Overview
Before beginning this section review with your students the objectives listed in the Student Edition. Tell students that the purpose of this lesson is to teach them about the general structural and physiological characteristics of mollusks, including their body plan and organ systems. They will also learn about distinguishing characteristics of the three major groups of mollusks: the gastropods, bivalves, and cephalopods.

Bellringer
Ask students to think about a snail, a clam, and an octopus. Tell students that these are all mollusks. Ask them to write down some characteristics that these animals have in common. (Students will most likely note the prominent foot, or its modification.)

Motivate
Identifying Preconceptions — BASIC
Ask students to hypothesize why some mollusks secrete a shell and others do not. Guide their thinking by asking how mollusks without shells might protect themselves. (Students should recall that squids and octopuses spray ink and can propel themselves away from danger. Slugs secrete noxious substances that discourage predators.)

Focus
Objectives
- Summarize the evolutionary relationship between mollusks and annelids. TAKS 2, TAKS 3
- Describe the key characteristics of mollusks. BC TAKS 2
- Describe excretion, circulation, respiration, and reproduction in mollusks. BC TAKS 2
- Compare the body plans and feeding adaptations of gastropods, bivalves, and cephalopods. BC TAKS 2

Key Terms
- trochophore
- visceral mass
- mantle
- foot
- radula
- nephridium
- adductor muscle
- siphon

Evolutionary Milestone
5 Coelom
A true coelom develops entirely within the mesoderm. Contact between the mesoderm and endoderm during the development of the embryo leads to the development of complex organs.

A True Coelom
While most of the simple invertebrates you read about in the last chapter may be unfamiliar to you, chances are good that you have seen many mollusks and annelids. Snails, slugs, oysters, clams, scallops, octopuses, and squids are all mollusks. If you have seen an earthworm, then you know what an annelid is. While a snail may not seem to have much in common with an earthworm, these two very different-looking animals are related.

Mollusks and annelids were probably the first major groups of organisms to develop a true coelom. (Recall that in animals that have a true coelom, or body cavity, the gut and other internal organs are suspended from the body wall and cushioned by the fluid within the coelom.) Another feature shared by mollusks and annelids is a larval stage called a trochophore (TRAH kohs fawr), which develops from the fertilized egg. In some species, the trochophore, shown in Figure 1, is free-swimming and propels itself through the water by movement of cilia on its surface. The presence of a trochophore larva in mollusks and annelids suggests that they share a common ancestor.

Members of the phylum Mollusca make up the second largest animal phyla, exceeded only by phylum Arthropoda. Mollusks are abundant in almost all marine, freshwater, and terrestrial habitats. There are more species of terrestrial mollusks than there are of terrestrial vertebrates. These mollusks often go unnoticed because people are not accustomed to looking for them. Seven classes of mollusks make up the phylum Mollusca. The three major classes are Gastropoda (snails and slugs), Bivalvia (clams, oysters, and scallops), and Cephalopoda (octopuses and squids).
**Activity**

**Mollusks on the Menu**

Provide students with menus from several seafood restaurants and seafood cookbooks from the library. Ask students to identify all the mollusks they can find. (Students should be able to identify oysters, clams, and scallops. Depending on the menu or cookbook, there may also be snails [escargot], squids [calamari], octopuses, abalone, and mussels.) Ask students what part of the body is eaten for each mollusk they identify. (oysters, clams, snails, abalone, mussels – the whole body, except the shell; squids and octopuses – the foot, which is modified into tentacles and the mantle; scallops – the adductor muscle) **TAKS 2 Bio 8C**

**Interactive Reading**

Assign Chapter 29 of the Holt Biology Guided Audio CD Program to help students achieve greater success in reading the chapter.

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**Key Characteristics of Mollusks**

Despite their varied appearance, the members of the different groups of mollusks share a number of key characteristics.

1. **Body cavity.** The body cavity in mollusks is a true coelom, although in most species it is reduced to a small area immediately surrounding the heart.

2. **Symmetry.** Most mollusks exhibit bilateral symmetry.

3. **Three-part body plan.** The body of every mollusk has three distinct parts: the visceral mass, the mantle, and the muscular foot, as shown in Figure 2. The *visceral* (VIS uh url) mass is a central section that contains the mollusk's organs. The mantle is wrapped around the visceral mass like a cape. The *mantle* is a heavy fold of tissue that forms the outer layer of the body. Finally, every mollusk has a muscular region called a *foot*, which is used primarily for locomotion.

4. **Organ systems.** Mollusks have organ systems for excretion, circulation, respiration, digestion, and reproduction.

5. **Shell.** Many mollusks have either one or two shells that serve as an exoskeleton, protecting their soft body. The shell is composed of protein that is strengthened by calcium carbonate, an extremely hard mineral.

6. **Radula.** All mollusks except bivalves have a *radula* (RAJ uhl), a tongue-like organ located in their mouth. The radula, shown in Figure 2, has thousands of pointed, backward-curving teeth arranged in rows. When a mollusk feeds, it pushes its radula out of its mouth, and the teeth scrape fragments of food off rocks or plant matter. Mollusks that are predators use their radula for attacking their prey.

**MISCONCEPTION ALERT**

**Mantle versus Shell**

Students often confuse the mantle with the shell or assume that the mantle composes part of the shell. Be sure students understand the distinction between the two: the mantle, which is composed of tissue, secretes the shell, which is composed of protein and calcium carbonate.

**TAKS 3 Bio 7B**
**Teach, continued**

**Teaching Tip**

**Excretory Strategies** Relate the excretion of wastes in nephridia to cleaning up a table after a meal. Nephridia get rid of wastes as well as substances that the mollusk needs; thus, some substances must be reabsorbed before the wastes are discharged. The process is similar to throwing away everything on the table after the meal, and then going through the trash to recover the plates, silverware, and leftovers.

**Trends in Marine Biology**

**Mollusk Classes** The living mollusks are divided into the following seven classes:

- **Aplacophora** contains about 250 species of marine, wormlike animals that have no shell. Monoplacophora has about a dozen living species; they are very small and covered with a shell. They live at great ocean depths. Polyplacophora has about 800 species of animals known as chitons. Chitons have a shell of eight plates that usually overlap. Scaphopods have elongate, tubular shells that are open at both ends. All 350 or so species are marine. The cephalopods include the octopus, squid, cuttlefish, and nautilus. The foot of cephalopods is modified into tentacles, and only a few have a shell. All 600 to 650 species are marine predators or scavengers. Gastropods usually have a single, coiled shell and a well-developed foot. They are found in marine, freshwater, and terrestrial habitats. The gastropods have about 10,000 living species of bivalves. **TAKS 3 Bio 7B; Bio 8B**
Reproduction in Oysters

Oysters are broadcast spawners, ejecting sperm and eggs into the water, where fertilization occurs. Oysters may spawn multiple times during the season, with each female releasing millions of eggs during each spawning event. Oysters are “protandric” because they develop first as males and then become females due to regression of the testes and subsequent development of the ovaries. Fertilized eggs develop in a free-floating environment, and a trochophore larva hatches from the egg 6–9 hours after fertilization. After about three weeks, the larvae progress through a number of larval stages. The last larval stage has a muscular foot that the larva uses to crawl on the bottom, searching for a suitable place to attach. Attachment sites include almost any hard surface such as other living oysters, oyster shell, rocks, docks, pilings, and glass bottles. Larvae often settle on top of other oyster shells, forming large beds or oyster reefs. Once attached, the newly settled oysters stay in the same location throughout their lives.

Understanding an Open Circulatory System

You can model an open circulatory system using simple items to represent the heart, blood vessels, blood, and body tissues of a living organism.

**Materials**

- Surgical tubing, 15 cm (about 6 in.) piece; clear plastic tubing, 15 cm (about 6 in.) and 7.5 cm (about 3 in.) pieces; shallow pan filled with water; eyedropper; food coloring

**Procedure**

1. Connect the surgical tubing to the two pieces of clear plastic tubing, as shown above.
2. Place the tubing into the tray filled with water. Allow the tubing to fill with water and rest on the bottom.
3. With the tubing still submerged, use an eyedropper to place two drops of food coloring into the short piece of clear plastic tubing.
4. With your thumb and index finger, squeeze along the piece of surgical tubing to pump the food coloring through the system.
5. As you continue to pump, observe the movement of food coloring.

**Analysis**

1. Describe what happened when you squeezed along the tubing.
2. Identify the structures represented by the pan of water, the surgical tubing, and the clear plastic tubing.

**3. Critical Thinking**

**Evaluating Results**

Evaluate your model’s efficiency at pumping blood through the system.

**4. Critical Thinking**

**Analyzing Methods**

How does this model differ from a real circulatory system?

**5. Critical Thinking**

**Analyzing Methods**

How could you modify the model to make it more accurate?

**Teacher’s Notes**

Make sure that students remove any air from the tubing once it is submerged. Use a dark dye. If the dye diffuses too quickly in the water, try using an oil-based dye or small, lightweight colored beads.

**Answers to Analysis**

1. The dye moves away from the pumping action but is also drawn back into the open tubing.
2. The pan of water represents the body and tissues of the mollusk, surgical tubing represents the heart, and the clear plastic tubing represents the blood vessels.
3. Answers will vary.
4. In a real system, there would be many more vessels carrying the blood out to the tissues and back toward the heart. The oxygenated blood would also be absorbed by the various tissues, and the used blood would be reoxygenated by the gills.
5. Answers will vary, but may include adding models for individual organs, adding more “blood,” and adding more blood vessels.
Teaching Tip

Mollusk Shells The beauty, diversity, and hardness of mollusk shells accounts for their wide use as decorations. Even the inside linings of shells are used. Shells of freshwater mussels are used to make pearl buttons, and mother-of-pearl from oysters is used to decorate ornamental boxes, jewelry, and musical instruments.

Activity

Snail Behavior Allow students to explore snail behavior. Obtain several land snails from gardens, wooded areas, or a biological supply house. Have students devise ways to test the snails’ responses to touch, light, moisture, and gravity. Caution students to use extreme care in handling snails, making sure not to let them dry out. When not in use, keep the snails in a cool, moist terrarium with pieces of lettuce. Kinesthetic Bio 11B

Body Plans of Mollusks

The basic mollusk three-part body plan differs in each class of mollusks. As you read about the different classes of mollusks, you will see how the mollusk shell and foot are adapted for many different living conditions.

Gastropods

Gastropods—snails and slugs—are primarily a marine group that has successfully invaded freshwater and terrestrial habitats. They range in size from microscopic forms to the sea hare Aplysia, which reaches 1 m (almost 40 in.) in length. Most gastropods have a single shell. During the evolution of slugs and nudibranchs (NOO dih branks), the shell was lost completely. Figure 5 shows three terrestrial tree snails and a nudibranch (sea slug). The foot of gastropods is adapted for locomotion. Terrestrial species secrete mucus from the base of their foot, forming a slimy path that they can glide along. Most gastropods have a pair of tentacles on their head with eyes often located at the tips.

Gastropods display varied feeding habits. Many are herbivores that scrape algae off rocks using their radula. Some terrestrial snails can be serious garden and agricultural pests, using their radula to saw off leaves. Sea slugs and many other gastropods are active predators. Whelks and oyster drills, for example, use their radula to bore holes in the shells of other mollusks. Then they suck out the soft tissues of their prey. In cone shells, such as the one shown in Figure 6, the radula is modified into a kind of poison-tipped harpoon that is shot into prey. The poison paralyzes the prey, which is then swallowed whole.

Throughout human history, snails have been a source of food for humans. Land snails belonging to the genus Helix are raised on snail farms and are consumed in great quantities. While freshwater snails are rarely eaten, a few marine species, such as conchs (KAHNGKKS), are considered delicacies.

Organizing Information

Make a table to organize information about mollusks. Across the top, write the headings Gastropods, Bivalves, and Cephalopods. Along the side, write Foot, Shell, Feeding, Reproduction. Add information (and perhaps more terms along the side) to the table as you read.

Cultural Awareness

Uses of Shells Mollusk shells have served many different functions in various cultures, especially in making jewelry and crafts. In addition, shells have been used for several practical purposes. Phoenicians and Romans used Murex sea snails to make a purple dye for coloring fabric. Native North Americans carved large clam shells into wampum beads and used other shells as money. Filipinos cut thin Placuna oyster shells to fit into wooden frames as windowpanes.
Demonstration

Show students a dissected fresh or preserved mollusk such as a clam or oyster. Ask them to sketch the mollusk and label the following parts: shell, mantle, coelom, foot, gut, heart, and gills.

Visual Activity

Identifying Mollusks
Obtain several fossil mollusks, and set them out for students to view. Fossil mollusks are some of the most common and inexpensive fossils you can obtain, and they are easily identifiable as bivalves, gastropods, or shelled cephalopods. Have students match modern varieties of mollusks to their fossils.

Bivalves

Bivalves are unique among the mollusks because they do not have a distinct head region or a radula. A nerve ganglion above their foot serves as a simple brain. Most bivalves have some type of simple sense organs. For example, some bivalves have sensory cells located along the edge of their mantle that respond to light and touch.

Most bivalves are either male or female, but a few species are hermaphroditic. Bivalve reproduce sexually by releasing sperm and eggs into the water, where fertilization occurs. The fertilized eggs develop into free-swimming trochophore larvae. The larvae of a few freshwater mussels are brooded in a pouch within the mollusk's gills. The larvae are then released into the water, and they complete their larval stage as parasites on fish. This is a very unusual life cycle for a mollusk.

Most bivalves are filter feeders. Many, such as the clam illustrated in Figure 7, use their muscular foot to dig down into the sand. Once there, the cilia on their gills draw in sea water through hollow tubes called siphons (SIE fuhns). The water moves down one siphon tube, over the gills, and out the other siphon tube. The gills are used for feeding as well as respiration. A sticky mucus covers the gills, and as water moves over the gills, small marine organisms and organic material become trapped in the mucus. The cilia then direct the food-laden mucus to the bivalve's mouth.

GEOGRAPHY CONNECTION

The zebra mussel is a small, freshwater bivalve native to Europe. At some point, zebra mussels hitchhiked across the Atlantic Ocean in the ballast water of ships. Although they were not here in detectable numbers before 1985, they have infested waters in the Great Lakes, where they have no natural predators. Although small, the mussels attach themselves to any hard surface, including ship hulls, docks, and even other mussels.

Figure 6 Cone shell. This cone shell searches the ocean bottom for prey. Once located, the prey is secured by the cone shell’s radula and swallowed whole.

Figure 7 Clam. Many bivalves, like this clam, burrow into sand or mud and feed by drawing sea water in one siphon and expelling it out the other.

WORD Origins

The class name Bivalvia comes from the Latin bi, meaning “two,” and valva, meaning “part of a door.”
Like clams, oysters and scallops use their gills to filter food from the water. Oysters are permanently attached to rocks in the open water, where they feed. Scallops swim, and water passes over their gills as they move.

Many species of bivalves, such as the oyster in Figure 8, produce pearls. Pearls form when a tiny foreign object, such as a grain of sand, becomes lodged between the mollusk’s mantle and shell. Bivalves respond to these irritants by coating them with thin sheets of nacre (nay KUHR), also called mother-of-pearl. Nacre is the same hard, shiny substance that composes the inner shell surface. Successive layers of nacre are added until the foreign body is completely enclosed in the newly formed pearl.

While many bivalves form pearls, only a few species produce the beautifully colored nacre essential for gem-quality pearls. In fine pearls, the nacre contains tiny, overlapping mineral crystals. These crystals act like prisms, breaking up any light that falls on them into rainbows of color. This is what gives these pearls their iridescence. The mineral crystals found in the nacre of ordinary pearls are larger and do not reflect light as beautifully.

### Eating Mollusks Safely

Since prehistoric times, mollusks have served as a human food resource. Today the annual worldwide harvest for bivalve mollusks alone amounts to an astounding 3 million metric tons (6,615,000,000 lb). But severe illness has been associated with eating mollusks. What causes these illnesses, and are mollusks really safe to eat?

Bivalves—oysters, mussels, clams, and scallops—are filter feeders. Any contaminant in a bivalve’s environment circulates through and accumulates in its body. One source of contamination is water that is polluted with sewage, an ideal breeding ground for some bacteria and viruses. Because of this, harvesting is prohibited in certain areas. The primary danger is from eating infected bivalves raw. Contrary to popular opinion, hot sauce will not kill dangerous organisms that infect them. But it is now evident that brief cooking, such as lightly steaming clams, does not destroy all pathogens either.

### Follow the Guidelines

An estimated 20 million Americans eat oysters, and the yearly consumption of mollusks is increasing. To reduce the risk of illness from eating mollusks, the Food and Drug Administration (FDA) has developed guidelines for preparing them. If you observe these guidelines, the health risk from eating mollusks is very low. Avoid eating raw bivalves. Make your purchases from reputable sources to assure that the mollusks were not illegally harvested. Test for freshness by trying to move the shells sideways. If the shells move, the mollusk is not fresh and should be discarded. Follow FDA recommendations for proper cooking times and temperatures. By following these guidelines, you can safely enjoy this delicious and healthful food choice.
Cephalopods
Squids, octopuses, cuttlefish, and nautiluses are all cephalopods. Most of their body is made up of a large head attached to tentacles (a foot divided into numerous parts), as shown in Figure 9. The tentacles are equipped with either suction cups or hooks for seizing prey. Squids have 10 tentacles, while octopuses have eight. The nautilus has 80–90 tentacles, although they are not nearly as long as those of the other cephalopods. Although cephalopods evolved from shelled ancestors, most modern cephalopods lack an external shell. The nautilus is the only living cephalopod species that still has an outer shell. Squids as well as the cuttlefish have a small internal shell. Cuttlefish “bones” are often attached to bird cages to provide calcium for canaries and other pet birds.\(^1\)\(^3\)

Cephalopods are the most intelligent of all invertebrates. They have a complex nervous system that includes a well-developed brain. Cephalopods are capable of exhibiting complex behaviors. Octopuses can easily be trained to distinguish between classes of objects, such as between a square and a cross, and they are the only invertebrates with this ability.\(^2\)\(^3\)

The structure of a cephalopod eye is similar in many ways to that of a vertebrate eye, and some species have color vision. The eyes of a squid can be very large. A giant squid that washed up on a beach in New Zealand in 1933 had eyes that were 40 cm (almost 15 in.) across. At over 20 m (65 ft) in length, the giant squid is the largest of all invertebrates and has the largest eyes known in any animal.\(^2\)\(^3\)

Like most aquatic mollusks, cephalopods draw water into their mantle cavity and expel it through a siphon. In squids and octopuses, this system functions as a means of jet propulsion. When threatened, they quickly close their mantle cavity, causing water to shoot forcefully out of the siphon. Squids and octopuses can also

![Squid](image1)

![Nautilus](image2)

![Cuttlefish](image3)

**Figure 9 Cephalopods.** Like all cephalopods, the squid is an active predator. Cuttlefish are agile swimmers that hunt at night, seeking small fishes and crustaceans. The nautilus swims with its coiled shell positioned over its head.

**Activity**
**Major Characteristics of Mollusks** Ask students to develop a table similar to the Graphic Organizer at the bottom of this page, to compare the major characteristics of bivalves, gastropods, and cephalopods.\(^5\) Logical

**Demonstration**
Have students test the suction of dry and wet suction cups. Ask them whether suction cups work better when dry or wet. (They work better when wet.) Cephalopods have suction cups on their tentacles that have tremendous gripping power. Even sperm whales can receive suction disk scars during fights with giant squids. The suction disks hold so tight that they can damage the flesh.\(^5\) Kinesthetic

**TAKS 2 Bio 10A**

**Analyzing the Molluscan Body Plan**

**Skills Acquired**
Observing, applying information, predicting

**Teacher’s Notes**
If possible, display examples of shells from a cephalopod, gastropod, and bivalve.

**Answers to Analysis**
1. A. cephalopod; B. gastropod; C. bivalve
2. The shells of the different classes have evolved to support different ways of life.
3. In cephalopods, the foot is modified into tentacles and aids in movement and in capturing food. The flat-bottomed foot of gastropods secretes a substance that allows the animal to glide over surfaces. The foot of a bivalve allows it to bury itself in the sand.
4. Slugs would be more abundant in areas with acidic soils because the environment cannot support many shell-building organisms.
release a dark fluid that clouds the water and conceals the direction of their escape. The ink of the cuttlefish contains a reddish brown pigment called sepia. For centuries this ink was used by artists as a pigment and is found in many famous paintings.

All cephalopods are active marine predators. They feed on fish, mollusks, crustaceans, and worms. Once the prey has been snared by the tentacles, it is pulled to the mouth, where it is torn apart by strong, beaklike jaws. The cephalopod's radula then pulls the pieces into the mouth.

### Analyzing the Molluscan Body Plan

#### Background
Mollusks share many common characteristics, yet there is great variety among the classes. The drawings on the right show how the shell (brown) and foot (green) vary in three classes of mollusks. Use the drawings to answer the analysis questions.

#### Analysis
1. **Determine** the class of mollusk A, mollusk B, and mollusk C.
2. **Compare** the shell modifications. Why might a shell suited to one mollusk be inappropriate for another?
3. **Critical Thinking** Identifying Functions
   For each class shown, explain how the foot is useful for the animal's environment or kind of movement.

#### Critical Thinking
4. **Predicting Outcomes**
   Terrestrial snails and squids possess one or more siphons used for filter feeding. Cephalopods have large eyes on the body of movement.

5. **Critical Thinking** Forming Hypotheses
   A chemical pollutant accidentally spills into a bay. One of the effects of the chemical is that it paralysis cilia. The next day almost all of the oysters in the bay are dead. Develop a hypothesis that explains why the oysters died.

### Section 1 Review

1. Identify two characteristics that mollusks and annelids have in common. (7B 8B 8C)
2. Summarize six characteristics common to most groups of mollusks. (8C)
3. Describe how a nephridium functions in waste removal. (10A)
4. Compare the distinguishing features of each of the three major classes of mollusks. (8B 8C)
5. **Critical Thinking** Forming Hypotheses
   A chemical pollutant accidentally spills into a bay. One of the effects of the chemical is that it paralysis cilia. The next day almost all of the oysters in the bay are dead. Develop a hypothesis that explains why the oysters died. (2C)
6. **TAKS Test Prep** A gastropod's radula is part of what organ system? A respiratory, C digestive, B circulatory, D excretory

### Answers to Section Review

1. Mollusks and annelids both exhibit true coeloms, and most members of both groups develop from larvae called trochophores. **TAKS 2 Bio 8C**
2. Most mollusks share the following key characteristics: coelom, bilateral symmetry, a three-part body plan (visceral mass, mantle, and foot), organ systems, a shell, and a radula. **TAKS 2 Bio 8C**
3. A nephridium funnels coelomic fluid, which includes wastes, into the mantle cavity, where it is excreted to the outside environment. **TAKS 2 Bio 8C**
4. Most gastropods have a single shell, a single large foot, and, on their head, tentacles tipped with eyes. Bivalves have a two-part hinged shell and lack a head and radula. Most bivalves possess one or more siphons used for filter feeding. Cephalopods have large eyes on a large head attached to numerous tentacles. **TAKS 2 Bio 8C**
5. The beating of cilia moves water over the gills. Therefore, the oysters suffocated when the chemical paralyzed their cilia. **TAKS 1 Bio/IPC 2C**
6. A. Incorrect. The gill is part of the respiratory system. B. Incorrect. The heart is part of the cardiovascular system. C. Correct. The radula is part of the digestive system. D. Incorrect. The nephridium is part of the excretory system. **TAKS 2 Bio 10A**
Section 2

Overview
Before beginning this section review with your students the objectives listed in the Student Edition. Tell students that the purpose of this lesson is to teach them about the distinguishing structural and functional characteristics of the annelids, the segmented worms. They will also learn about the three major groups of annelids: the marine or Polychaete worms, the Oligochaetes, and the leeches or Hirudinea. TAKS 2 Bio 10A

Motivate
Ask students to write a short description of the evolutionary advantages of body segmentation. (It allowed specialization of the body segments.) TAKS 3 Bio 7B

Demonstration
Obtain earthworms from garden soil or a bait shop, and have students observe their behavior. Ask students to describe how they can tell which end of the earthworm is the head. If students say that the head is the leading end, remind them that squid sometimes move tail first. Direct their attention to the earthworm’s mouth. Caution students to keep their worms moist.

The First Segmented Animals
You have probably heard the expression “a can of worms,” which calls up an image of a lot of wiggly, wriggly creatures. An earthworm may come to mind, but there are many different species of segmented worms. Worms might not look like much, but this group of coelomates belongs to an ancient group, phylum Annelida. Annelid fossils can be found in rock that is 530 million years old. Scientists think that annelids evolved in the sea, where two-thirds of today’s annelid species live. Most other annelid species are terrestrial earthworms. Annelids range in size from less than 1 mm (0.04 in.) long to more than 3 m (10 ft) long.

Annelids, such as the earthworm and fireworm shown in Figure 10, are easily recognized by their segments, which are visible as a series of ringlike structures along the length of their body. Each segment contains digestive, excretory, circulatory, and locomotor (movement) organs. Some of the segments are modified for specific functions, such as reproduction, feeding, or sensation. A well-developed cerebral ganglion, or primitive brain, is located in one anterior segment. The brain is connected to a nerve cord that runs along the underside of the worm’s body.

Evolutionary Milestone
Annelids were the first organisms to have a body plan based on repeated body segments. Segmentation underlies the body organization of all coelomate animals except mollusks.

Figure 10  Annelids
The ringlike segments of this earthworm and marine fireworm identify them as annelids.

Annelids
Objectives
- Identify the major change in body plan that distinguishes annelids from mollusks. TAKS 2
- Describe the basic annelid body plan. TAKS 2
- Describe the annelid digestive system. TAKS 2
- Compare the three classes of annelids. TAKS 2

Key Terms
- cerebral ganglion
- septa
- seta
- parapodium

Chapter Resource File
- Lesson Plan
- Directed Reading
- Active Reading
- Data Sheet for Quick Lab

Transparencies
- TT Bellringer
- TT Nereis
- TT Anatomy of the Earthworm
Modeling a Closed Circulatory System

Skills Acquired
Observing, modeling, interpreting results, applying information, evaluating

Teacher’s Notes
Have students conduct Quick Lab: Modeling an Open Circulatory System before conducting this lab. Ask students how oxygen and nutrients get to the tissues that need them if the blood never touches the body tissues directly. (The oxygen and nutrients pass through the vessel walls.) Use a dark dye. If the dye diffuses too quickly in the water, try using an oil-based dye or small, lightweight colored beads.

Answers to Analysis
1. The “blood” moved through the blood vessels.
2. The pan of water represents the body and tissues, surgical tubing represents the heart, and clear plastic tubing represents the blood vessels.
3. Answers will vary.
4. Answers will vary, but may include adding model tissues and increasing the number of model blood vessels.
5. Students should note that the closed system exerted a greater pressure on the fluid than the open system.

Insect Larvae
Many people mistake grubs, maggots, and caterpillars for worms. These animals are arthropods, not annelids, and are the larval form of certain insects (beetles, flies, and moths or butterflies, respectively). Have students list the annelid characteristics that are shared by these unrelated insects. (Answers may vary, but arguments could be made for each of the four characteristics of annelids.)

Characteristics of Annelids
In addition to segmentation, annelids share a number of other characteristics.

1. Coelom. The fluid-filled coelom is large and is located entirely within the mesoderm.
2. Organ systems. The organ systems of annelids show a high degree of specialization and include a closed circulatory system and excretory structures called nephridia. The gut has different regions that perform different functions in digestion.
3. Bristles. Most annelids have external bristles called setae (SEET ee). The paired setae located on each segment provide traction as the annelid crawls along. Some annelids, like the fireworm shown in Figure 10 on the previous page, also have fleshy appendages called parapodia (par uh POH dee uh).
Annelid Groups

Annelids differ in the number of setae (bristles) they have on each segment, and not all annelids have parapodia. These two external characteristics are used to classify annelids.

Marine Worms

Marine segmented worms are members of class Polychaeta (PAHL ih keet uh), the largest group of annelids. Polychaetes live in virtually all ocean habitats. They are often beautiful, showing unusual forms and iridescent colors. A distinctive characteristic of polychaetes is the pair of fleshy, paddle-like parapodia that occur on most of their segments. The parapodia, which usually have setae, are used to swim, burrow, or crawl. Parapodia also greatly increase the surface area of the polychaete’s body, making gas exchange between the animal and the water more efficient.

Many polychaetes are burrowing species, but others live in protective tubes formed by the hardened secretions of glands located on their segments. Grains of sand or other foreign material may be cemented into the tube. Such tubeworms, like the feather duster shown in Figure 11, live with only their head stuck out of the tube. Featherlike head structures trap food particles from the water that passes over them. Other species of polychaetes feed by pumping water through their body. Free-swimming polychaetes, such as Nereis shown in Figure 12, are predators that use their strong jaws to feed on small animals.

![Figure 11](image1.png)

Figure 11 Feather duster. Feather dusters filter-feed by trapping food particles in their featherlike head structures.

Many polychaetes are burrowing species, but others live in protective tubes formed by the hardened secretions of glands located on their segments. Grains of sand or other foreign material may be cemented into the tube. Such tubeworms, like the feather duster shown in Figure 11, live with only their head stuck out of the tube. Featherlike head structures trap food particles from the water that passes over them. Other species of polychaetes feed by pumping water through their body. Free-swimming polychaetes, such as Nereis shown in Figure 12, are predators that use their strong jaws to feed on small animals.

![Figure 12](image2.png)

Figure 12 Nereis

Nereis, a polychaete worm, grasps its prey in its jaws, which open when it thrusts out its pharynx.

Tentacles
Jaw
Pharynx
Eyes
Setae
Parapodia

Tentacles
Jaw
Pharynx
Eyes
Setae
Parapodia

did you know?

Importance of Polychaetes

Polychaetes are some of the most important animals in marine benthic (bottom-dwelling) communities. Though few people notice polychaetes or even know of their existence, these worms exert a strong influence in marine benthic food webs. Some of the 10,000 species so far described eat animals, others eat plants, and many more provide food for commercially important fish.

TAKS 3 Bio 12E

Career

Oceanographer

Oceanography is a diverse field with branches in the biological chemical, physical, geological, and engineering fields. A graduate degree is usually required, along with an undergraduate degree in biology, chemistry, or engineering. Biological oceanographers study the interrelationships of marine life, energy transfer, and the impact of human activities on marine communities. Encourage students to learn more about this field at the library or on the Internet.

Bio 3D

Teaching Tip

The Ultimate Worm

Ask students to list the anatomical features that make earthworms more advanced than flatworms or roundworms. Help students recall that earthworms have a segmented body, a true coelom, a highly specialized gut, a closed circulatory system, and external bristles.

Using the Figure

Ask a volunteer to examine Figure 11 and offer an explanation for how feather duster worms acquire food. (Bristle-like appendages filter small organisms and organic matter out of water that flows over them.) Have the class name an advantage and a disadvantage of this feeding strategy. (Advantage: Allows for a sessile lifestyle. Disadvantage: Potential food must pass close by to be captured.) Visual TAKS 3 Bio 7B

IPC Benchmark Review

To prepare students for the TAKS and accompany the discussion of earthworms, have students review Water Produces Physical Change, TAKS 4 IPC 8A, on p. 1052 of the IPC Refresher in the Texas Assessment Appendix of this book.
Earthworms and other related freshwater worms are members of the class Oligochaeta (AHL ih goh KEET uh). Oligochaetes have no parapodia and only a few setae on each segment. Earthworms lack the distinctive head region of polychaetes and have no eyes. They do, however, have light-sensitive and touch-sensitive organs located at each end of their body. They have other sensory cells that detect moisture.

Earthworms, such as the ones in Figure 13, are highly specialized scavengers. They literally eat their way through the soil, consuming their own weight in soil every day. As they tunnel, earthworms take in organic matter and other materials using their muscular pharynx. The ingested soil moves through their one-way gut, down the esophagus and into a storage chamber called the crop. From here, the soil moves to an area called the gizzard. The grinding action of the gizzard crushes the soil particles together, breaking them down. The crushed material moves to the intestine, which extends to the posterior end of the earthworm's body. Digested food molecules are absorbed into the intestinal wall, and the remaining material passes out through the anus in a form called castings. The tunneling activity of earthworms allows air to penetrate the soil, and their castings fertilize it. Rich, organic soil may contain thousands of earthworms per acre.

Hydrostatic Skeleton

The fluid within the coelom of each body segment creates a hydrostatic skeleton that supports the segment. Each segment contains muscles that pull against this hydrostatic skeleton. Circular muscles wrap around the segment, while longitudinal muscles span increasing in diameter. An earthworm crawls by alternately contracting the two sets of muscles in its segments. The brain coordinates the muscular activity of each body segment, thus controlling movement.

Earthworms come to the surface only at night or during heavy rains. During dry or cold weather, they burrow deep into the soil and become inactive.

**Figure 13** Earthworms burrowing. Earthworms come to the surface only at night or during heavy rains. During dry or cold weather, they burrow deep into the soil and become inactive.

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### Graphic Organizer

Use this graphic organizer with the Group Activity: Comparing Mollusks and Annelids on this page.

<table>
<thead>
<tr>
<th>Body cavity</th>
<th>Body plan</th>
<th>Organ systems</th>
<th>Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mollusks</strong></td>
<td>True coelom</td>
<td>Muscular foot, head, visceral mass</td>
<td>Circulatory (usually open system), respiratory, digestive, excretory</td>
</tr>
<tr>
<td><strong>Annelids</strong></td>
<td>True coelom</td>
<td>Segmented with bristles</td>
<td>Circulatory (closed), respiratory, digestive, excretory</td>
</tr>
</tbody>
</table>
Charles Darwin (1809–1882), the British naturalist famous for his theory of evolution by natural selection, was fascinated with the ways that earthworms aerate and enrich soil. In his last botanical book, The Formation of Vegetable Mould Through the Action of Worms, Darwin noted the service of earthworms in recycling organic matter in soil. He also observed that an earthworm could ingest its weight in soil each day and that in one year, the earthworms inhabiting one hectare could digest 22 to 40 metric tons of soil. The work was published only 6 months prior to Darwin’s death and was called a pioneering study in quantifying ecology. Bio 3F

HISTORY CONNECTION

Leeches Make a Comeback

Teaching Strategies

Have students research past and present uses of leeches in medicine and write a brief (one-page) paper that describes their findings.

Discussion

• How do earthworms loosen soil and help recycle soil nutrients? (Earthworms make holes in the soil by moving through it, digesting soil matter into simpler components.)
• What is the role of the clitellum? (It secretes a protective layer of chitin for the fertilization and incubation of eggs.)

BIOWatch

Leeches Make a Comeback TAKS 3 Bio 7B

Teaching Strategies

Have students research past and present uses of leeches in medicine and write a brief (one-page) paper that describes their findings.

Discussion

Ask if any students have ever had a leech attach while swimming or wading in a pond or stream. Did it hurt as it attached? (Usually there is no sensation.) Did you bleed after the leech was removed? (If the leech was fully attached and feeding, students should answer yes because leeches use anticoagulants to facilitate feeding. The bleeding stops soon after the leech is removed.)

Characteristics

Respiration  Oxygen and carbon dioxide diffuse through the earthworm’s skin. This exchange can take place only if the worm’s skin is kept moist.

Digestion  Earthworms “eat” soil, which is ground up in a thick, muscular gizzard. Food molecules pass across the walls of the intestine and are absorbed into the bloodstream.

Reproduction  Earthworms are hermaphrodites, each individual containing both sexes. Mating occurs when two earthworms join ventrally head to tail, exchanging sperm. During egg laying, the clitellum (a thickened, glandular ring of cells) of each worm secretes a mucous cocoon that encloses the fertilized eggs. Young worms emerge from the cocoon several weeks later.

Movement  As shown in the diagram, 1) first the earthworm anchors several of its rear segments by sinking their setae into the ground. 2) The worm then contracts the circular muscles in front of the anchored segments. This causes the anterior segments to elongate. 3) Then the setae in front of the stretched region are anchored and the rear setae are released. 4) The circular muscles relax and the longitudinal muscles contract, pulling the rear segments forward.

Brain  The brain coordinates the muscular activity of each body segment. It also processes sensory information from light-sensitive and touch-sensitive organs located at each end of the body.

Earthworms, which have no teeth, eat their way through soil and grind it up for nutrients. Ask students what structure earthworms use to grind up soil. (gizzard) Ask them which other toothless animals use gizzards to grind food. (birds) Finally, ask why food needs to be ground up. (Smaller particles are digested more easily.)

Chapter 29 • Mollusks and Annelids

Up Close

Earthworm TAKS 2

• Scientific name: Lumbricus terrestris
• Size: Grows up to 30 cm (12 in.) long
• Range: Europe; eastern and northwestern North America
• Habitat: Damp soil
• Diet: Organic matter contained in soil

Up Close

Earthworm TAKS 3 Bio 7B, 8C, 10A

Teaching Strategies

Have students research past and present uses of leeches in medicine and write a brief (one-page) paper that describes their findings.

Discussion

Ask if any students have ever had a leech attach while swimming or wading in a pond or stream. Did it hurt as it attached? (Usually there is no sensation.) Did you bleed after the leech was removed? (If the leech was fully attached and feeding, students should answer yes because leeches use anticoagulants to facilitate feeding. The bleeding stops soon after the leech is removed.)

BIOWatch

Leeches Make a Comeback TAKS 3 Bio 7B

Teaching Strategies

Have students research past and present uses of leeches in medicine and write a brief (one-page) paper that describes their findings.

Discussion

Ask if any students have ever had a leech attach while swimming or wading in a pond or stream. Did it hurt as it attached? (Usually there is no sensation.) Did you bleed after the leech was removed? (If the leech was fully attached and feeding, students should answer yes because leeches use anticoagulants to facilitate feeding. The bleeding stops soon after the leech is removed.)
Chapter 29 • Mollusks and Annelids

1. Why is “poly-” an appropriate prefix for polychaete worms? (They have many body segments.)
2. Why are earthworms likely to be found in richly organic soil but not in a very sandy soil? (Because they use the energy they obtain from organic matter in the soil as their source of energy for survival.)
3. Why is it advantageous for parasitic leeches to be able to distend their bodies by ingesting a huge meal? (Because they have to search for food, consuming a large meal at one time would last them until they can find another source of food.)

Alternative Assessment

Have students combine their new understanding of annelids with their artistic skills and draw a “new” species of annelid. Tell them to label their annelids and to make any reasonable adaptations to their designated environment.

Section 2 Review

1. Summarize how you can tell if a wormlike organism is an annelid worm. TAKS 2 Bio 8C
2. Relate an annelid’s septa to its overall body plan. TAKS Test Prep 8C 10A 10B
3. Describe the major features of an earthworm’s digestive system. TAKS Test Prep 8C 10A
4. Compare the external appearance of marine annelids, earthworms, and leeches. TAKS Test Prep 8B 8C
5. What happens to a segment in an earthworm when the circular muscles in that segment contract? TAKS Test Prep 10A
A. It elongates.
B. It shortens.
C. It increases in diameter.
D. It bends to one side.

Answers to Section Review

1. Annelid worms have segments, and most have external bristles. TAKS 2 Bio 8C, Bio 8B
2. Septa are internal body walls that separate the segments of most annelids. Blood vessels and a nerve cord connect the segments to one another, and to the annelid’s brain. TAKS 2 Bio 8C, 10A, 10B
3. The earthworm’s digestive system is a highly modified gut consisting of the following regions: mouth, pharynx, esophagus, crop, gizzard, intestine, and anus. TAKS 2 Bio 8C, 10A
4. Marine annelids are often very colorful and have a head region with eyes; their segments usually have a pair of fleshy extensions called parapodia. Earthworms lack parapodia and have no head region. Usually there are several bristly setae on each segment of an earthworm. Leeches lack setae and parapodia, and their bodies are generally flat. TAKS 2 Bio 8C; Bio 8B
5. A. Correct. B. Incorrect. Contraction of the longitudinal muscles results in shortening. C. Incorrect. Contraction of the circular muscles does not increase the diameter of the worm. D. Incorrect. Contraction of the circular muscles does not cause the worm to bend to one side. TAKS 2 Bio 10A

Leeches

When people hear the word leech, they usually associate it with bloodsucking, and for a good reason. A leech, shown in Figure 14, has suckers at both ends of its body. Most species are predators or scavengers, but some are parasites of vertebrates and crustaceans.

Leeches are the only members of class Hirudinea (hih ryoo DHNN ee uh). Leeches lack both setae and parapodia. The body of a leech is flattened, and unlike other annelids, its segments are not separated internally.

Leeches Make a Comeback

For many centuries, it was commonly believed that an excess amount of blood was the cause of a wide range of illnesses, from a fever or headache to severe heart disease. A standard treatment for these conditions was bloodletting using leeches. Physicians applied leeches to the patient’s body, allowing the leeches to suck out the patient’s “bad blood.”

Use in Microsurgery

Although doctors no longer believe in “bad-blood,” leeches are making a comeback in the field of health care. One use of leeches is during surgery to reattach severed limbs, fingers, or toes. In this type of operation, called microsurgery, the surgeon uses tiny instruments and a microscope to reconnect tendons, blood vessels, and nerves. It is not possible to reconnect the smallest of the blood vessels, so circulation in the reattached part is usually poor. Often tissues in the region die, and the reattached part cannot heal. By applying leeches to suck out the accumulated blood, tissues remain healthy until new blood vessels grow and circulation is restored to normal. As a result, the success rate of surgery for reattachments has increased.

Other Applications

Leeches possess other useful qualities. Their saliva contains anticoagulants—substances that prevent blood from clotting—and enzymes that can break up blood clots. It is not necessary to apply leeches to a patient to take advantage of these chemicals. Today these substances are produced through genetic engineering and have proven useful in the treatment of some heart patients.
Alternative Assessment

Have students design a new species of mollusk. Students might draw and describe their animal or create a model. They should give their creation a scientific name based on its features and describe its habitat, reproductive habits, and feeding habits. Designs must include the key characteristics of a mollusk.
Using Key Terms

1. In mollusks, ______ extract useful molecules from coelomic fluid.  
a. radula  
b. ganglia  
c. nephridia  
d. parapodia
2. All of the following are a part of the mollusk’s three-part body plan except a  
a. radula  
b. mantle  
c. visceral mass  
d. foot
3. The valves of bivalves are connected by the  
a. siphons  
b. parapodia  
c. visceral mass  
d. adductor muscles
4. Annelids are most easily recognizable by their  
a. cephalization  
b. segmentation  
c. nephridia  
d. body cavity
5. For each pair of terms, explain the difference in their meanings.  
a. setae, parapodia  
b. mantle, visceral mass

Understanding Key Ideas

6. Both mollusks and annelids have ______.  
a. are coelomates  
b. have at least a remnant of a shell  
c. have no larval form  
d. have a visceral mass
7. Terrestrial snails respire  
a. with gills  
b. with a primitive lung  
c. through their skin  
d. through their siphon
8. Which of the following is not true of bivalves?  
a. They have a distinctive head region.  
b. They have sense organs.  
c. They have an open circulatory system.  
d. Most are filter feeders.
9. Cephalopods have all of the following characteristics except  
a. bilateral symmetry.  
b. a three-part body plan.  
c. an open circulatory system.  
d. a true coelom.
10. Annelids are divided into three classes. This classification is based on the number of setae and the presence or absence of  
a. segments.  
b. hearts.  
c. a gizzard.  
d. parapodia.
11. Blood in the circulatory system of an annelid  
a. flows into its body cavity.  
b. delivers carbon dioxide to its tissues.  
c. passes through gills.  
d. stays within its circulatory system.
12. Earthworm movement requires all of the following except  
a. circular muscles.  
b. secretion of mucus.  
c. muscle contractions.  
d. traction provided by setae.
13. What are some possible risks associated with purchasing bivalves from an unknown vendor?  
14. How can leeches be beneficial following microsurgery?
15. Concept Mapping Make a concept map that shows the characteristics and diversity of the mollusks. Include the following words in your map: foot, visceral mass, mantle, radula, siphons, gastropod, bivalve, cephalopod, open circulatory system, and closed circulatory system.

Assignment Guide

<table>
<thead>
<tr>
<th>Section</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1, 2, 3, 5b, 8, 9, 13, 17–21</td>
</tr>
<tr>
<td>2</td>
<td>4, 5a, 6, 7, 10, 11, 12, 14, 16, 22</td>
</tr>
</tbody>
</table>
**Critical Thinking**

16. **Recognizing Patterns** The gizzards of annelids that have returned to an aquatic environment are smaller and less muscular than those of terrestrial annelids, such as earthworms. How do the differences between the gizzards represent adaptations in aquatic and terrestrial feeding?  

17. **Relating Concepts** Explain the significance of the evolution of a coelom in mollusks.

18. **Evaluating Results** A particular bivalve mollusk called a shipworm can do extensive damage to ocean pier pilings (supports) by burrowing into them with its radula. As a project, a student decides to determine if a new paint can reduce shipworm damage more than other paints do. What variables must the student control in order for the experimental results to be considered valid?

19. **Justifying Conclusions** Classification of organisms has traditionally been based on physical similarities. Given the physical differences of gastropods, bivalves, and cephalopods, how did they come to be grouped into the phylum Mollusca?

**Alternative Assessment**

20. **Finding and Communicating Information** Use the library or Internet resources to compile a list of mollusks used by humans as food sources. For each mollusk listed, tell where it is harvested and which part of the mollusk is eaten. Prepare a brochure to summarize your findings. Include a visual that informs the reader of the geographic location of the food source.

21. **Summarizing Information** Throughout history, people around the world have used mollusk shells for adornment and other purposes. Research some specific ways humans have used shells, and prepare an oral or visual report of your findings. If you can obtain some mollusk shells, display them to illustrate your report.

22. **Career Connection** **Worm Farmer** Research the field of growing segmented worms for use in research, as fishing bait, and for soil improvement. Your report should include a job description, training required, kinds of employers, growth prospects, and starting salary.

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**TAKS Test Prep**

Use the diagram below and your knowledge of science to answer questions 1–3.

1. Which structure is part of the respiratory system?  
   - A.  
   - B.  
   - C.  
   - D.  

2. Which structure is part of the digestive system?  
   - F.  
   - A.  
   - G.  
   - B.  
   - H.  
   - C.  
   - J.  
   - D.  

3. One characteristic shown by this mollusk is:  
   - A. cephalization.  
   - B. radial symmetry.  
   - C. body segmentation.  
   - D. a pseudocoelom.

**Test Tip**

Focus on one question at a time unless you are asked to refer to previous answers.

---

**Standardized Test Prep**

1. A. Incorrect. The foot is used for locomotion.  
   - B. Correct. The gill is used in respiration.  
   - C. Incorrect. The heart is used in circulation.  
   - D. Incorrect. The intestine is used in digestion.  

2. F. Incorrect. The foot is used in locomotion.  
   - G. Incorrect. The gill is used in respiration.  
   - H. Incorrect. The heart is used in circulation.  
   - J. Correct. The intestine is used in digestion.

3. A. Correct. This mollusk has a distinct head region—cephalization.  
   - B. Incorrect. Mollusks are bilaterally symmetrical.  
   - C. Incorrect. Mollusks are not coelomate.  
   - D. Incorrect. Mollusks have a coelom.

---

**Critical Thinking**

16. The food of aquatic annelids is not as coarse and does not require as much grinding for digestion as the food of terrestrial annelids.

17. The coelom allowed for the evolution of complex organs composed of more than one tissue type. A coelom also allows the internal organs to be suspended from the body wall and cushioned by fluid. This allows mollusks to move around without damaging their organs or interfering with their function.

18. Every variable other than type of paint must be identical, including the shape and size of the pier pilings, the type of wood, the thickness of paint, the method of application, and the numbers of mollusks used.

19. Gastropods, bivalves, and cephalopods are grouped together as mollusks because they share a common evolutionary ancestor and because they share several key characteristics, including the presence of a coelom, a three-part body plan, and a trochophore larval stage.

**Alternative Assessment**

20. Answers will vary. Students should list a variety of mollusks that are used for human consumption. They should also describe areas where each mollusk can be found.

21. Answers will vary, but could include trade currency, tools, jewelry, and dishes.

22. Answers will vary. Worm farmers have varying degrees of education, from high school through graduate school. They all share a working knowledge of growing, breeding, and harvesting worms on a large scale. Worm farmers usually own their own businesses or work as part of a larger agricultural products business. They may also be employed by waste management agencies. The growth potential for this field is fair. Starting salary will vary by region.