops are unique, very mobile forms
    - a. Adductor muscles are what is eaten by humans, not whole organism
    - b. Edge of body lined with tentacle-like projections
  - 5. Abundant in marine and freshwater habitats
    - a. Pearly freshwater mussels distributed worldwide
    - b. More than 500 species live in lakes and rivers of North America
- E. Class Cephalopoda: The Octopuses, Squids, and Nautilus
- 1. Most intelligent invertebrates
  - 2. Active predators that compete successfully with fish
  - 3. Foot has evolved into a series of tentacles fig 45.10
    - a. Squids have 10 tentacles
    - b. Octopuses have 8 tentacles
    - c. Nautilus have 80 to 90 tentacles
    - d. Tentacles snare prey, paired beaklike jaws bite, pulled into mouth by radula
  - 4. Have highly developed nervous systems
    - a. Rapid responses result from giant nerve fibers attached to mantle
    - b. Eyes are elaborate with structure similar to vertebrates
    - c. Exhibit complex behaviors and high level of intelligence
  - 5. Most have closed circulatory system
  - 6. Lack external shells except for the few nautilus species
  - 7. Take water into mantle and expel it through siphon for propulsion
  - 8. Capable of changing color
    - a. Imitate color of background, display mood or as communication
    - b. Have pouches of pigments, chromatophores, embedded in epithelium

## 45.2 Annelids were the first segmented animals

### I. SEGMENTED ANIMALS

- A. Key Transition in Coelomates Was Segmentation
- 1. Body built from series of similar segment
  - 2. Probably first evolved in segmented worms fig 45.11
  - 3. Advantage of segmentation
    - a. Development and function more precisely controlled
    - b. Segments can be modified for various activities
- B. Annelids
- 1. Two-thirds are marine, rest are terrestrial
  - 2. Characterized by three principle features
    - a. Repeated segments fig 45.12
      - 1) Visible as ring-like structures along body length
      - 2) Separated internally by partitions called septa
      - 3) Each segment contains excretory and locomotor organs
      - 4) Fluid in segments creates hydrostatic skeleton that gives the segment rigidity
      - 5) Each segment can expand or contract independently

- b. Specialized segments
  - 1) Anterior segments modified with sensory organs
  - 2) Well-developed brain contained within one anterior segment
- c. Connections
  - 1) Provide ways for materials to pass between segments
  - 2) Closed circulatory system carries blood between segments
  - 3) Ventral nerve cords connect ganglia in each segment

### C. Body Plan of the Annelids

1. Annelid tube within a tube design
  - a. Digestive tract tube within a coelom tube
  - b. Runs from mouth to anus
  - c. Pharynx, esophagus, crop, gizzard, intestine have specialized functions
2. Use hydrostatic skeleton for locomotion
  - a. Contract circular muscles around each segment
  - b. Coelomic fluid squirts outward, but stays in segment due to septa
  - c. Causes segment to elongate and become thinner
  - d. Contract longitudinal muscles to return to original shape
3. Each segment has setae: External bristles of chitin
  - a. Help provide anchorage during movement
  - b. Can retract them in segments that are moving
4. Possess a more efficient closed circulatory system
  - a. Lack respiratory systems and exchange gases across body surfaces
  - b. Earthworms have five pulsating blood vessels that serve as hearts
5. Excretory units, ciliated funnel-shaped nephridia, similar to those of mollusks
  - a. Repeated in each segment
  - b. Transport waste out of coelom

## II. CLASSES OF ANNELIDS

### A. Diverse Forms Appear in Many Different Habitats

1. Three classes
  - a. Polychaetes: Free-living, marine bristleworms
  - b. Oligochaetes: Terrestrial earthworms, marine, and freshwater forms
  - c. Hirudinea: Freshwater predatory or bloodsucking leeches
2. Evolutionary trends
  - a. Evolved in sea, polychaetes most primitive
  - b. Oligochaetes evolved from polychaetes
  - c. Leeches possess clitellum as do oligochaetes
  - d. Evolved from oligochaetes by specialization in habits

### B. Class Polychaeta: The Polychaetes

1. Great variety of marine worms fig 45.13,1
  - a. Include clamworms, plume worms, scaleworms, lugworms, sea mice, peacock worms
  - b. Crucial part of marine food chains
2. Some live in tubes or burrows and are sedentary filter feeders
3. Others are active predators
4. Well-developed heads with specialized sense organs
5. Possess distinct paddle-like parapodia
  - a. Function in locomotion
  - b. Provide increased surface area for gas exchange

6. Sexes separate, fertilization generally external
    - a. Usually lack permanent gonads
    - b. Gametes produced directly from cells lining coelom or on septa
    - c. Produce mobile trochophore larvae similar to those of mollusks
- C. Class Oligochaeta: The Earthworms
1. Possess 100 to 175 similar segments, mouth on first, anus on last
  2. Seem to eat their way through the soil
    - a. Contraction of pharynx sucks in organic debris
    - b. Muscular gizzard grinds food with aid of soil particles
    - c. Castings (undigested materials) are deposited outside burrows
    - d. Aerate and enrich soil
  3. Lack eyes, but have light-, chemo-, and touch-sensitive organs
  4. Have fewer setae than polychaetes, no parapodia
  5. Are hermaphroditic, individuals trade gametes during mating
    - a. Mucus from clitellum holds worms together, forms cocoon
    - b. Passes along body after separation, picks up deposited sperm
    - c. Clitellum secretes mucus cocoon, fertilization occurs within
    - d. Contains fertilized eggs which ultimately hatch into young worms
- fig 45.14
- D. Class Hirudinea: The Leeches
1. Most are freshwater, few marine, and terrestrial forms
  2. Usually dorsoventrally flattened
  3. Are hermaphroditic, seasonally develop a clitellum, cross-fertilize
  4. Coelom is reduced, continuous through the body, and unsegmented
  5. Have a sucker at one or both ends, for attachment and locomotion
  6. Lack setae, except for one species
  7. Most are predators or scavengers, some suck blood
  8. Example: *Hirudo medicinalis*, medicinal leech
    - a. Mouth has chitinous teeth, secretes an anticoagulant
    - b. Used to remove blood after special surgeries

### 45.3 Lophophorates appear to be a transitional group

- I. LOPHOPHORATES
- A. Include Three Phyla of Marine Animals
1. Ectoprocts
  2. Brachiopoda
  3. Phoronida
- B. Biology of the Lophophorates
1. Lophophore is a circular or U-shaped ridge around the mouth
    - a. Coelomic cavity lies within lophophore and its tentacles
    - b. Functions in gas exchange and food collection
  2. Share features of protostomes and deuterostomes
    - a. Cleavage is radial as in deuterostomes
    - b. Formation of coelom varies, resembles deuterostomes or protostomes
    - c. Ribosomes of all are protostomic
- C. Phylum Phoronida: The Phoronids
1. Superficially resemble tube worms
  2. Individuals secrete a tube made of chitin
  3. Possess U-shaped gut within a sac
- fig 45.16

4. Development
  - a. Develop as protostomes with radial cleavage
  - b. Anus develops secondarily
  
- D. Phylum Ectoprocta: The Bryozoans fig 45.17
  1. Commonly called moss animals
  2. Anus (proct) is external to lophophore (ecto)
  3. Form colonies, freshwater and marine forms
  4. Secrete a zoecium chamber and live within it
  5. Development
    - a. Develop as deuterostomes
    - b. Mouth develops secondarily
    - c. Exhibit radial cleavage
  
- E. Phylum Brachiopoda: The Brachiopods fig 45.18
  1. Superficially resemble clams
  2. Some attach to substrate with a stalk
  3. Lophophore located within shell
  4. Few living species, many extinct species
  5. Example: *Lingula*, most ancient surviving genus of all animals
  6. Development
    - a. Develop as deuterostomes
    - b. Exhibit radial cleavage

## INSTRUCTIONAL STRATEGY

### PRESENTATION ASSISTANCE:

Suggest that your students create a flow chart of the animals according to symmetry, type of coelom, and whether protostome or deuterostome.

Discuss the advantages of segmentation in terms of automobiles with multicylinder engines. If one piston is slightly off, the rest can power the car. If one of the chambers in the battery or radiator go bad, the rest continue to work. But, if the water pump fails so does the vehicle!

Compare flat, round, and segmented worms in terms of advances in structure and function.

Discuss the advantages of being hermaphroditic. Generally the animal needs only to find another animal like itself rather than finding one that is the opposite sex. If both reproductive systems are functional, twice as many offspring can be produced.

Some species of pond leech are quite maternal. I have teased leech eggs from a "mother's" brood pouch, only to have "her" collect the eggs again and continue to brood them against the glass wall of the bowl.

### VISUAL RESOURCES:

Show photographs illustrating the diversity of mollusks and relate these multitudes to the variety of niches and habitats. These animals have developed a number of ways to solve the same problems, especially those of locomotion and feeding.

Obtain small specimens of terrestrial oligochaetes, marine polychaetes, and/or pond leeches and view their movements on the overhead projector. (Not for too long or you will have cooked annelids. Perhaps they could be served over linguini with a garlic sauce and a side of escargot!)