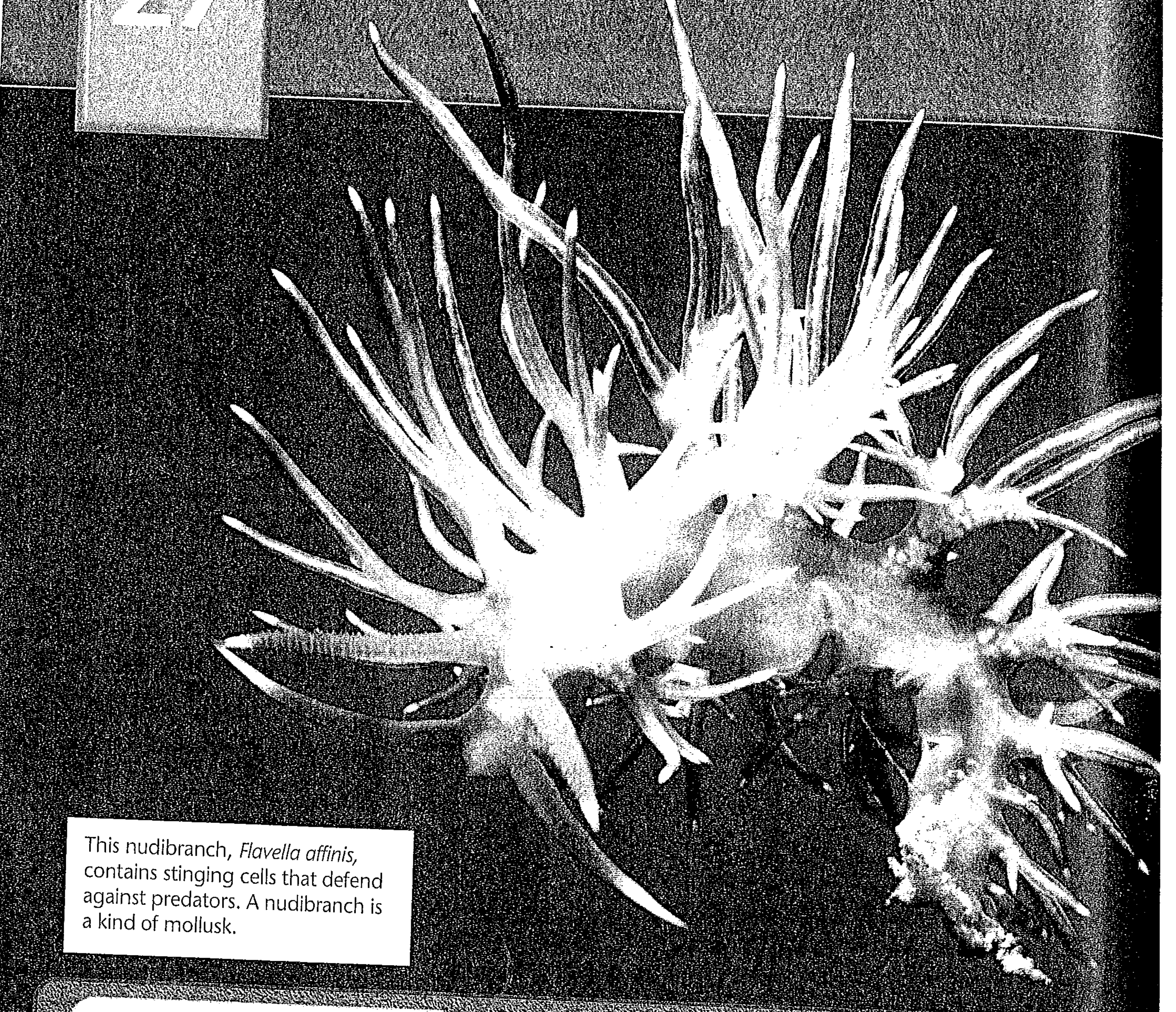
CHAPTER 27

Worms and Mollusks



This nudibranch, *Flavella affinis,* contains stinging cells that defend against predators. A nudibranch is a kind of mollusk.

Inquiry Activity

Does a planarian have a head?

Procedure

1. Put on plastic gloves. Cover half of the outside of a petri dish with black paper. Place a white sheet of paper under the other half. Place a planarian in the center of the dish, and add spring water to keep it moist. Observe the planarian for 2 minutes. Record how long it stays on each side of the dish.
2. Where did the planarian spend more time? Hypothesize why the planarian preferred this side.
3. Tape a 4-cm piece of rubber band to a pencil so that 1 cm of the rubber band hangs freely. Use the tip of the rubber band to gently prod each end of the planarian. Observe its behavior. Wash your hands with soap and warm water before leaving the lab.

Think About It

1. **Observing** When the planarian moved, did one end always go first?
2. **Drawing Conclusions** How might the behaviors that you observed help the planarian survive?

27–1 Flatworms

When most people think of worms, they think of long, squiggly earthworms. But there are many other kinds of worms. Some are the length of your body or as thick as your arm. Others look like glowing, furry blobs. Worms can flutter and glide, or climb around with paddlelike bristles. Still others are very small and live in tubes cemented to rocks.

How is their body shape beneficial to worms? A long, slender body allows an animal to move about more rapidly than a radially symmetrical body, like that of a cnidarian. Worms can move forward in a single direction rather than remaining stationary or drifting in currents. In addition, the mouth, sense organs, and brain (if there is one) are usually located at the head, or anterior end, of the body. This arrangement allows worms to locate food and respond to stimuli as they move. Many groups of organisms have worm-shaped bodies. The familiar earthworm is a segmented worm, which you will read about later in this chapter. The unsegmented worms include flatworms and roundworms. The simplest of these are the flatworms.

Guide for Reading

Key Concepts
- What are the defining features of flatworms?
- What are the characteristics of the three groups of flatworms?

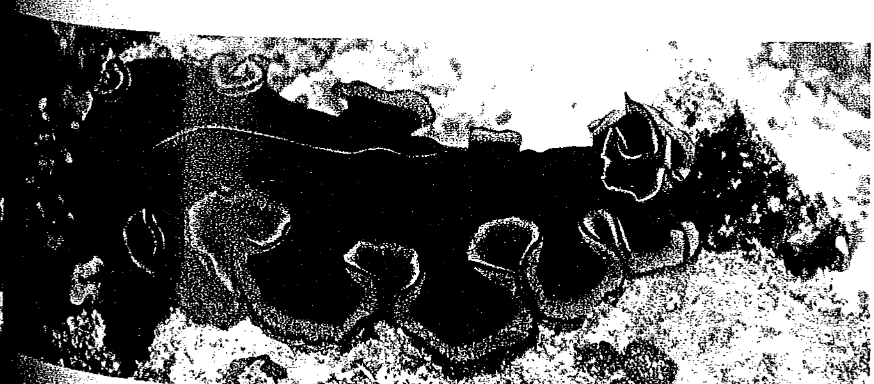
Vocabulary
acoelomate • coelom
pharynx • flame cell
ganglion • eyespot
hermaphrodite
fission • scolex
proglottid • testis

Reading Strategy: Outlining Before you read, use the headings of the section to make an outline about the characteristics of flatworms. As you read, fill in subtopics where they apply in the outline. Add phrases after each subtopic to provide key information.

What Is a Flatworm?

The phylum Platyhelminthes (plat-ih-hel-MIN-theez) consists of the flatworms. Most flatworms are no more than a few millimeters thick. **Flatworms are soft, flattened worms that have tissues and internal organ systems. They are the simplest animals to have three embryonic germ layers, bilateral symmetry, and cephalization.**

Flatworms are known as **acoelomates** (ay-SEE-luh-mayts), meaning "without coelom." A **coelom** (SEE-lum) is a fluid-filled body cavity that is lined with tissue derived from mesoderm. No coelom forms between the tissues of flatworms. **Figure 27–1** shows that the digestive cavity, which is lined with tissue derived from endoderm, is the only body cavity. Flatworms also have bilateral symmetry. This means that the animal has two well-formed sides that can be identified as left and right. Most flatworms exhibit enough cephalization to have what is called a head.



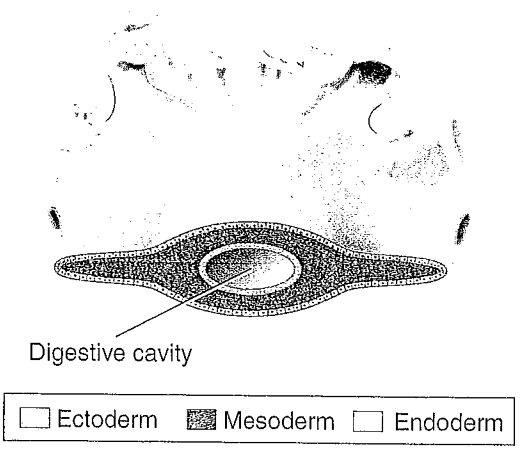
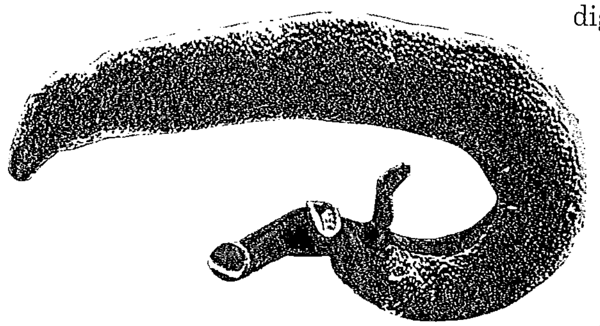


Figure 27–1 **Flatworms are the simplest animals to have three embryonic germ layers—ectoderm, endoderm, and mesoderm.** Shown here is the tropical, free-living flatworm *Pseudobiceros gloriosus.*

Form and Function in Flatworms

Because flatworms are thin and most of their cells are close to the external environment, materials can pass easily into and out of their bodies. All flatworms rely on diffusion for some essential body functions, such as respiration, excretion, and circulation. Other processes are carried out in different ways in different species. Free-living flatworms have organ systems for digestion, excretion, response, and reproduction.

Parasitic species of flatworms, such as the fluke in **Figure 27–2**, probably evolved from free-living ancestors. As the worms evolved into parasites, internal organs and other structures were modified or even lost. As a result, parasitic species are typically simpler in structure than their free-living relatives.



▲ **Figure 27–2** Blood flukes are parasitic flatworms that mature in the blood vessels of humans. Unlike free-living flatworms, parasitic worms take in nutrients from another organism. **Comparing and Contrasting** *How do the internal structures of parasitic flatworms compare to those of free-living flatworms?*

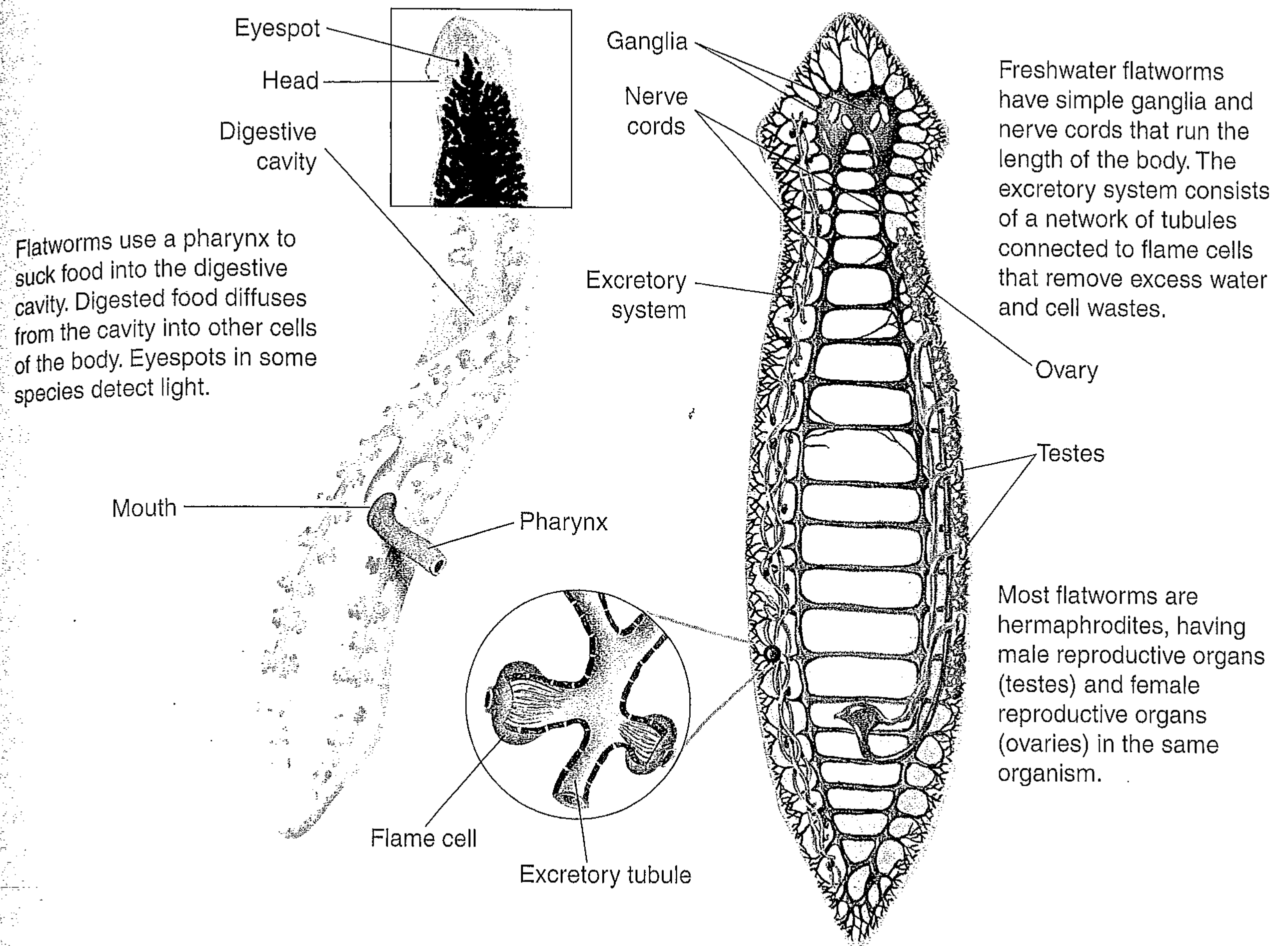
Feeding Free-living flatworms can be carnivores that feed on tiny aquatic animals, or they can be scavengers that feed on recently dead animals. Like cnidarians, flatworms have a digestive cavity with a single opening, or mouth, through which food and wastes pass. Near the mouth is a muscular tube called a **pharynx** (FAR-inks). Flatworms extend the pharynx out of the mouth. The pharynx then pumps food into the digestive cavity, or gut. Once inside, food is digested by cells of the gut, where digestion and nutrient absorption take place. Digested food diffuses from the digestive cavity into all other body tissues.

Parasitic worms feed on blood, tissue fluids, or pieces of cells within the host's body. Many parasitic worms obtain nutrients from foods that have already been digested by their host. Therefore, most parasitic worms do not need a complex digestive system. Many parasitic species have a digestive tract that is simpler than that of free-living forms. Some species have a pharynx that pumps food into a pair of dead-end intestinal sacs for digestion. Tapeworms, on the other hand, have no digestive tract at all. They live within the intestine of their host, such as a cow or a human, and simply absorb digested nutrients that are in their host's intestine.

Respiration, Circulation, and Excretion Because their bodies are so flat and thin, many flatworms do not need a circulatory system to transport materials. Instead, flatworms rely on diffusion to transport oxygen and nutrients to their internal tissues, and to remove carbon dioxide and other wastes from their bodies. Flatworms have no gills or other respiratory organs, and no heart, blood vessels, or blood.

Some flatworms have flame cells that function in excretion. **Flame cells** are specialized cells that remove excess water from the body. They may also filter and remove metabolic wastes such as ammonia and urea. Many flame cells are joined together to form a network of tubes that empties into the outside environment through tiny pores in the animal's skin.

✓CHECKPOINT *What is the function of flame cells?*



▲ **Figure 27–3** All flatworms, including this planarian, have organ systems that perform essential life functions. The digestive cavity (left) is branched throughout the body and opens to the outside through the pharynx. The diagram on the right shows the excretory system, nervous system, and reproductive system. The excretory system (in purple) consists of many flame cells (in red) that maintain water balance and may remove waste. The nervous system (in dark gray) consists of ganglia and two nerve cords that run the length of the body. The reproductive system (in green) has both testes and ovaries along both sides of the body. **Inferring** *How is a branched digestive cavity advantageous to a flatworm?*

Response Most flatworms have more complex structures for detecting and responding to external stimuli than those of cnidarians or sponges. In free-living flatworms, a head encloses several **ganglia** (singular: ganglion), or groups of nerve cells, that control the nervous system. These ganglia are not complex enough to be called a brain. Two long nerve cords run from the ganglia along both sides of the body. Locate these nerve cords in **Figure 27–3.** Observe that shorter nerve cords run across the body, like the rungs of a ladder. Parasitic flatworms interact little with their external environment and typically have a less complex nervous system.

Many free-living flatworms have what look like eyes near the anterior end of their body. Each "eye" is actually an **eyespot,** or group of cells that can detect changes in the amount of light in their environment. In addition to having eyespots, most flatworms have specialized cells that detect external stimuli, such as chemicals found in food or the direction in which water is flowing. These cells are usually scattered throughout the body.

The nervous systems of free-living flatworms allow them to gather information from their environment. They use this information to locate food and to find dark hiding places beneath stones and logs during the day.

Movement Free-living flatworms typically move in two ways. Cilia on their epidermal cells help them glide through the water and over the bottom of a stream or pond. Muscle cells controlled by the nervous system allow them to twist and turn so that they are able to react rapidly to environmental stimuli.

Reproduction Most free-living flatworms are hermaphrodites that reproduce sexually. A **hermaphrodite** (hur-MAF-roh-dyt) is an individual that has both male and female reproductive organs. During sexual reproduction, two worms join in a pair. The worms in the pair deliver sperm to each other. The eggs are laid in clusters and hatch within a few weeks.

Asexual reproduction is common in free-living flatworms. It takes place by **fission,** in which an organism splits in two, and each half grows new parts to become a complete organism. In some species, a worm simply "falls to pieces," and each piece grows into a new worm. Parasitic flatworms often have complex life cycles that involve both sexual and asexual reproduction.

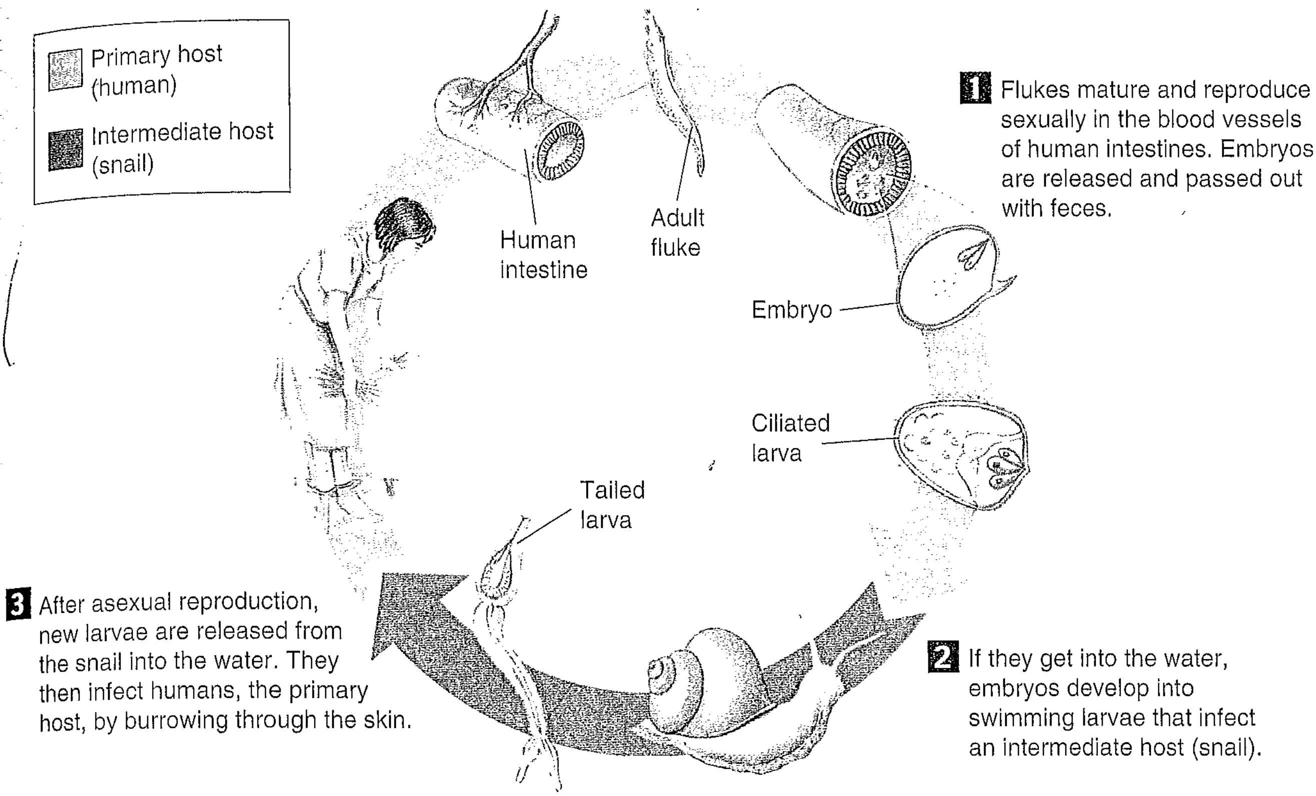
✓ CHECKPOINT *What method of asexual reproduction is common in flatworms?*

Groups of Flatworms

Flatworms are an enormously diverse group with many different forms. The three main groups of flatworms are turbellarians, flukes, and tapeworms. Most turbellarians are free-living. Most other flatworm species are parasites.

Turbellarians Free-living flatworms belong to the class Turbellaria (tur-buh-LAYR-ee-uh). **Turbellarians are free-living flatworms. Most live in marine or fresh water.** Most species are bottom dwellers, living in the sand or mud under stones and shells. The most familiar flatworms of this group are the planarians, the "cross-eyed" freshwater worms. Turbellarians can vary greatly in color, form, and size, as shown in **Figure 27–4.**

Figure 27–4 **Free-living flatworms are called turbellarians.** Turbellarians vary in size, shape, coloration, and habitat. The species at left is feeding on a coral reef, and the species at right lives in the leaf litter in a tropical forest.



▲ **Figure 27–5** **Flukes usually infect the internal organs of their host.** The life cycle of the blood fluke *Schistosoma mansoni* involves two hosts: humans and snails.

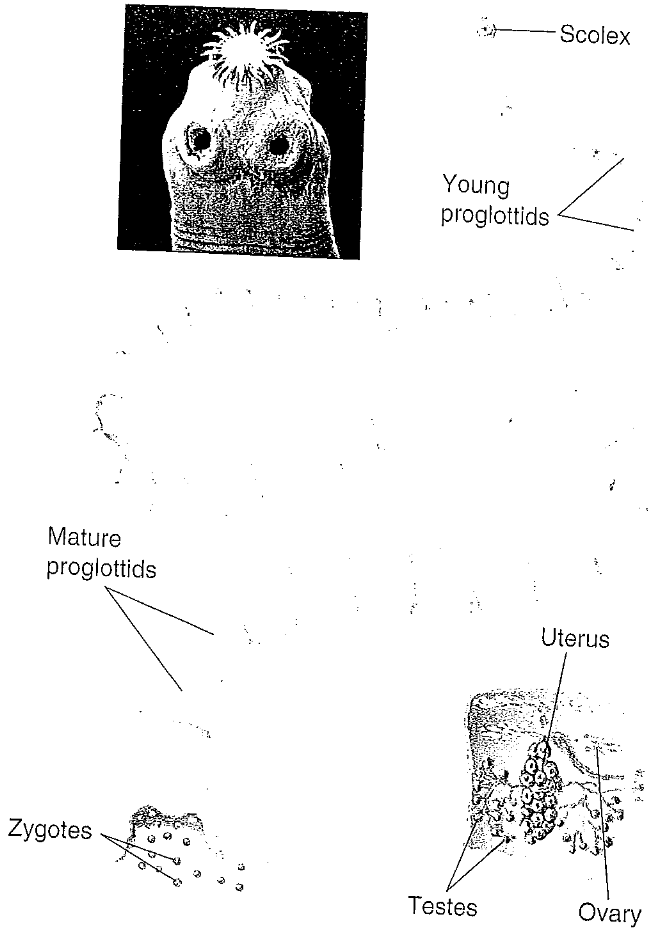
Flukes Members of the class Trematoda (trem-uh-TOH-duh) are known as flukes. **Flukes are parasitic flatworms. Most flukes infect the internal organs of their host.** They can infect the blood or virtually any internal organ of the host. Some flukes are external parasites that live on the skin, mouth, gills, or other outside parts of a host.

The blood fluke *Schistosoma mansoni* has a life cycle that is typical of parasitic flukes and of many parasites in general. As shown in **Figure 27–5,** the fluke lives in multiple hosts. Its primary host, the organism in which it reproduces sexually, is a human. Blood flukes infect humans by burrowing through exposed skin. Once inside, they are carried to the tiny blood vessels of the intestine. There, the flukes mature into adults, reproduce sexually, and release embryos into the intestine. The embryos are passed out of the body in feces.

If the embryos reach water, they develop into swimming larvae and infect freshwater snails, the intermediate host. An intermediate host is an organism in which a parasite reproduces asexually. Larvae that result from asexual reproduction are eventually released to begin the cycle again.

The *Schistosoma* fluke causes schistosomiasis (shis-tuh-soh-MY-uh-sis) in humans. Schistosomiasis is a serious disease in which the *Schistosoma* eggs clog blood vessels, causing swelling and tissue decay in the lungs, liver, spleen, or intestines. Schistosomiasis affects millions of people worldwide. It is particularly widespread in tropical areas that lack proper sewage systems, where human wastes are tossed into streams or used as fertilizer. There, the parasites are transmitted to intermediate hosts and back to humans with deadly efficiency.

Go Online NSTA SCILINKS
For: Links on flukes
Visit: www.SciLinks.org
Web Code: cbn-8271



▲ **Figure 27–6** **Tapeworms are parasitic flatworms that live in the intestines of their host.** A tapeworm attaches to the host using hooks or suckers on its scolex. A single tapeworm is made of many proglottids. The youngest proglottids are at the anterior (head) end, and the largest and most mature proglottids are at the posterior (tail) end. After eggs have been fertilized, proglottids break off and release zygotes that are then passed out of the host in feces.

Tapeworms Members of the class Cestoda (ses-TOHD-uh) are called tapeworms. **Tapeworms are long, flat, parasitic worms that are adapted to life inside the intestines of their hosts.** There, they are surrounded by food that has already been digested, so it can be absorbed directly through their body walls. They have no digestive tract.

Figure 27–6 shows the structure of a tapeworm. The head of an adult tapeworm, called a **scolex** (SKOH-leks), is a structure that can contain suckers or hooks. The tapeworm uses its scolex to attach to the intestinal wall of its host, where it absorbs nutrients from the host's intestine. Behind the scolex is a narrow region that divides to produce many **proglottids** (proh-GLAHT-idz), which are the segments that make up most of the worm's body. Mature proglottids contain both male and female reproductive organs. Sperm produced by the **testes** (singular: testis), or male reproductive organs, can fertilize eggs of other tapeworms or of the same individual. After the eggs are fertilized, proglottids break off and burst to release the fertilized eggs, or zygotes. These zygotes are passed out of the host in feces.

If food or water contaminated with tapeworm zygotes is consumed by cows, fishes, or other intermediate hosts, the eggs enter the host and hatch into larvae. These larvae grow and then burrow into the muscle tissue of the intermediate host. There they form a dormant protective stage called a cyst. If a human eats incompletely cooked meat containing these cysts, the larvae become active and grow into adult worms within the human's intestines, beginning the cycle again.

27–1 Section Assessment

1. **Key Concept** What is a flatworm?
2. **Key Concept** List the three groups of flatworms and give an example of each.
3. How do the feeding methods of parasitic and free-living flatworms relate to their specific environments?
4. Describe the life cycle of the blood fluke, *Schistosoma mansoni.*
5. **Critical Thinking Applying Concepts** How do a turbellarian's nervous system and digestive system work together to provide the food that the worm's body needs?

Writing in Science

Compare-Contrast Paragraph

Write a paragraph comparing free-living and parasitic flatworms. Be sure to explain how these worms are alike as well as how they are different. *Hint:* Before you write, construct a Venn diagram to organize your ideas.

27–2 Roundworms

Members of the phylum Nematoda, also known as roundworms, are among the most numerous of all animals. It is difficult to imagine how many live around us. A single rotting apple can contain as many as 90,000 roundworms. A cubic meter of garden soil can be home to more than a million!

What Is a Roundworm?

Roundworms are slender, unsegmented worms with tapering ends. They range in size from microscopic to a meter in length. Most species of roundworms are free-living, inhabiting soil, salt flats, aquatic sediments, and water, from polar regions to the tropics. Many others are parasitic and live in hosts that include almost every kind of plant and animal.

Like flatworms, roundworms develop from three germ layers. However, roundworms have a body cavity between the endoderm and mesoderm tissues. Because this cavity is lined only partially with tissue derived from the mesoderm, it is called a **pseudocoelom** (soo-doh-SEE-lum), which means "false coelom." Observe the pseudocoelom in **Figure 27–7.**

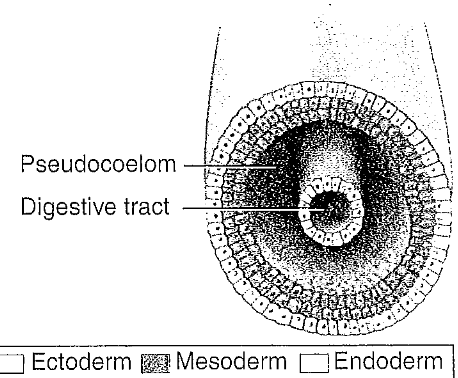
Also, unlike most flatworms, roundworms have a digestive tract with two openings. This body plan is often called a tube-within-a-tube. The inner tube is the digestive tract, and the outer tube is the body wall. This arrangement makes digestion in roundworms very different from that in flatworms because food moves in one direction through the digestive tract. Any material in the food that cannot be digested leaves through the anus. The **anus** is the posterior opening of the digestive tract. **Roundworms are unsegmented worms that have pseudocoeloms and digestive systems with two openings—a mouth and an anus.**

Guide for Reading

Key Concepts
- What are the defining features of roundworms?
- What roundworms are important in human disease?

Vocabulary
pseudocoelom
anus

Reading Strategy: Using Visuals As you read, write a statement explaining how each illustration or photograph reinforces or enhances the content of the section.



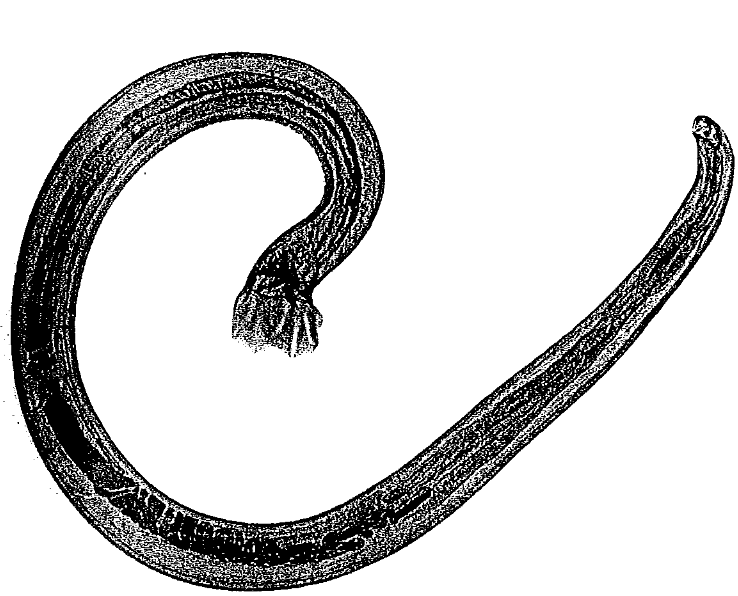


Figure 27–7 **Roundworms such as hookworms are unsegmented worms that have a pseudocoelom and a digestive system with a mouth and an anus.** Roundworms develop from three germ layers, and a pseudocoelom forms between the endoderm and mesoderm layers.

Figure 27–8 Parasitic roundworms include trichinosis-causing *Trichinella* worms (top) and hookworms (inset). *Trichinella* worms reproduce in the intestines of their host and then form cysts in the muscle tissue. Hookworms affect as many as one quarter of the world's population. They suck the host's blood from inside the intestines, weakening the host.

Form and Function in Roundworms

Roundworms have specialized tissues and organ systems that carry out essential physiological functions. In general, the body systems of free-living roundworms tend to be more complex than those of parasitic forms.

Feeding Many free-living roundworms are predators that use grasping mouthparts and spines to catch and eat other small animals. Some soil-dwelling and aquatic forms eat algae, fungi, or pieces of decaying organic matter. Others digest the bacteria and fungi that break down dead animals and plants.

Respiration, Circulation, and Excretion Like flatworms, roundworms exchange gases and excrete metabolic waste through their body walls. They have no internal transport system. Therefore, they depend on diffusion to carry nutrients and waste through their bodies.

Response Roundworms have simple nervous systems, consisting of several ganglia. Several nerves extend from ganglia in the head and run the length of the body. These nerves transmit sensory information and control movement. Roundworms have several types of sense organs. Some include simple structures that detect chemicals given off by prey or hosts.

Movement The muscles of roundworms extend the length of their bodies. Together with the fluid in the pseudocoelom, these muscles function as a hydrostatic skeleton. Aquatic roundworms contract these muscles to move like snakes through the water. Soil-dwelling roundworms simply push their way through the soil by thrashing around.

Reproduction Roundworms reproduce sexually, and most species have separate sexes—an individual is either male or female. Roundworms reproduce using internal fertilization. Usually, the male deposits sperm inside the female's reproductive tract. Parasitic roundworms often have life cycles that involve two or three different hosts or several organs within a single host.

✓CHECKPOINT *How do free-living roundworms that are predators obtain their food?*

Roundworms and Human Disease

Although most roundworms are free-living, the phylum is better known for species that parasitize their hosts, including humans. Parasitic roundworms, such as those in **Figure 27–8**, have been evolving relationships with other organisms for hundreds of millions of years. Unfortunately, this process has produced worms that cause a great deal of pain and suffering in humans. **Parasitic roundworms include trichinosis-causing worms, filarial worms, ascarid worms, and hookworms.**

Careers in Biology

Meat Inspector

Job Description: work with farms and meat-processing plants to ensure that all meat and poultry products use healthy animals, are processed in a sanitary manner, and are labeled truthfully with no harmful ingredients added; enforce government regulations to ensure that proper safety, sanitation, preservation, disposal, and packaging procedures are followed

Education: college courses in sanitation and public health; USDA certification

Skills: knowledge of food-borne illnesses, proper sanitation practices, and regulations; public relations skills for dealing with different people in the industry; patience and communication skills for educating the public; ability to work independently and with a team

Highlights: You help protect the safety of the public by working to eliminate food-borne illnesses. You inspect farms to make sure that sanitary procedures are followed.

Go Online
PHSchool.com

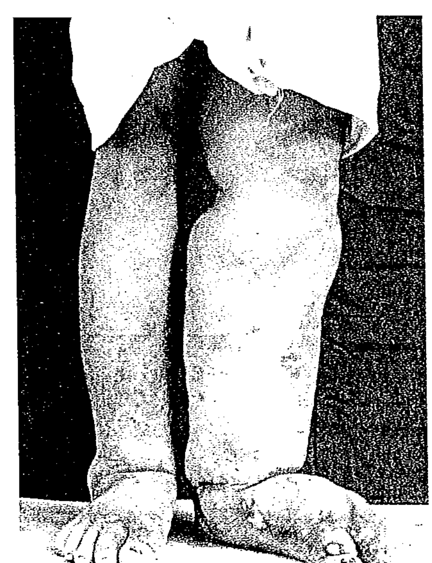
For: Career links
Visit: PHSchool.com
Web Code: cbb-8272

Trichinosis-Causing Worms Trichinosis (trik-ih-NOH-sis) is a terrible disease caused by the roundworm *Trichinella*. Adult worms live and mate in the intestines of their hosts. Female worms carrying fertilized eggs burrow into the intestinal wall and then release larvae. These larvae travel through the bloodstream and burrow into organs and tissues, causing terrible pain for the host. The larvae form cysts and become inactive in the host's muscle tissue.

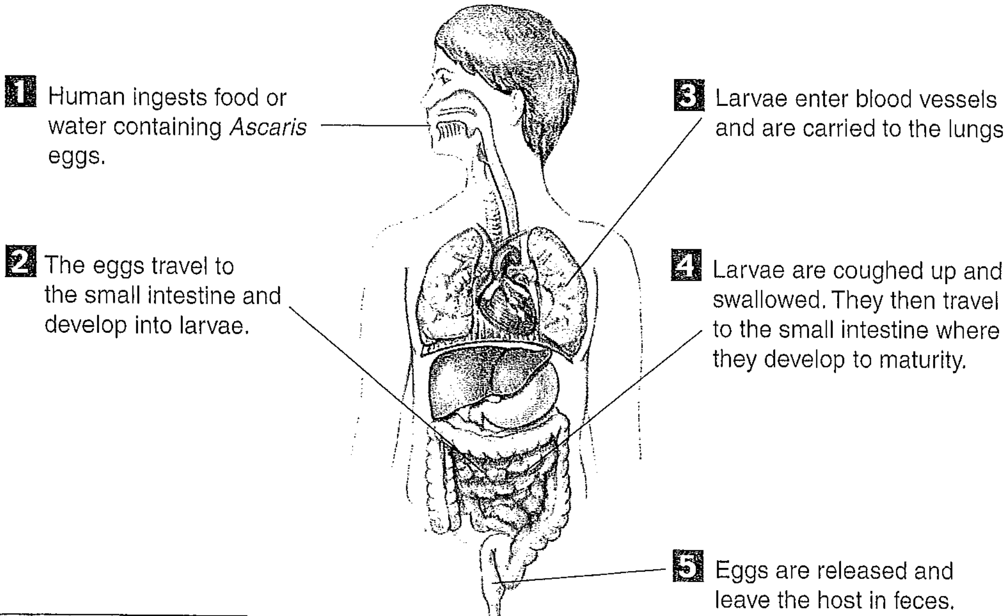
Trichinella completes its life cycle only when another animal eats muscle tissue containing these cysts. Two common hosts for *Trichinella* are rats and pigs. Humans get trichinosis almost exclusively by eating raw or incompletely cooked pork.

Filarial Worms Filarial worms, which are found primarily in tropical regions of Asia, are threadlike worms that live in the blood and lymph vessels of birds and mammals, including humans. They are transmitted from one primary host to another through biting insects, especially mosquitoes. In severe infections, large numbers of filarial worms may block the passage of fluids within the lymph vessels. This causes elephantiasis, shown in **Figure 27–9**, a condition in which the affected part of the body swells enormously.

✓CHECKPOINT *Describe the cause of elephantiasis.*



▲ **Figure 27–9** **Filarial worms are one kind of parasitic roundworm.** Elephantiasis, shown here in an advanced stage, is a disease caused by filarial worms.



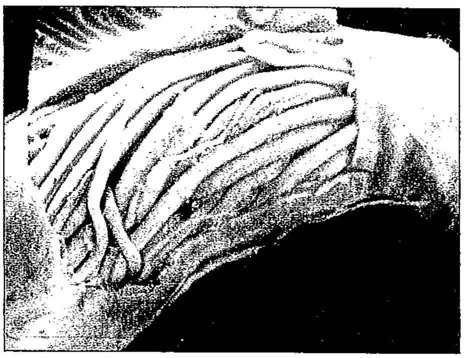


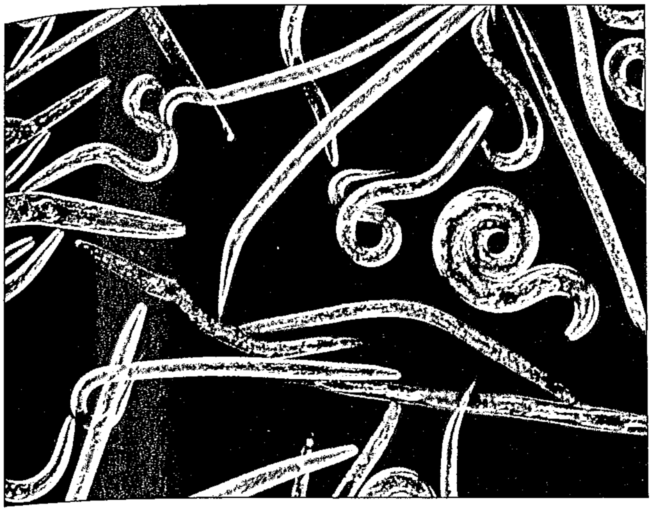
Figure 27–10 *Ascaris lumbricoides* fill the host's intestine. These worms absorb the host's digested food and can cause severe malnutrition. Blockage of the intestine can be severe enough, as shown in a pig intestine in the photograph, that it causes death. **Interpreting Graphics** *What is the sequence of organs that* Ascaris *travels through in humans?*

Ascarid Worms *Ascaris lumbricoides* is a serious parasite of humans and many other vertebrate animals. It causes malnutrition in more than 1 billion people worldwide. It does this by absorbing digested food from the host's small intestine. *Ascaris lumbricoides* is commonly spread by eating vegetables or other foods that are not washed properly.

The life cycle of *Ascaris* is summarized in **Figure 27–10** above. *Ascaris* matures in the intestines of its host, such as a human, and can reach a length of almost 50 cm. In the intestine, the ascarid worms produce a large number of fertilized eggs, which leave the body in the feces. If food or water contaminated with these feces is eaten by another host, then the eggs hatch in the small intestine of the new host. The young worms burrow into the walls of the intestines and enter the surrounding blood vessels. The worms are carried in the blood until they reach the lungs. There, they spread into air passages and into the throat, where they are swallowed. Carried back into the intestines, they mature, and the cycle repeats itself.

Species that are closely related to *Ascaris* affect horses, cattle, pigs, chickens, dogs, cats, and many other animals. *Ascaris* and its relatives, which are collectively known as ascarids, have life cycles that are similar to one another. One of the reasons puppies are wormed while they are young is to rid them of the ascarid worms that affect dogs.

Hookworms Today, as many as one quarter of the people in the world are infected with hookworms. Hookworm eggs hatch outside the body of the host and develop in the soil. If they find an unprotected foot, they use sharp toothlike plates and hooks to burrow into the skin and enter the bloodstream. Hookworms travel through the blood of their host to the lungs and down to the intestines. There, they suck the host's blood, causing weakness and poor growth.



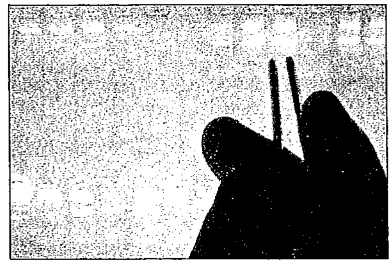


Figure 27–11 The DNA of *C. elegans,* a free-living roundworm, was the first genome of any multicellular animal to be sequenced completely. Biologists used techniques such as gel electrophoresis, shown above, to determine the exact sequence of base pairs in each chromosome. **Predicting** *How might these results be important to our understanding of human development?*

Research on *C. elegans*

Roundworms have recently been making headlines in scientific research. The free-living roundworm *Caenorhabditis elegans*, or *C. elegans*, is shown in **Figure 27–11,** above left. This worm lives a modest existence feeding on rotting vegetation. However, this species is extraordinary because its DNA was the first of any multicellular animal's to be sequenced completely.

Scientists now have the sequence of all 97 million base pairs of *C. elegans* DNA. This is roughly one thirtieth the number of base pairs in human DNA. They have also traced the differentiation and development of each body cell of *C. elegans*, starting from a single fertilized egg. Researchers are still learning how this differentiation is controlled by the animal's DNA. This research will lead to a better understanding of how eukaryotes became multicellular. Information from *C. elegans* may also shed light on how genes make multicellular organisms both similar to and different from one another.

27–2 Section Assessment

1. **Key Concept** What is a roundworm?
2. **Key Concept** What are the parasitic roundworms?
3. Describe how humans become infected with the parasitic roundworm *Ascaris lumbricoides.*
4. How do hookworms enter the human body?
5. What have scientists already learned about *Caenorhabditis elegans*? What do they hope to learn in the future?
6. **Critical Thinking Problem Solving** What steps might individual people and governments take to reduce the spread of elephantiasis?

Thinking Visually

Creating a Poster
Choose a type of roundworm that can cause disease in humans. Design an educational poster that promotes prevention of the disease. Be sure to include information about how the roundworm infects humans.

27–3 Annelids

Guide for Reading

Key Concepts
- What are the defining features of annelids?
- What are the characteristics of the three classes of annelids?

Vocabulary
septum • seta
crop • gizzard
closed circulatory system
gill • nephridium
clitellum

Reading Strategy: Using Visuals Before you read, preview **Figure 27–16.** How does this animal seem to differ from the other worms you have already studied? Briefly summarize any differences you notice.

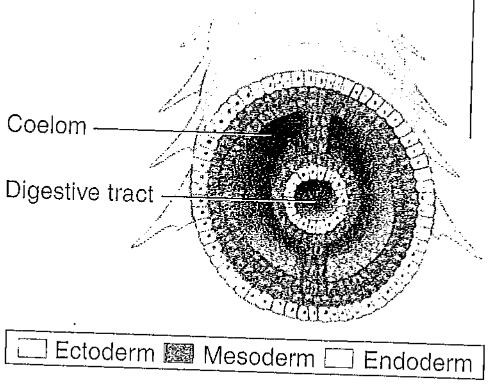
If you have ever dug in a garden in the spring, you have probably seen earthworms wriggling through the soil. Earthworms are annelids, members of the phylum Annelida. Other annelids include exotic seafloor worms and parasitic, blood-sucking leeches. Because their bodies are long and narrow, some annelids look a bit like flatworms or roundworms. However, the annelids are a distinct group that is probably more closely related to clams and snails. One piece of evidence for this relationship is the fact that annelids, clams, and snails all share a similar larval stage.

What Is an Annelid?

The name Annelida (uh-NEL-ih-duh) is derived from the Latin word *annellus*, which means "little ring." The name refers to the ringlike appearance of annelids' body segments. The body of an annelid is divided into segments that are separated by **septa** (singular: septum), which are internal walls between each segment. Most segments are similar to one another, although they may be modified to perform special functions. Some body segments may carry one or more pairs of eyes, several pairs of antennae, and other sense organs. Other segments may be specialized for functions such as respiration. In many annelids, bristles called **setae** (SEE-tee; singular: seta) are attached to each segment.

Annelids are worms with segmented bodies. They have a true coelom that is lined with tissue derived from mesoderm. These structures are shown in **Figure 27–12.** Recall that flatworms have no coelom, whereas roundworms have a pseudocoelom. Like the roundworms, annelids have a tube-within-a-tube digestive tract that food passes through from the mouth to the anus.

CHECKPOINT What are some functions performed by specialized segments?



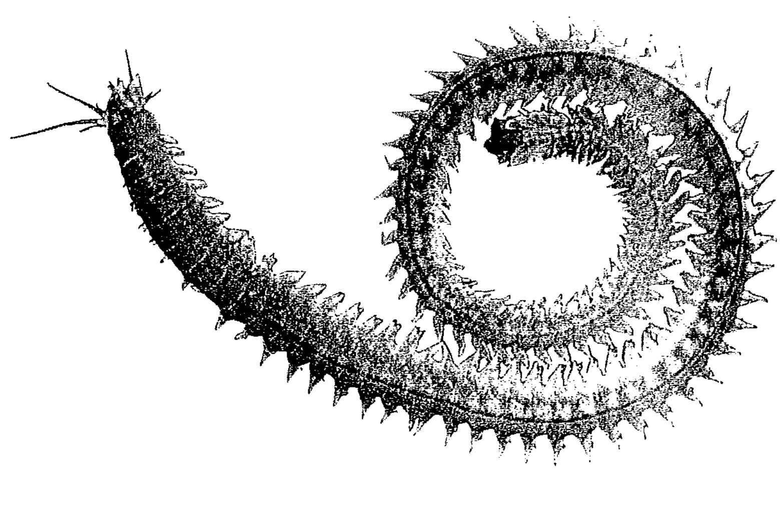
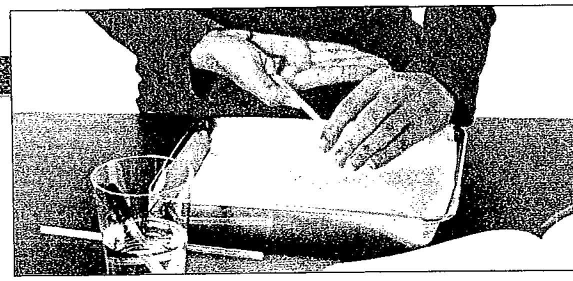


Figure 27–12 Annelids are among the simplest animals to have a true coelom that is lined with mesoderm. Annelids are also called segmented worms because the body is divided into many similar segments. The photo shows a marine annelid.

Quick Lab



How does an earthworm pump blood?

Materials earthworm; dropper pipette; nonchlorinated water; large, clear plastic soda straw; dissecting microscope; clock or watch with second hand

Procedure

1. Carefully insert an earthworm into a clear plastic straw. Do not force the worm into the straw. **CAUTION:** *Handle the earthworm carefully to avoid harming it. Wash your hands after handling the worm.*
2. Use a dropper pipette to add a drop or two of nonchlorinated water into the straw.
3. Examine the straw using a microscope. Direct light through the straw from below. Look near the front of the worm for the large ring blood vessels. Count how often these organs beat during a one minute period. Observe the rest of the circulatory system.

Analyze and Conclude

1. **Inferring** Did you see the worm breathing? Explain your answer. Why must the earthworm's skin be kept moist? How do your answers relate to how earthworms live in their environment?
2. **Observing** Is an earthworm's circulatory system open or closed? Explain your answer.

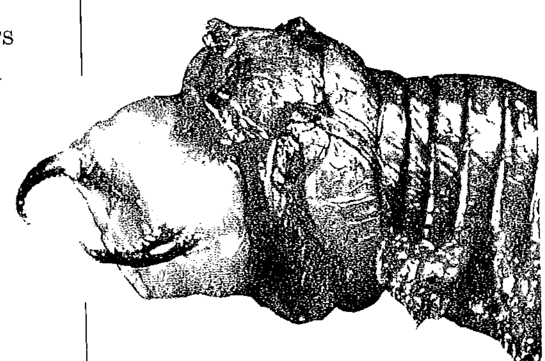
Form and Function in Annelids

Annelids have complex organ systems. Many of these systems are unique because of the segmented body plan of this group.

Feeding and Digestion Annelids range from filter feeders to predators. Many annelids get their food using a pharynx. In carnivorous species, such as the *Nereis* in **Figure 27–13,** the pharynx usually holds two or more sharp jaws that are used to attack prey. In annelids that feed on decaying vegetation, the pharynx is covered with sticky mucus. The worm collects food particles by extending its pharynx and pressing it against the surrounding sediments. Other annelids obtain nutrients by filter feeding. They fan water through tubelike burrows and catch food particles in a mucous bag.

In earthworms, the pharynx pumps food and soil into a tube called the esophagus. The food then moves through the **crop,** where it can be stored, and through the **gizzard,** where it is ground into smaller pieces. The food is absorbed farther along in the digestive tract, in an organ called the intestine.

Circulation Annelids typically have a **closed circulatory system,** in which blood is contained within a network of blood vessels. An earthworm's blood circulates through two major blood vessels that run from head to tail. Blood in the dorsal (top) vessel moves toward the head of the worm. Blood in the ventral (bottom) vessel runs from head to tail. In each body segment, a pair of smaller blood vessels connect the dorsal and ventral blood vessels and supply blood to the internal organs. The dorsal blood vessel functions like a heart because it contracts rhythmically and helps pump blood.



▲ **Figure 27–13** The annelid *Nereis* uses jaws to capture prey. When prey approaches, the worm lunges forward, rapidly extends its pharynx, and grabs the prey using its jaws. **Inferring** *How is the structure of a* Nereis*'s jaws related to their function?*

▲ **Figure 27–14** These feather-duster worms exchange gases underwater using feathery gills. **Applying Concepts** *How do land-dwelling annelids exchange gases?*

Respiration Aquatic annelids often breathe through gills. A **gill** is an organ specialized for the exchange of gases underwater. In feather-duster worms, shown in **Figure 27–14,** feathery structures that function as gills protrude from the opening of the worm's burrow or tube. Land-dwelling annelids, such as earthworms, take in oxygen and give off carbon dioxide through their moist skin. These annelids secrete a thin protective coating of mucus, which keeps their skins moist.

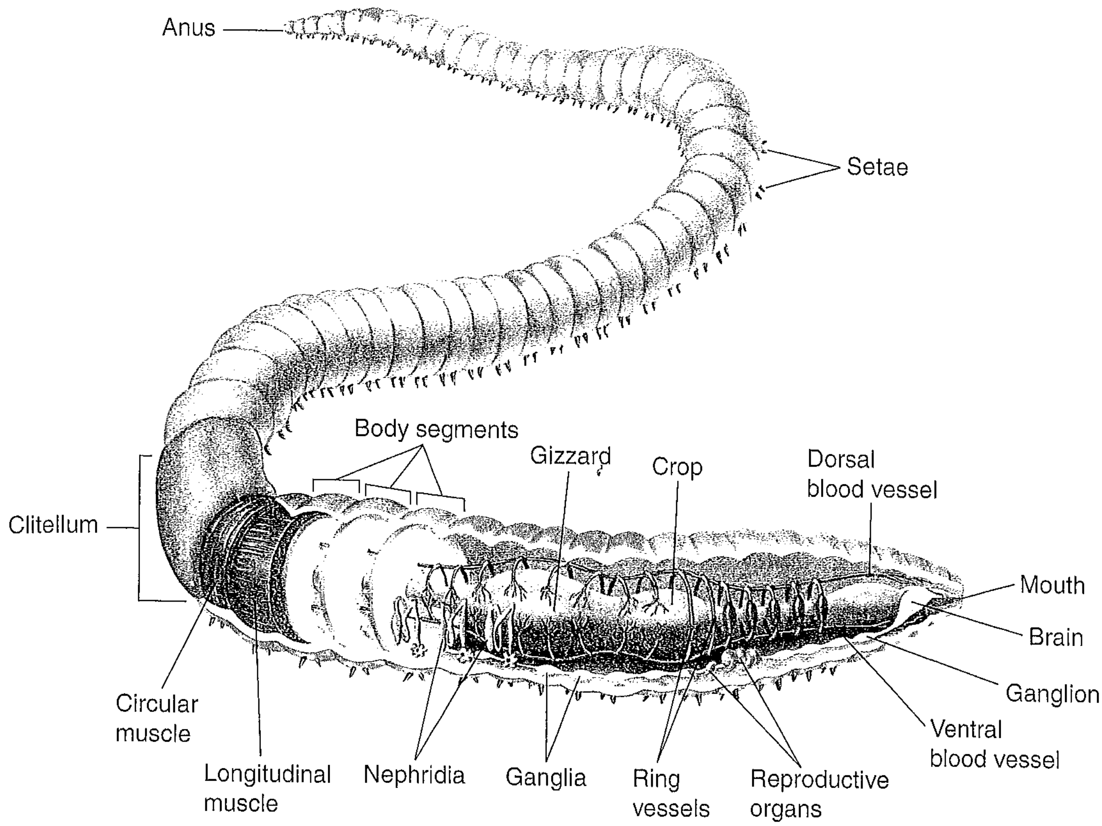
Excretion Like other animals, annelids produce two kinds of waste. Digestive waste passes out through the anus at the end of the digestive tract. Cellular waste containing nitrogen is eliminated by **nephridia** (nee-FRID-ee-uh; singular: nephridium), which are excretory organs that filter fluid in the coelom.

Response Most annelids have a well-developed nervous system consisting of a brain and several nerve cords. However, the sense organs are best developed in free-living marine annelids. Many of these species have a variety of adaptations for detecting stimuli: sensory tentacles, chemical receptors, statocysts that help detect gravity, and two or more pairs of eyes.

Movement Annelids have two major groups of body muscles that function as part of a hydrostatic skeleton. Longitudinal muscles run from the front of the worm to the rear and can contract to make the worm shorter and fatter. Circular muscles wrap around each body segment and can contract to make the worm longer and thinner. The earthworm moves by alternately contracting these two sets of muscles, using its setae to prevent slipping. Burrowing annelids use their muscles to force their way through heavy sediment. Marine annelids have paddlelike appendages, or parapodia (singular: parapodium), on each segment, which they use for swimming and crawling.

Reproduction Most annelids reproduce sexually. Some species use external fertilization and have separate sexes. Other annelids are hermaphrodites. Individuals rarely fertilize their own eggs. Instead, two worms attach to each other, as shown in **Figure 27–15,** exchange sperm, and then store the sperm in special sacs. When eggs are ready for fertilization, a **clitellum** (kly-TEL-um), or band of thickened, specialized segments, secretes a mucous ring into which eggs and sperm are released. Fertilization takes place within this ring. The ring then slips off the worm's body and forms a protective cocoon. Young worms hatch weeks later.

▶ **Figure 27–15** Some annelids, including these earthworms, are hermaphrodites. Each worm produces both eggs and sperm. During mating, the worms exchange sperm, which will eventually be used to fertilize egg cells. **Applying Concepts** *When are the eggs fertilized?*



Groups of Annelids

Because of their visible segmentation, all annelids show a basic similarity. Annelids are divided into three classes—oligochaetes, leeches, and polychaetes.

Oligochaetes The class Oligochaeta, or oligochaetes (AHL-ih-goh-keets), contains earthworms and their relatives. **Oligochaetes are annelids that typically have streamlined bodies and relatively few setae compared to polychaetes. Most oligochaetes live in soil or fresh water.** Earthworms, such as the one shown in **Figure 27–16**, are long, pinkish-brown worms that are common in woods, fields, and gardens. Tubifex worms—another common oligochaete—are red, threadlike aquatic worms that are sold in pet stores as food for tropical fish.

Although earthworms spend most of their lives hidden underground, you may find evidence of their presence above ground in the form of squiggles of mud known as castings. Recall that an earthworm—which swallows just about anything it can get into its mouth—uses its pharynx to suck a mixture of detritus and soil particles into its mouth. As the mixture of food and soil passes through the intestine, part of it is digested and absorbed. Sand grains, clay particles, and indigestible organic matter pass out through the anus in large quantities, producing castings. Some tropical earthworms produce enormous castings—as large as 18 centimeters long and 2 centimeters in diameter!

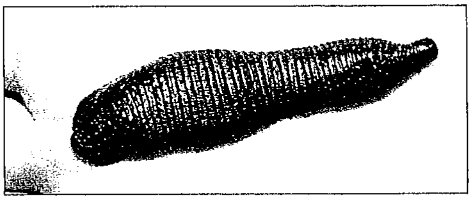
CHECKPOINT *What are earthworm castings?*

▲ **Figure 27–16** **Earthworms are oligochaetes that live in soil.** Earthworms carry out essential functions using digestive, circulatory, excretory, nervous, and reproductive systems. Many organs, including nephridia and blood vessels, repeat in nearly every body segment.

Word Origins

Oligochaete comes from the Greek words *oligos*, meaning "few" or "small," and *chaite*, meaning "hair." **If *poly-* means "many," what is a characteristic of the group of annelids known as polychaetes?**

Figure 27–17 **Most leeches are external parasites.** Medicinal leeches, such as the one below, were once used routinely to attempt to treat conditions ranging from headaches to mental illness to obesity. Doctors believed that diseases were caused by an excess of blood, so they applied leeches to the patient's skin to remove blood from the body. Here, a man who lived in the Middle Ages has become so fat that he has been confined to a room and covered with leeches.

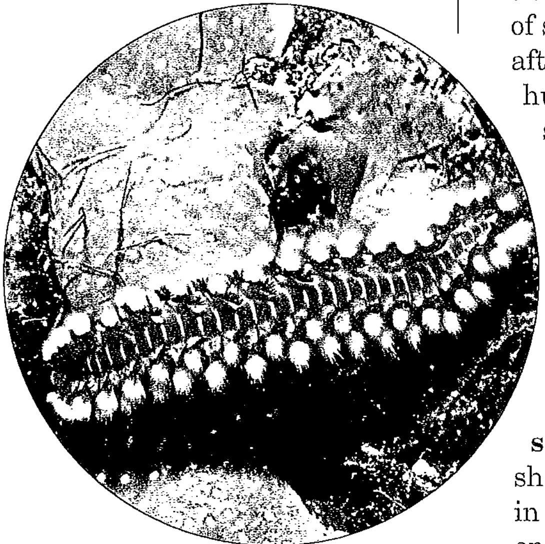


Leeches The class Hirudinea (hir-yoo-DIN-ee-uh) contains the leeches, most of which live in moist habitats in tropical countries. **Leeches are typically external parasites that suck the blood and body fluids of their host.** Roughly one fourth of all leeches are carnivores that feed on soft-bodied invertebrates such as snails, worms, and insect larvae.

Leeches have powerful suckers at both ends of their bodies that help them cling to their hosts. The posterior sucker can also anchor a leech to rocks or leaves as it waits for a host to pass. Some leeches force a muscular extension called a proboscis (proh-BAHS-is) into the tissue of their host. Others slice into the skin with a razor-sharp pair of jaws. Once a wound has been made, the leech uses its pharynx to suck blood from the area. Some leeches also release a substance that anesthetizes the wound—keeping the host from knowing it has been bitten.

Leeches were once commonly used to treat medical conditions. Today the use of medicinal leeches is undergoing a revival of sorts. Doctors are finding that leeches can reduce swelling after surgery. After surgeries in which a body part is reattached, hungry leeches are applied to the area. These leeches can suck several milliliters of blood at a time—up to five times their own weight! They also secrete a fluid that prevents blood from clotting. This anti-clotting mechanism helps relieve pressure and congestion in the healing tissues.

▼ **Figure 27–18** **Polychaetes are marine annelids.** The bearded fireworm is a polychaete that lives in coral reefs. It is best known for its method of defense—its setae, or bristles, break off when touched and cause irritation and burning.



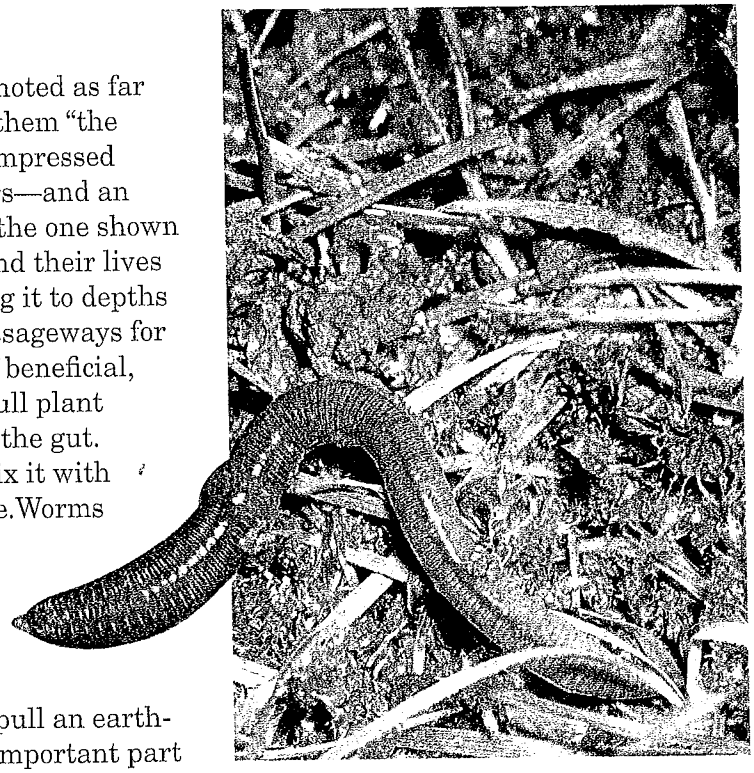
Polychaetes The class Polychaeta, or polychaetes (PAHL-ih-keets), contains sandworms, bloodworms, and their relatives. **Polychaetes are marine annelids that have paired, paddlelike appendages tipped with setae.** The setae are the brushlike structures on the worm shown in **Figure 27–18.** Polychaetes live in cracks and crevices in coral reefs; in sand, mud, and piles of rocks; or even out in the open water. Some burrow through or crawl over sediment.

Ecology of Annelids

The importance of earthworms in nature was noted as far back as ancient Greece, when Aristotle called them "the intestines of the earth." Charles Darwin was impressed enough with earthworms that he devoted years—and an entire book—to their study. Earthworms, like the one shown in **Figure 27–19**, and many other annelids spend their lives burrowing through soil, aerating it, and mixing it to depths of 2 meters or more. Their tunnels provide passageways for plant roots and water and allow the growth of beneficial, oxygen-requiring soil bacteria. Earthworms pull plant matter down into the soil and pass it through the gut. There, they grind it, partially digest it, and mix it with bacteria that help the plant matter decompose. Worms also "mine" minerals from deeper soil layers, bringing them up to the surface. Earthworm feces (castings) are rich in nitrogen, phosphorus, potassium, micronutrients, and beneficial bacteria.

You've probably seen a bird struggling to pull an earthworm out of the ground. Earthworms are an important part of the diet of many birds, such as robins. Moles, skunks, toads, and snakes also prey on earthworms.

In the sea, annelids participate in a wide range of food chains. Many marine annelids have free-swimming larvae that are part of the animal plankton that is consumed by fishes and other plankton feeders. As adults, some marine annelids are mud-dwelling filter feeders that are common in areas where sediment is disturbed or large amounts of organic material are present. These worms are especially numerous where pollution from sewage promotes the growth of bacteria and algae. As any fisher knows, many bottom-dwelling polychaetes are important in the diets of fishes. Crustaceans, such as crabs and lobsters, also include annelids in their diets.



▲ **Figure 27–19** Some annelids, including this earthworm, burrow through soil, mixing it as they go. **Predicting** *What might happen to a garden if all the annelids in the soil were killed?*

27–3 Section Assessment

1. **Key Concept** What features distinguish annelids from roundworms?
2. **Key Concept** List the defining characteristics for each class of annelid.
3. Describe the feeding strategies of earthworms and leeches.
4. **Critical Thinking Inferring** An earthworm has more light-sensitive cells in its anterior and posterior segments than in other parts of its body. Explain how this is advantageous for the worm.

Focus on the BIG Idea

Interdependence in Nature Review what you learned about food chains in Chapter 3. Then, draw a possible food chain involving an annelid. The food chain should include at least three levels.

ISSUES in Biology

What Can Be Done About the Zebra Mussel?

Zebra mussels *(Dreissena polymorpha)* were introduced into the United States from Eastern Europe and Asia when ships from the areas emptied their ballast tanks. They were first spotted in the Great Lakes in the mid-1980s. Zebra mussels have few natural enemies here and reproduce very rapidly. They have already colonized the entire Great Lakes region and have spread to rivers in more than ten states.

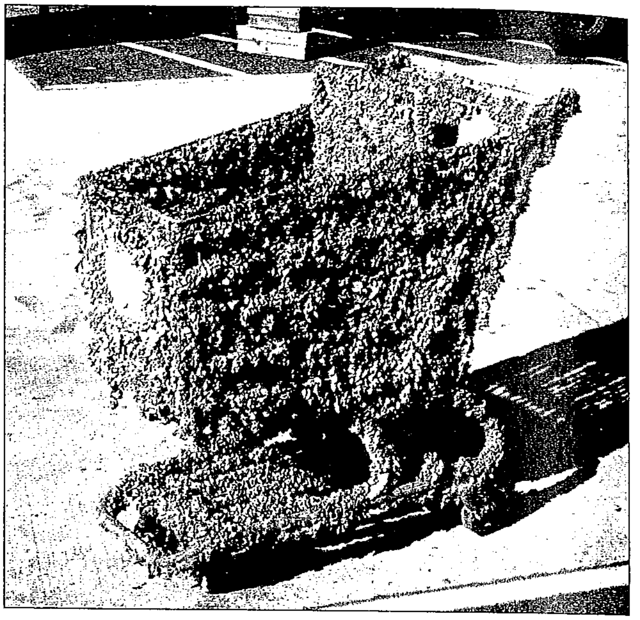
Zebra mussels live attached to almost any surface—from shopping carts to fiberglass boats—and can form layers up to 20 centimeters thick. They have caused serious structural damage and have clogged water supply lines to power plants and water treatment facilities. One paper company, for example, spent over a million dollars to remove zebra mussels that were clogging its cooling pipes.

Zebra mussels also threaten the ecology of aquatic communities. They can tolerate a wide range of temperatures and light intensities. In some habitats, they have displaced native mollusks, almost making them extinct. Zebra mussels have also depleted the food of many fish species. What can be done to control zebra mussels and other exotic (nonnative) species and prevent new ones from arriving?

The Viewpoints

Control and Prevention

Many scientists believe that there is no way to remove zebra mussels and many other established exotic species. Instead, these scientists attempt to control the growth of populations and prevent the transfer of exotic species to new areas. One regulation, for example, could require boaters to filter and chemically clean all ballast water. Another approach would be to find beneficial uses for zebra mussels. Scientists are already exploring the ability of zebra mussels to filter large volumes of waste water.



Eradication

Other groups contend that zebra mussels should be eradicated. Engineers, for example, are developing robotic submarines that can remove mussels from pipelines. Chemists are testing chemicals for the potential to destroy or disrupt the life cycle of zebra mussels. Other scientists are adding chemicals to paints and plastics to prevent mussels from attaching to new surfaces.

Research and Decide

1. **Analyzing the Viewpoints** To make an informed decision, learn more about this issue by consulting library or Internet resources. Then, determine the advantages and disadvantages of each proposed solution to the problems caused by zebra mussels.
2. **Forming Your Opinion** What measures do you think would be most effective in dealing with exotic species?

Go Online
PHSchool.com
For: Links from the authors
Visit: PHSchool.com
Web Code: cbe-8273

27–4 Mollusks

They climb trees in tropical rain forests and float over coral reefs. They crawl into garbage cans, eat their way through farm crops, and speed through the deep ocean. Some are so small that you can hardly see them with the unaided eye, while others are 20 meters long! They are the mollusks—one of the oldest and most diverse phyla. Mollusks come in so many sizes, shapes, and forms that you might wonder why they are classified in the same phylum. To learn the answer, read on.

Guide for Reading

Key Concepts
- What are the defining features of mollusks?
- What is the basic body plan of mollusks?
- What are the characteristics of the three main classes of mollusks?

Vocabulary
trochophore • foot
mantle • shell • visceral mass
radula • siphon
open circulatory system

Reading Strategy: Building Vocabulary
As you read, make notes about the meaning of each term in the list above. After you read the section, make a table listing the different types of mollusks on the left and the vocabulary words that apply on the right.

What Is a Mollusk?

Members of the phylum Mollusca, known as mollusks, are named from the Latin word *molluscus*, which means "soft." **Mollusks are soft-bodied animals that usually have an internal or external shell.** Mollusks include snails, slugs, clams, squids, and octopi. But a snail looks very different from a squid, which looks very different from a clam. So why are these animals all placed in the same phylum? One reason is that many mollusks share similar developmental stages. Many aquatic mollusks have a free-swimming larval stage called a **trochophore** (TRAHK-oh-fawr). The trochophore larva, which is shown in **Figure 27–20**, is also characteristic of annelids, indicating that these two groups may be closely related. Molecular studies suggest that a common ancestor of annelids and mollusks lived more than 550 million years ago.

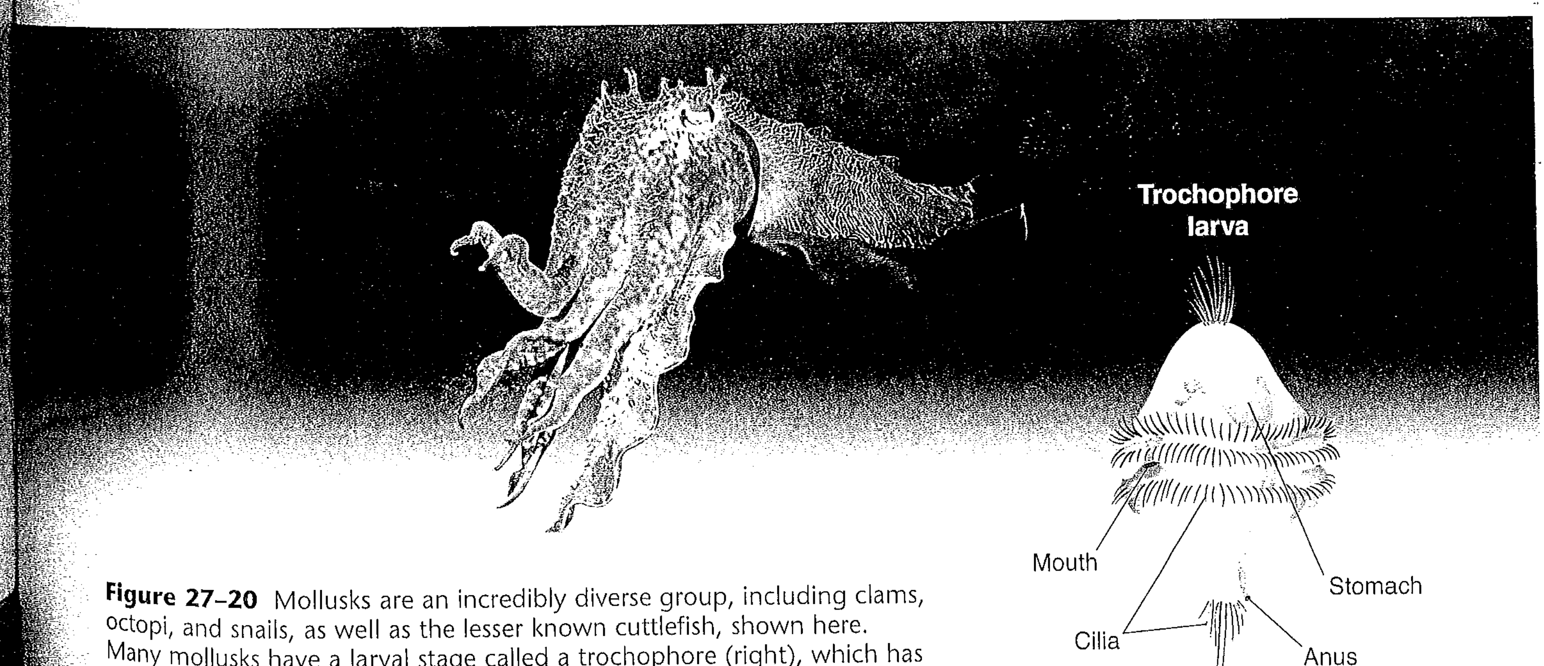
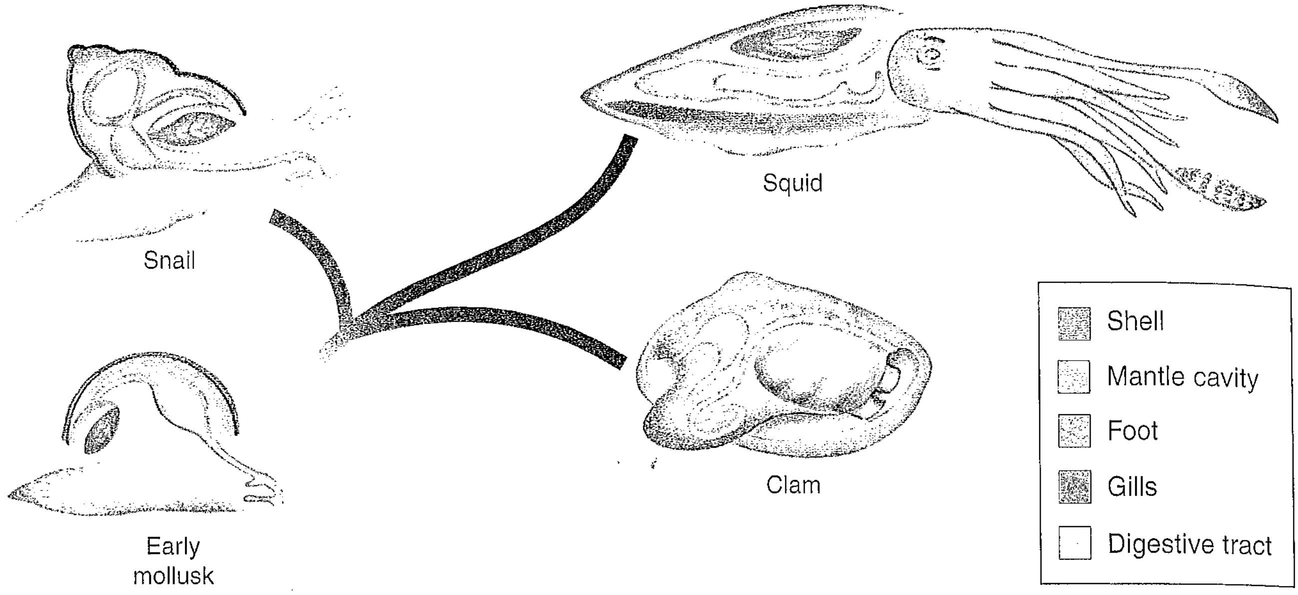


Figure 27–20 Mollusks are an incredibly diverse group, including clams, octopi, and snails, as well as the lesser known cuttlefish, shown here. Many mollusks have a larval stage called a trochophore (right), which has at least one band of cilia encircling its body. **All mollusks have a soft body, and most mollusks have an internal or external shell.**



▲ **Figure 27–21** **The body plan of most mollusks includes a foot, mantle, shell, and visceral mass.** Early mollusks may have looked like the animal shown at the bottom. As they evolved, their body parts became adapted for different functions.

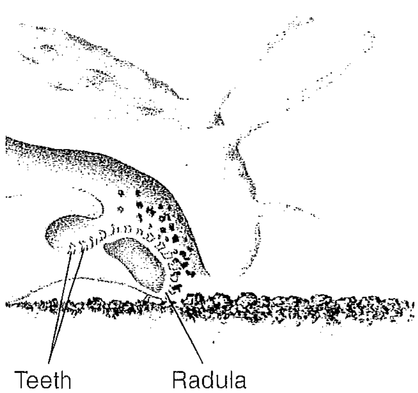
Form and Function in Mollusks

Like the annelids, mollusks have true coeloms surrounded by mesoderm tissue. They also have complex, interrelated organ systems that function together to maintain the body as a whole.

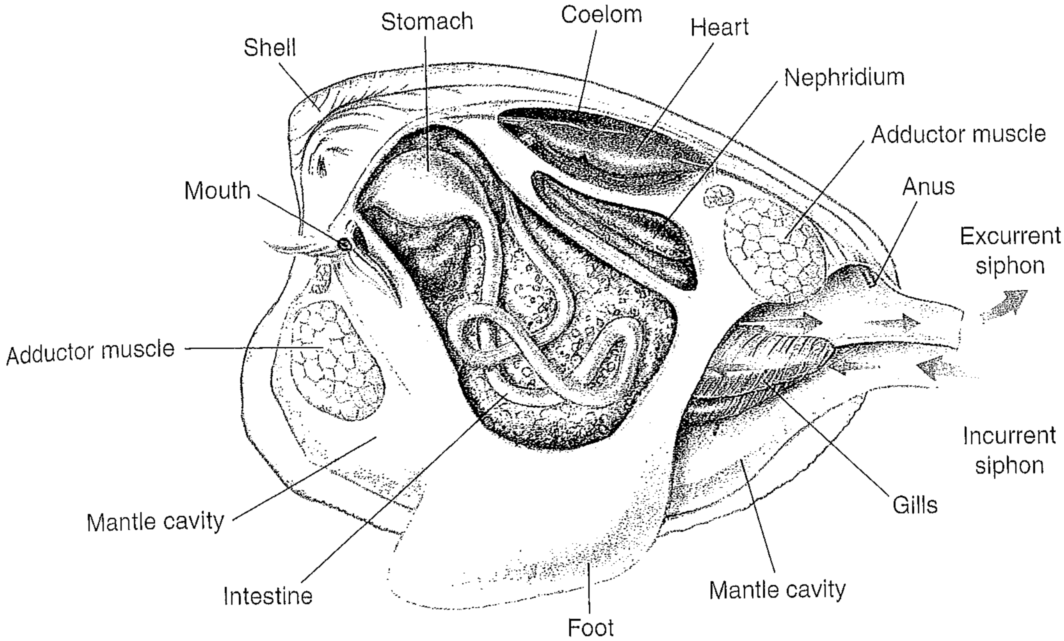
Body Plan The different body shapes of mollusks are variations on a single body plan, shown in **Figure 27–21.** **The body plan of most mollusks has four parts: foot, mantle, shell, and visceral mass.** The muscular **foot** takes many forms, including flat structures for crawling, spade-shaped structures for burrowing, and tentacles for capturing prey. The **mantle** is a thin layer of tissue that covers most of the mollusk's body, much like a cloak. The **shell** is made by glands in the mantle that secrete calcium carbonate. The shell has been reduced or lost in slugs and some other mollusk groups. Just beneath the mantle is the **visceral mass,** which consists of the internal organs.

Feeding Mollusks can be herbivores, carnivores, filter feeders, detritivores, or parasites. Snails and slugs feed using a flexible, tongue-shaped structure known as a **radula** (RAJ-oo-luh; plural: radulae), shown in **Figure 27–22,** to which hundreds of tiny teeth are attached. Herbivorous mollusks use their radula to scrape algae off rocks or to eat the soft tissues of plants. Carnivorous mollusks use their radula to drill through shells of other animals and to tear up and swallow the prey's soft tissue.

✓CHECKPOINT *How is a mollusk's shell made?*



◀ **Figure 27–22** Snails use a radula for feeding. The teeth of a radula give it the look and feel of sandpaper. Beneath the radula is a stiff supporting rod of cartilage. When the mollusk feeds, it places the tip of the radula on its food and pulls the sandpapery layer back and forth. **Formulating Hypotheses** *How might radulae with different structures allow snails to inhabit different environments?*



▲ **Figure 27–23** The anatomy of a clam is typical of bivalves, or two-shelled mollusks. The mantle and part of the foot have been cut away to show internal organs. The adductor muscles are used to open and shut the two exterior shells. The gills exchange oxygen and carbon dioxide between the body and the surrounding water. The arrows show the path of water over the gills. **Predicting** *What might happen if a clam's incurrent siphon became blocked?*

Octopi and certain sea slugs use their sharp jaws to eat their prey. To subdue their prey, some octopi also produce poisons. Clams, oysters, and scallops lead a quieter existence by filter feeding using feathery gills. Food is carried by water, which enters through the incurrent siphon, shown on the right in **Figure 27–23.** A **siphon** is a tubelike structure through which water enters and leaves the body. The water flows over the gills and then leaves by the excurrent siphon. As water passes over the gills, plankton become trapped in sticky mucus. Cilia on the gills move the mixture of mucus and food into the mouth.

Respiration Aquatic mollusks such as snails, clams, and octopi typically breathe using gills inside their mantle cavity. As water passes through the mantle cavity, oxygen in the water moves into blood flowing through the gills. At the same time, carbon dioxide moves in the opposite direction—from the blood into the water. Land snails and slugs do not have gills. Instead, they respire using a mantle cavity that has a large surface area lined with blood vessels. Because this lining must be kept moist so that oxygen can diffuse across its surface, land snails and slugs typically live in moist places.

Circulation Oxygen and nutrients are carried to all parts of a mollusk's body by a circulatory system. The circulatory system of mollusks is either open or closed. "Open" does not mean that blood can spill to the outside of the animal! In an **open circulatory system,** blood is pumped through vessels by a simple heart. Blood eventually leaves the vessels and works its way through different sinuses. A sinus is a large saclike space. The blood passes from the sinuses to the gills, where oxygen and carbon dioxide are exchanged, and then back to the heart.

Open circulatory systems work well for slow-moving mollusks such as snails and clams. Faster-moving mollusks such as octopi and squid have a closed circulatory system. A closed circulatory system can transport blood through an animal's body much more quickly than an open circulatory system.

Excretion Cells of the body release nitrogen-containing waste into the blood in the form of ammonia. Tube-shaped nephridia remove ammonia from the blood and release it outside the body.

Response The complexity of the nervous system and the ability to respond to environmental conditions vary greatly among mollusks. Clams and other two-shelled mollusks have a simple nervous system consisting of small ganglia near the mouth, a few nerve cords, and simple sense organs, such as chemical receptors and eyespots.

In contrast, octopi and their relatives are active and intelligent predators that have the most highly developed nervous system of all invertebrates. Because of their well-developed brains, these animals can remember things for long periods and may be more intelligent than some vertebrates. Octopi are capable of complex behavior, such as opening a jar to get food inside, and they have been trained to perform different tasks for a reward or to avoid punishment.

Movement Mollusks move in many different ways. Snails secrete mucus along the base of the foot, and then move over surfaces using a rippling motion of the foot. The fast-moving octopus uses a form of jet propulsion. It draws water into the mantle cavity and then forces the water out through a siphon. Water leaving the body propels the octopus in the opposite direction.

Reproduction Mollusks reproduce in a variety of ways. Many snails and two-shelled mollusks reproduce sexually by external fertilization. They release enormous numbers of eggs and sperm into the open water. The eggs are fertilized in the water and then develop into free-swimming larvae. In tentacled mollusks and certain snails, fertilization takes place inside the body of the female. Some mollusks are hermaphrodites, having both male and female reproductive organs. Individuals of these species usually fertilize eggs from another individual.

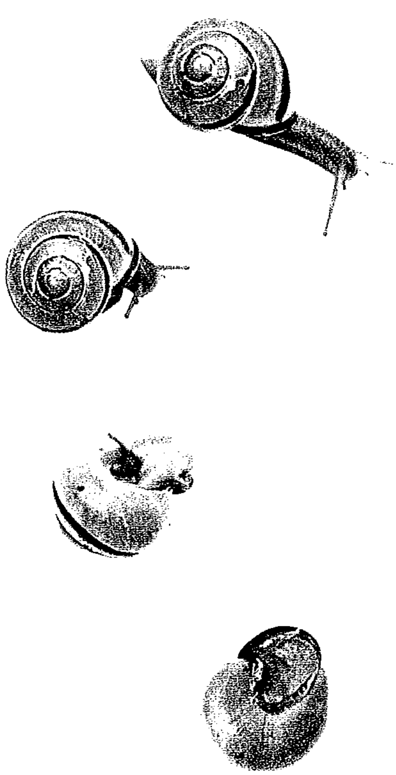
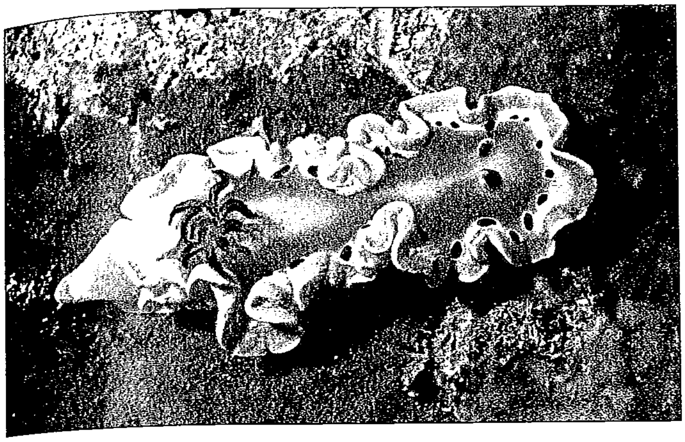


Figure 27–24 Mollusks have evolved a variety of ways of responding to potential danger. Snails (above) protect themselves by withdrawing into their shells in a matter of seconds. In some snails, a hard plate blocks the entrance to the shell, protecting the snail inside. Octopi (right) and squids squirt ink from inside their digestive tracts. The ink startles predators and may also cause temporary numbness. **Predicting** *How might the hard plate protect snails during a period of drought?*



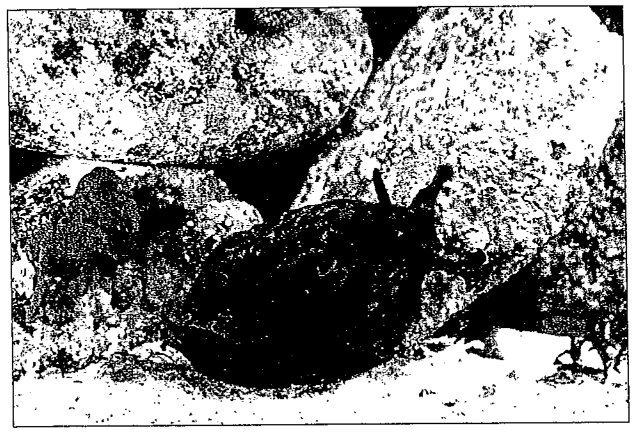


Figure 27–25 **Gastropods move by using a large, muscular foot located on the ventral side.** They can be shell-less, such as the nudibranch or sea slug (top left), or have a single shell, such as the tree snail (top right). Many sea hares (bottom) have a reduced shell covered by the mantle. The sea hare defends itself by "inking"—squirting ink at potential predators.

Groups of Mollusks

Mollusks are divided into several classes according to characteristics of the foot and the shell. The three major classes of mollusks are gastropods, bivalves, and cephalopods.

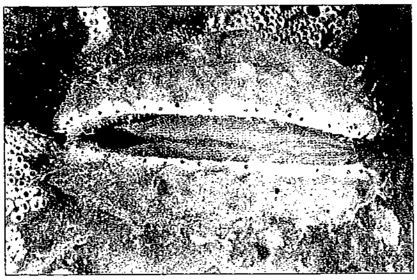
Gastropods Members of the class Gastropoda, or gastropods (GAS-truh-pahdz), include pond snails, land slugs, sea butterflies, sea hares, limpets, and nudibranchs (NOO-duh-branks). **Gastropods are shell-less or single-shelled mollusks that move by using a muscular foot located on the ventral side.**

Many gastropods, such as the snails shown on the top right in **Figure 27–25**, have a single shell that protects their bodies. When threatened, they can pull completely into their coiled shells. Some snails are also protected by a hard disk on the foot that forms a solid "door" at the mouth of their shell when they withdraw.

Land slugs and nudibranchs have no shell but protect themselves in other ways. Most land slugs spend daylight hours hiding under rocks and logs, hidden from birds and other potential predators. Some sea hares, when threatened, can squirt ink into the surrounding water, producing a "smoke screen" that confuses predators.

Some nudibranchs have chemicals in their bodies that taste bad or are poisonous. When a predator bites one of these nudibranchs, the predator becomes ill. Many nudibranchs are able to recycle the nematocysts from cnidarians they eat, using them to sting predators. These "booby-trapped" nudibranchs are usually brightly colored. The bright coloring serves as a warning to potential predators.

✓CHECKPOINT *How do shell-less gastropods protect themselves?*



▲ **Figure 27–26** **Bivalves are two-shelled mollusks that include clams, mussels, oysters, and scallops like the one above.** Observe the tiny blue eyespots along the open edges of the shell.

Bivalves **Members of the class Bivalvia have two shells that are held together by one or two powerful muscles.** Common bivalves include clams, oysters, mussels, and scallops. Most bivalves stay in one place for much of the time. Clams burrow in mud or sand, whereas mussels use sticky threads to attach themselves to rocks. Scallops, such as the one shown in **Figure 27–26,** are the least sedentary bivalves and can move around rapidly by flapping their shells when threatened.

Currents created by cilia on the gills circulate water through the body cavities of bivalves. Once water is inside the body, filter-feeding bivalves use mucus and cilia on their gills to trap food particles in the water. Some bivalves feed on material deposited in sand or mud. They use long, muscular extensions of tissue that surround the mouth to collect food particles from the surrounding sediments. The indigestible sand or mud particles are expelled from the mantle cavity.

✓*CHECKPOINT* *What are some common bivalves?*

Word Origins

Cephalopod comes from the Greek *kephale*, meaning "head," and *podos*, meaning "foot." **Pseudopods** are structures found in some single-celled organisms. If *pseudo-* means "false," what does *pseudopod* mean?

Cephalopods Cephalopods (SEF-uh-luh-pahdz)—members of the class Cephalopoda—are the most active of the mollusks. This class includes octopi, squids, cuttlefishes, and nautiluses. **Cephalopods are typically soft-bodied mollusks in which the head is attached to a single foot. The foot is divided into tentacles or arms.** Cephalopods have eight or more tentacles equipped with sucking disks that grab and hold prey. Nautiluses have many more tentacles than other cephalopods—in some cases up to 90! Their tentacles lack suckers but have a sticky, mucuslike covering.

As with some of the gastropods, most modern cephalopods have only small internal shells or no shells at all. The only present-day cephalopods with external shells are nautiluses, such as the one shown in **Figure 27–27.** These animals can control their depth in the water by regulating the amount of gas in their shells. Ancestors of the nautilus dominated the seas more then 500 million years ago.

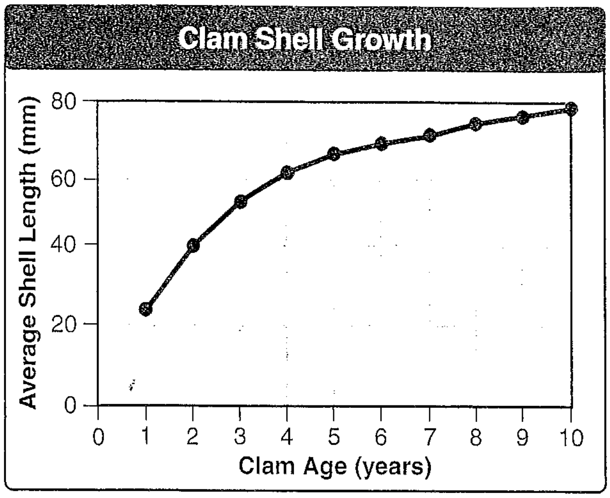
Figure 27–27 Nautiluses like the one shown here are the most primitive group of cephalopods. **Comparing and Contrasting** *How does this nautilus differ from most cephalopods?*

Analyzing Data

Raising Clams

Aquaculture is the growth of aquatic animals and plants for use by humans. In one example of aquaculture, hard clams are first grown in commercial hatcheries under very favorable conditions. The young clams are then removed from the hatcheries and placed into the mud beds of creeks, where they develop into adults. At that time, the size of the young clams is around 40 millimeters.

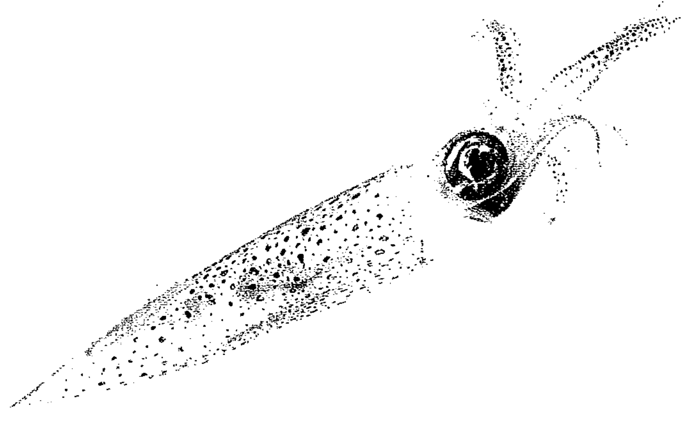
Because Georgian clams grow so quickly, they are ideal for aquaculture. Unlike the hard clams in the northeastern United States that grow only during the warm months, Georgian hard clams grow year-round. As a result, the Georgian clams grow to market size in less than half the time that the northeastern clams need to grow. The graph shows how clam shells grow over a period of 10 years.



1. **Using Tables and Graphs** Approximately how many years does it take clams to reach a size at which they can be removed from hatcheries and put in creeks?
2. **Applying Concepts** How does climate affect the growth of most clams?
3. **Using Tables and Graphs** How much did the clams grow during the first 5 years? The next 5?
4. **Formulating Hypotheses** Formulate a hypothesis to explain the slower growth rate from years 5 to 10.
5. **Drawing Conclusions** What general trends do you observe about growth from the graph?

Cuttlefishes have small shells inside their bodies. These are the cuttlebones given to pet birds to condition their beaks. A squid's internal shell has evolved into a thin supporting rod known as a pen. Octopi have lost their shells completely.

Cephalopods also have numerous complex sense organs that help them detect and respond to external stimuli. Cephalopods distinguish shapes by sight and texture by touch. The eyes of many cephalopods, such as the squid shown in **Figure 27–28**, are as complex as those of some vertebrates, such as fishes and humans. Cephalopod eyes can be large—the size of a dinner plate in some species—and can distinguish objects as small as 0.5 centimeters from a meter away, allowing squids to locate a wide variety of prey. Though cephalopod eyes may look something like vertebrate eyes from the outside, their internal structures are quite different.



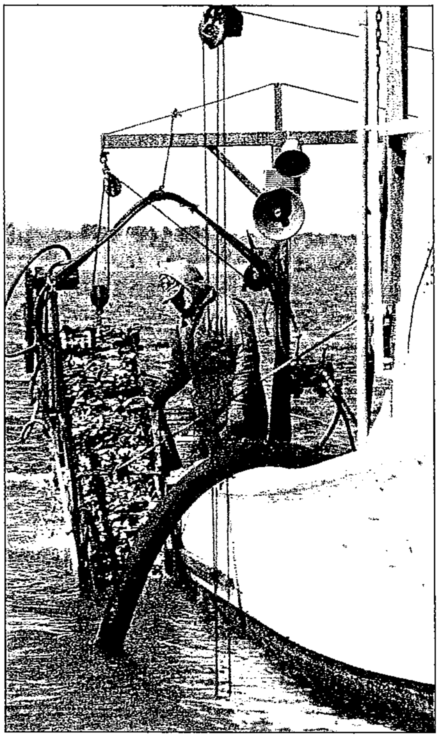
◀ **Figure 27–28** **Most cephalopods are mollusks in which the head is attached to a single foot that is divided into tentacles or arms.** They have the most complex nervous system of all the mollusks, with a highly developed brain and sense organs, such as the eye of this common squid.

Ecology of Mollusks

Mollusks play many different roles in living systems. For example, they feed on plants, prey on animals, and "clean up" their surroundings by filtering algae out of the water or by eating detritus. Some of them are hosts to symbiotic algae or to parasites; others are themselves parasites. In addition, mollusks are an important source of food for many organisms, including humans. **Figure 27–29** shows clams caught for human use.

Biologists' understanding of molluskan diversity and ecology is growing all the time. Recent explorations around deep-sea volcanic vents called "black smokers" have revealed a fascinating community that includes several bivalves. Researchers have discovered symbiotic bacteria within the foot-long bivalves clustered around these vents. These bacteria extract chemical energy from simple compounds released in the superheated water. From this energy, the bacteria produce food molecules that the mollusks can use. Without this mutualistic relationship with the bacteria, these mollusks would be unable to inhabit this extreme environment. Other research has discovered a similar symbiosis between related bacteria and bivalves that live in the mud of salt marshes and mangrove swamps.

Scientists have found some new uses for mollusks. Because filter-feeding bivalves concentrate dangerous pollutants and microorganisms in their tissues, they can be used to monitor water quality. Careful checks of bivalves can warn biologists and public health officials of health problems long before scientists can detect these dangers in the open water. Besides acting as environmental monitors, mollusks also serve as subjects in biological research. Some current investigations are based on the observation that snails and other mollusks never seem to develop any form of cancer. If scientists can determine what protects the cells of these animals from cancer, they will gain valuable insights into how to fight cancer in humans.



▲ **Figure 27–29** These clams will find their way to many people's dinner tables. **Applying Concepts** *Besides providing food for humans and other animals, what are some other roles that mollusks play in ecosystems?*

27–4 Section Assessment

1. **Key Concept** What is a mollusk?
2. **Key Concept** List and describe the four parts of the mollusk body plan.
3. **Key Concept** Describe the main characteristics of the three major classes of mollusks.
4. Why are land snails restricted to moist environments?
5. Describe how a cephalopod responds to external stimuli and explain how a cephalopod's nervous system is more complex than that of other mollusks.
6. **Critical Thinking Comparing and Contrasting** Compare open and closed circulatory systems. Why are open circulatory systems found mostly in small animals that move slowly?

Focus on the BIG Idea

Interdependence in Nature Recall from Chapter 4 the definition of symbiosis. The mutualism that exists between bivalves and bacteria near deep-sea vents is one type of symbiosis. Describe an example of another type of symbiosis that you have read about in this chapter. How is it different from mutualism?

Exploration

Investigating Land Snails

Although most mollusks are aquatic, some snails live on land. In this investigation, you will explore how land snails are adapted to survive in this environment.

Problem How do land snails move and react to various external stimuli?

Materials

- land snail
- glass slides
- dropper pipette
- dissecting tray
- black construction paper
- paper towels
- 40-watt desk lamp
- metric ruler
- dissecting microscope
- petri dish
- clock with second hand

Skills Observing, Calculating, Using Tables and Graphs

Procedure

1. Using a clean pipette, put a drop of water in the center of a glass slide. Gently place the snail in the water drop. Look for the mucous trail as the snail begins to move.
2. Gently turn the slide over and place it on top of a petri dish. Place the petri dish under the dissecting microscope and observe the movement of the muscular foot under low power. Look for the radula as it scrapes the slide.
3. Copy the data table onto a separate sheet of paper.
4. Line each half of a dissecting tray with a separate piece of paper towel. Place a sheet of black construction paper above one half of the tray. Shine the desk lamp on the other half of the tray from a distance of 30 cm. **CAUTION:** *Do not touch the lamp, because it may be hot.*
5. Place the snail in the center of the tray and observe how it responds to the external stimulus of bright light. Measure and record the number of seconds in each minute that the snail spends in the dark.
6. **Calculating** Exchange data with the class and determine class averages.
7. Return the snail to its habitat, clean up your materials, and wash your hands.

Data Table

Time (minutes)	Time in Dark (seconds)	
	Group	Class Average
0–1		
1–2		
2–3		
3–4		
4–5		

Analyze and Conclude

1. **Drawing Conclusions** Describe the movement of the snail across the glass slide. Name one advantage and one limitation of this type of movement.
2. **Using Tables and Graphs** Make a bar graph of the class average data that shows the time the snails spent in the dark for each of the five minutes. What trend do you see in your data? How can you explain this result?
3. **Drawing Conclusions** Do snails prefer dark places or bright places? Refer to the class average data to explain why your conclusion is valid. Communicate your conclusion by writing a short paragraph describing your results.

Go Online
PHSchool.com
For: Data sharing
Visit: PHSchool.com
Web Code: cbd-8274

Share Your Data Online Enter your data on the behavior of the land snails. Then, look at the data entered by other students. Based on the available data, do snails prefer dark places or light places? Why might your data differ from those of other students? Does this larger set of data support your results and indicate that your conclusions are valid?

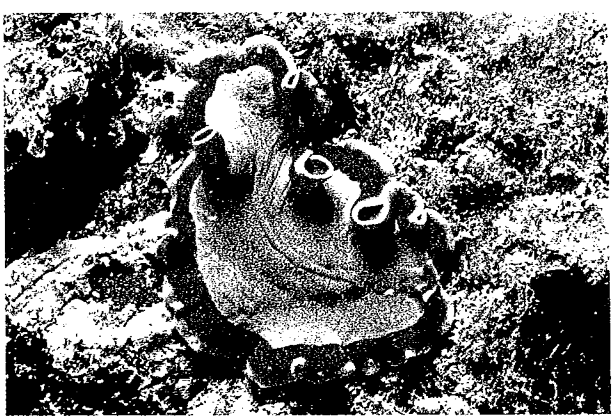
Chapter 27 Study Guide

27–1 Flatworms

Key Concepts

- Flatworms are soft, flattened worms that have tissues and internal organ systems. They are the simplest animals to have three embryonic germ layers, bilateral symmetry, and cephalization.
- Turbellarians are free-living marine or freshwater flatworms.
- Flukes are parasitic flatworms that usually infect the internal organs of their hosts.
- Tapeworms are long, flat, parasitic worms that are adapted to life inside the intestines of their hosts.

Vocabulary
acoelomate, p. 683 • coelom, p. 683
pharynx, p. 684
flame cell, p. 684
ganglion, p. 685
eyespot, p. 685
hermaphrodite, p. 686
fission, p. 686
scolex, p. 688
proglottid, p. 688
testis, p. 688



27–2 Roundworms

Key Concepts

- Roundworms are unsegmented worms that have pseudocoeloms and digestive systems with two openings—a mouth and an anus.
- Parasitic roundworms include trichinosis-causing worms, filarial worms, ascarid worms, and hookworms.

Vocabulary
pseudocoelom, p. 689
anus, p. 689

27–3 Annelids

Key Concepts

- Annelids are worms with segmented bodies. They have a true coelom that is completely lined with mesoderm.
- Oligochaetes are annelids that typically have streamlined bodies and relatively few setae compared to polychaetes. Most oligochaetes live in soil or fresh water.
- Leeches are typically external parasites that suck the blood and body fluids of their host.
- Polychaetes are marine annelids that have paired, paddlelike appendages tipped with setae.

Vocabulary
septum, p. 694 • seta, p. 694
crop, p. 695 • gizzard, p. 695
closed circulatory system, p. 695
gill, p. 696 • nephridium, p. 696
clitellum, p. 696

27–4 Mollusks

Key Concepts

- Mollusks are soft-bodied animals that usually have an internal or external shell.
- The typical mollusk body plan has four parts: foot, mantle, shell, and visceral mass.
- Gastropods are shell-less or single-shelled mollusks that move by using a muscular foot located on the ventral side.
- Bivalves have two shells that are held together by one or two powerful muscles.
- Cephalopods are typically soft-bodied mollusks in which the head is attached to a single foot. The foot is divided into tentacles or arms.

Vocabulary
trochophore, p. 701
foot, p. 702
mantle, p. 702 • shell, p. 702
visceral mass, p. 702
radula, p. 702
siphon, p. 703
open circulatory system, p. 703

Thinking Visually

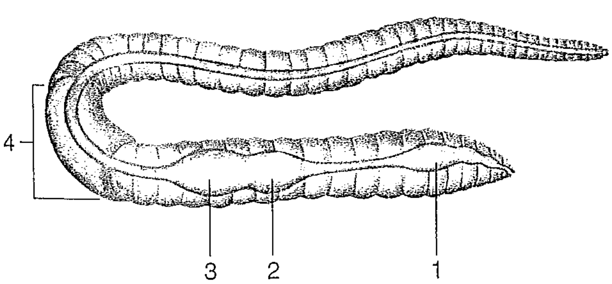
Create a concept map that shows the classes and main characteristics of mollusks. Include at least two examples of types of mollusks within each class.

Interactive textbook with assessment at PHSchool.com

Reviewing Content

Choose the letter that best answers the question or completes the statement.

1. The muscular tube found near the mouth of the digestive cavity in flatworms is called a(an)
   a. proglottid. c. anus.
   b. scolex. d. pharynx.
2. The head of an adult tapeworm is called a
   a. flame cell. c. cuticle.
   b. scolex. d. mantle.
3. The body cavity of a roundworm is called a
   a. coelom. c. gizzard.
   b. pseudocoelom. d. crop.
4. What are the clusters of nerve cells in roundworms called?
   a. flame cells c. ganglia
   b. proglottids d. radulae
5. In the earthworm, waste created by cellular metabolism is eliminated by the
   a. crop. c. gizzard.
   b. nephridia. d. flame cell.
6. The digestive organ in which an earthworm stores food is number
   a. 1. c. 3.
   b. 2. d. 4.



7. In earthworms, the clitellum is used in
   a. digestion. c. reproduction.
   b. excretion. d. respiration.
8. The tongue-shaped structure that some mollusks use for feeding is the
   a. radula.
   b. sinus.
   c. mantle.
   d. proglottid.
9. Mollusks eliminate nitrogen-containing wastes through simple tube-shaped organs called
   a. gills.
   b. nephrons.
   c. radulae.
   d. nephridia.
10. A mollusk with a shell consisting of two parts is a member of the class
    a. Cephalopoda. c. Bivalvia.
    b. Annelida. d. Gastropoda.

Understanding Concepts

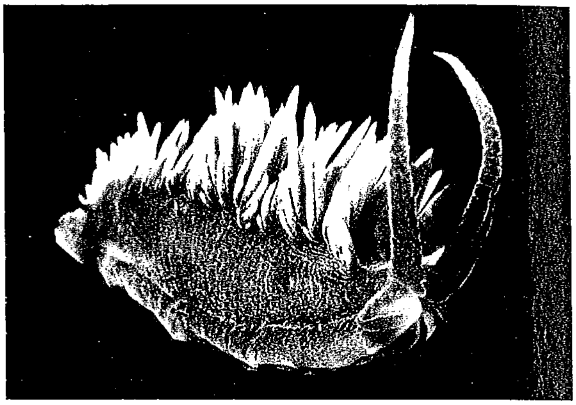
11. Distinguish between coelomates and acoelomates.
12. Describe how respiration, circulation, and excretion are accomplished in the flatworm.
13. Explain how feeding and digestion occur in planarians.
14. How is the nervous system of a flatworm more complex than the sensory cells and nerve net of a cnidarian?
15. How does the *Schistosoma* fluke affect humans? What step can be taken to limit the number of outbreaks of schistosomiasis?
16. What adaptations do tapeworms have for their parasitic life cycle?
17. How do tapeworms reproduce?
18. Describe how respiration, circulation, and excretion are accomplished in roundworms.
19. Outline the life cycle of the *Trichinella* roundworm.
20. How does the roundworm *Ascaris* cause malnutrition?
21. Evaluate the potential impact the research on *C. elegans* will have on scientific thought.
22. List three adaptations for feeding in annelids.
23. Explain the process by which earthworms move.
24. What is a hermaphrodite? Give an example.
25. Compare respiration in aquatic and land-dwelling annelids.
26. What evidence exists to indicate that annelids and mollusks may be closely related?
27. Compare the various feeding behaviors exhibited by the three classes of mollusks.
28. Describe the path of blood in an open circulatory system.
29. Distinguish between respiration in aquatic mollusks and that in land-dwelling mollusks.
30. Explain how many two-shelled mollusks reproduce.
31. Why can mollusks be used to measure water quality?

Critical Thinking

32. **Comparing and Contrasting** Which structures are used for locomotion in the planarian, earthworm, and scallop? How are they similar? How are they different?
33. **Predicting** What would happen to a land snail if its foot stopped producing mucus?
34. **Comparing and Contrasting** In what ways are the feeding habits of the earthworm and the clam similar? In what ways are they different?
35. **Applying Concepts** Why do people purchase earthworms to put in their gardens?
36. **Inferring** Although many bivalves live buried in sand or mud, the openings to their siphons remain above the surface. Why is this important for a bivalve?
37. **Predicting** In order for an oyster to produce a pearl, a grain of sand or other irritant must get inside its shell. The mantle then secretes a substance that forms a protective covering over the irritant. Why is this an advantage for the oyster?
38. **Formulating Hypotheses** Female octopi usually die after brooding their eggs (tending and protecting eggs until they hatch). However, if certain glands near the brooding octopus's eyes are surgically removed, the octopus stops brooding, resumes feeding, and has a lifespan longer than the normal three to four years. Develop a testable hypothesis to explain what might happen if the surgically altered octopi were treated with chemicals from the glands.
39. **Inferring** Why is it easier to study cell differentiation in a small organism such as *Caenorhabditis elegans* than in larger, more complex organisms?
40. **Predicting** During heavy rains, earthworms often emerge from their burrows. What might happen to an earthworm if it did not return to its burrow when the ground dried out?
41. **Inferring** Researchers have identified a chemical in leeches that suppresses blood clotting. Why is this chemical important in leeches?
42. **Applying Concepts** Suppose you are a meat inspector. You are checking uncooked pork to see whether it is contaminated with *Trichinella*. What would you look for?
43. **Comparing and Contrasting** Compare and contrast the functions of a mollusk's respiratory and circulatory systems. Then, explain how these two systems are interrelated in the function of delivering oxygen to the body as a whole.

Focus on the BIG Idea

Interdependence in Nature The nudibranch shown below is a hermaphrodite. Hermaphrodites rarely fertilize their own eggs. Explain why fertilization of another individual is more advantageous than self-fertilization. (*Hint:* See Section 1 in Chapter 26.)



Writing in Science

Imagine that you are a healthcare worker in an area in which *Ascaris lumbricoides* infections are common. Write a short explanation of the disease that you might distribute to people in the area to help prevent new cases. Your explanation should include the cause of the disease, how the disease is transmitted, and steps that people can take to prevent the spread of the disease. (*Hint:* Review **Figure 27–10** to recall how the disease is spread.)

Performance-Based Assessment

Worm Autobiography You are a reporter for a local newspaper and are working on the children's activity section. You decide to feature different animals as if each one were writing its autobiography. The first feature is entitled "A Day in the Life of an Earthworm." Include in your autobiography how the worm performs each of the life functions, its habitat, its importance, and illustrations. The reading level of the article should be fourth or fifth grade.

Go Online
PHSchool.com

For: An interactive self-test
Visit: PHSchool.com
Web Code: cba-8270

Standardized Test Prep

Success Tracker™
Online at PHSchool.com

Test-Taking Tip For questions containing the words NOT, EXCEPT, and so on, begin by eliminating each answer choice that *does* fit the characteristic in question. After eliminating four choices, check to see that your answer is correct by confirming that it does not fit the characteristic in question.

Directions: Choose the letter that best answers the question or completes the statement.

1. All of the following are mollusks EXCEPT
(A) leeches.
(B) squids.
(C) octopi.
(D) clams.
(E) snails.

2. Which invertebrates have segmented bodies?
(A) flatworms
(B) roundworms
(C) planarians
(D) annelids
(E) flukes

3. Which are NOT parasitic roundworms?
(A) hookworms
(B) filarial worms
(C) ascarid worms
(D) tapeworms
(E) trichinosis-causing worms

4. The body cavity in annelids is called a(an)
(A) coelom.
(B) pseudocoelom.
(C) scolex.
(D) trochophore.
(E) acoelom.

5. A scientist conducts an experiment to test the hypothesis that earthworms aid in the growth of plant roots. She grows two identical plants in pots A and B but adds earthworms only to pot B. Which of the following is true about the experiment?
(A) There is no control.
(B) There is no difference between pots A and B.
(C) Either pot could serve as the control.
(D) Pot A is the control.
(E) Pot B is the control.

6. The simplest animal to develop from three germ layers belongs in the phylum
(A) Mollusca.
(B) Annelida.
(C) Platyhelminthes.
(D) Nematoda.
(E) Gastropoda.

7. Water balance is maintained in the body of a planarian by
(A) nephridia.
(B) flame cells.
(C) proglottids.
(D) scolex.
(E) cilia.

8. Which characteristics apply to flatworms?
I. Cephalization
II. Bilateral symmetry
III. Segmented bodies
(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

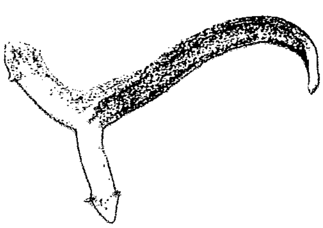
Questions 9–13 Use the lettered choices below to answer questions 9–13. Select the best lettered choice. A choice may be used once, more than once, or not at all.

(A) Flatworms
(B) Roundworms
(C) Annelids
(D) Snails
(E) Mollusks

9. Includes gastropods, bivalves, and cephalopods
10. Has internal walls, or septa, between body segments
11. Usually has an internal or external shell
12. Has a pseudocoelom
13. Includes turbellarians, flukes, and tapeworms

Questions 14–15

Observe that this planarian has two heads. Use your knowledge about flatworms to answer the questions that follow.



14. The process illustrated in the diagram is known as
(A) fission.
(B) sexual reproduction.
(C) scolex.
(D) hermaphroditism.
(E) metabolism.

15. Two spots on the heads of the planarian are sensitive to
(A) heat.
(B) light.
(C) sound.
(D) chemicals.
(E) touch.