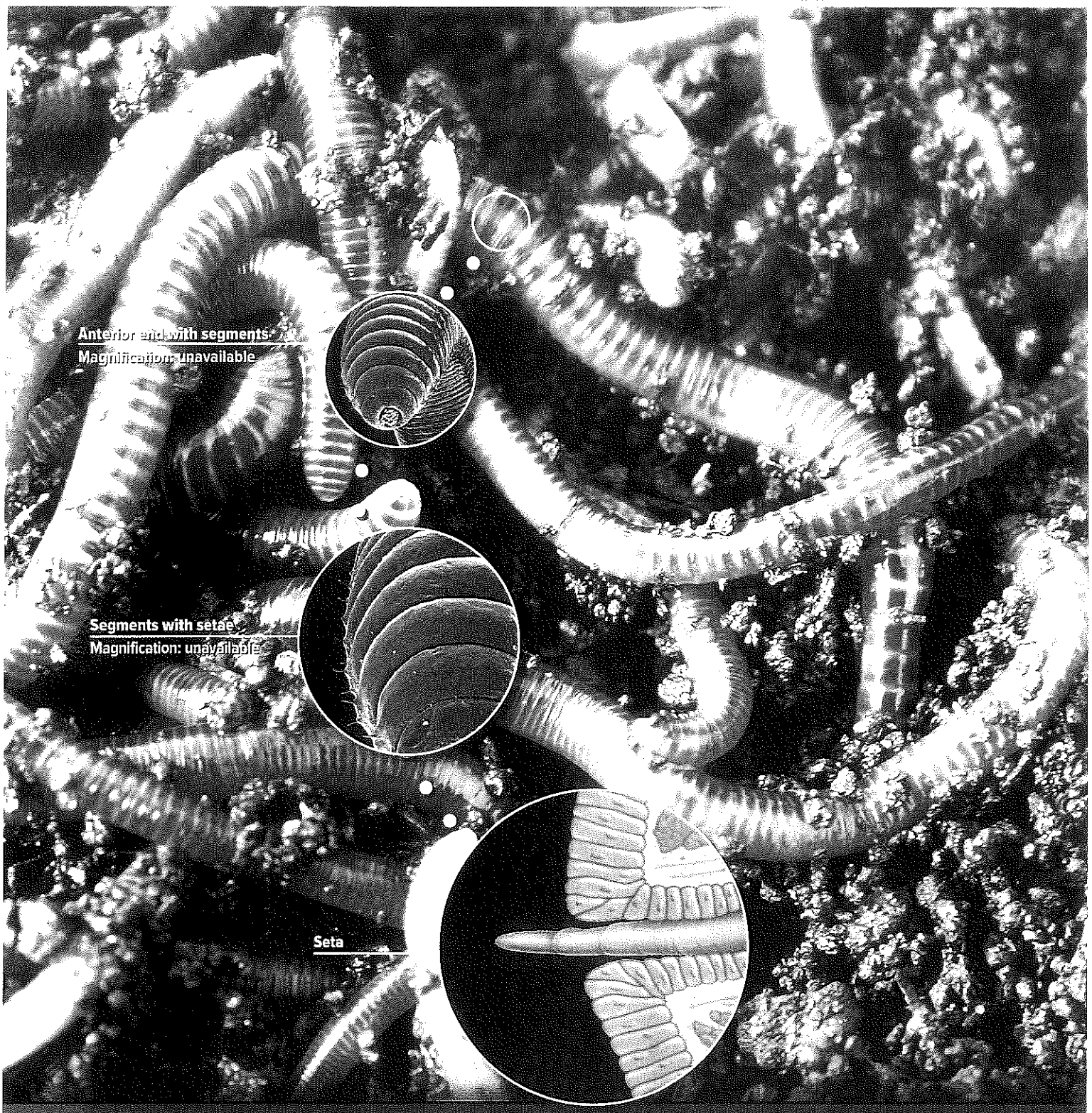


THEME FOCUS Energy and Matter
All worms obtain energy from other organisms.

BIG Idea Worms and mollusks have evolved to have a variety of adaptations for living as parasites or for living in water or soil.

Reading Preview

Essential Questions

- What are the adaptations of free-living flatworms and parasitic flatworms?
- How do flatworms maintain homeostasis?
- What are the three classes of flatworms and what are characteristics of each?

Review Vocabulary

acoelomate: an animal without any body cavities

New Vocabulary

pharynx
flame cell
ganglion
regeneration
scolex
proglottid

Multilingual eGlossary

Flatworms

MAIN Idea **Flatworms are thin, flat, acoelomate animals that can be free-living or parasitic.**

Real-World Reading Link Think about a time when you were caught in an unexpected rain shower without rain gear. If you were wearing layers of clothing, the rain might not have soaked through to your skin. As you read about worms, think about how it is easier for the rain to move through one thin layer than through multiple heavy layers.

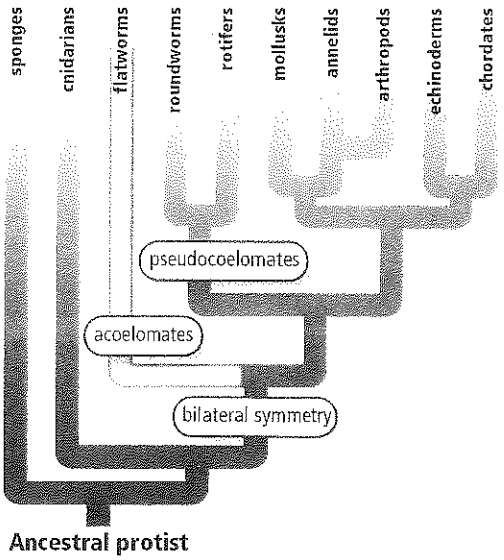
Body Structure

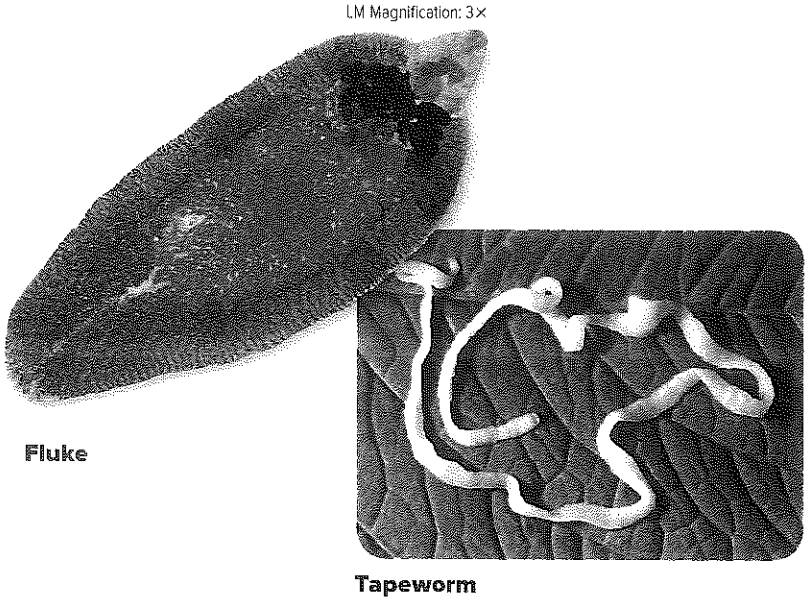
The evolutionary tree in **Figure 1,** shows that flatworms are on the acoelomate branch of the tree, while roundworms are on the pseudocoelomate branch. However, flatworms and roundworms both have bilateral symmetry. They can be divided along only one plane into mirror-image halves. Bilateral symmetry is a major evolutionary step that allows parts of the body to evolve different organs. Animals that have bilateral symmetry also have more efficient movement than animals with radial symmetry.

Phylum Platyhelminthes (pla tee HEL min theez)–flatworms–consists of about 20,000 species. **Figure 1** shows some of the variety seen in this phylum. Flatworms range in length from many meters to 1 mm or less. They have thin, flat bodies that resemble ribbons. Unlike sponges and cnidarians, flatworms have a definite head region and body organs. Recall that flatworms are acoelomates and therefore lacka coelom. Their bodies have no cavities.

Most flatworms are parasites living in the bodies of a variety of animals, but some others are free-living in marine, freshwater, or moist land habitats. Freshwater planarians are often seen on the underside of rocks in swiftly flowing streams.

Figure 1 Notice on the evolutionary tree that flatworms, such as flukes and tapeworms, were among the first animals to show bilateral symmetry.
Explain *how the symmetry of flatworms is different from that of cnidarians.*





(t)Dr. Keith Wheeler/Photo Researchers; (r)James H. Robinson/Science Source

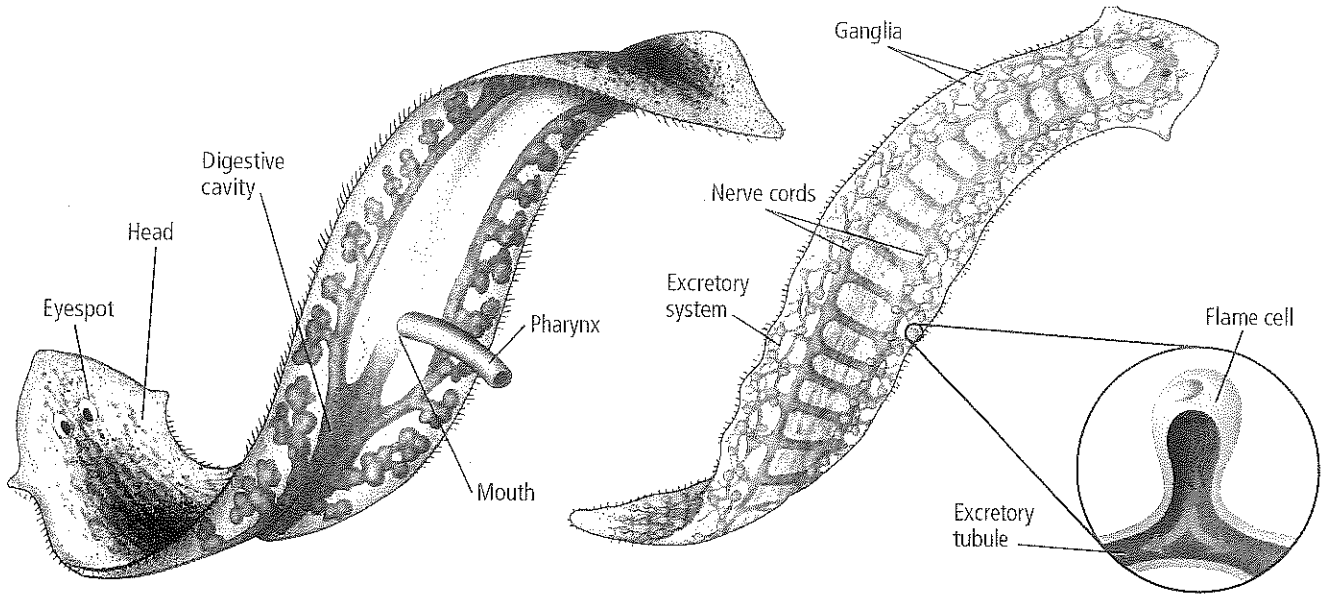


Figure 2 Simple organ systems, such as the excretory and nervous systems, are found in flatworms.

Animation

Feeding and digestion Free-living flatworms feed on dead or slow-moving organisms. They extend a tubelike muscular organ, called the **pharynx** (FAHR ingks), out of their mouths. The pharynx, shown in **Figure 2,** releases enzymes that begin the digestion of prey. Then food particles are sucked into the digestive tract, where digestion continues. Because flatworms have only one body opening, wastes are ejected through the mouth.

Parasitic flatworms have modified feeding structures called hooks and suckers, which enable them to stay attached to their hosts. Some parasitic flatworms have a reduced digestive system and feed on blood and other body tissues. Other parasitic flatworms lack a digestive system. Because they are so thin, like a single layer of cloth, and are surrounded by nutrients in their host's intestines, these parasites can absorb directly through their body walls partially or completely digested food eaten by the host.

Video Lab

Reading Check **Compare** feeding and digestion in free-living flatworms and parasitic flatworms.

Respiration, circulation, and excretion Like sponges and cnidarians, flatworms do not have circulatory organs or respiratory organs. Because flatworms are so thin, their cells can use the process of diffusion to move dissolved oxygen and nutrients to all parts of their bodies. Carbon dioxide and other wastes also are removed from flatworm cells by diffusion.

Unlike sponges and cnidarians, flatworms have an excretory system that consists of a network of small tubes that run through the body. On side branches of the tubes, as shown in **Figure 2,** bulblike **flame cells** lined with cilia sweep water and excretory substances into tubules. These substances then exit through pores to the outside of the body. Flame cells were so named because the flickering movements of the cilia inside the cells look like the light of a candle flame. Because flame cells move water out of the body, they keep flatworm cells from becoming waterlogged. In addition to the action of flame cells, flatworms also excrete waste products and maintain homeostatic water balance through their mouths.

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Host

Science usage: an animal or plant on which or in which a parasite lives
Some parasitic worms live in the intestines of their hosts.

Common usage: a person who entertains guests
Tyler's dad was the host for the football party.

MiniLab 1

MiniLab

Observe a Planarian

LM Magnification: 10×

Planarian

How does a planarian behave?
Investigate the physical features and behavior of a planarian by observing this common flatworm.

Procedure

1. Read and complete the lab safety form.
2. Observe the **planarian** in a **water-filled observation dish** by using a **magnifying lens.**
3. Create a data table to record your observations.
4. Record the physical characteristics and behaviors of the flatworm.
5. Place a small piece of **cooked egg white** into the dish, and observe the feeding behavior of the planarian.

Analysis

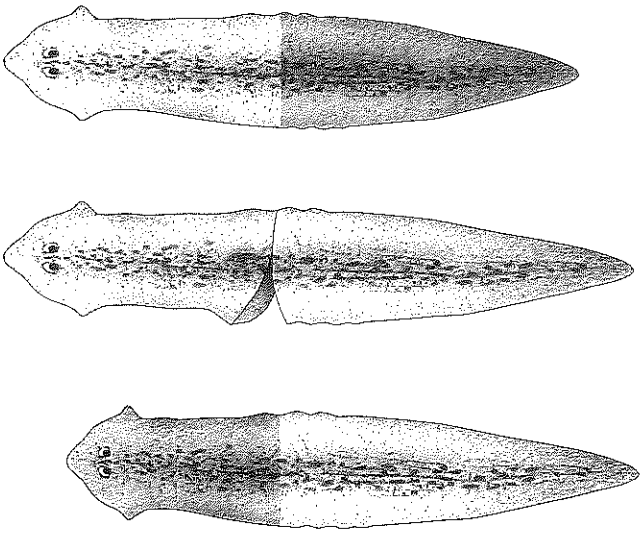
1. **Compare and contrast** the physical features of the planarian with the features of the earthworm you observed in the Launch Lab.
2. **Analyze** how the body shape and movement of a planarian enables it to live in its environment.
3. **Infer** why scientists classify planaria into a group separate from other worms.

Response to stimuli The nervous system regulates the body's response to stimuli. In most flatworms, the nervous system consists of two nerve cords with connecting nerve tissue that run the length of the body. In most flatworms, the connecting nerve tissue looks like the rungs of a ladder, as illustrated in **Figure 2.** At the anterior end of the nerve cords is a small swelling composed of ganglia, which send nerve signals to and from the rest of the body. A **ganglion** (plural, ganglia) is a group of nerve cell bodies that coordinates incoming and outgoing nerve signals.

Movement Some flatworms move by contracting muscles in the body wall. To escape predators and to find food, most free-living flatworms glide by using cilia located on their undersides. Mucus lubricates the worms and improves the gliding motion, while muscular action lets the animals twist and turn. If you have ever tried to loosen planaria worms from the bottoms of rocks, you know that their outer mucus covering enables them to stick tightly–an important adaptation in a swiftly moving stream. You can observe the features and behavior of a flatworm in **MiniLab 1.**

Reproduction Flatworms are hermaphrodites because they produce both eggs and sperm. During sexual reproduction, two different flatworms exchange sperm, and the eggs are fertilized internally. In marine flatworms, zygotes in cocoons are released into the water, where they hatch within a few weeks.

Free-living flatworms can reproduce asexually by **regeneration,** a process in which body parts that are missing because of damage or predation can be regrown. A planarian that is cut in half horizontally can grow a new head on the tail end and a new tail on the head end, forming two new organisms, as shown in **Figure 3.**



Michael Abbey/Photo Researchers

Figure 3 Two new planaria form when one planarian is cut in half horizontally. Some planaria can regenerate from almost any piece of their bodies.

Diversity of Flatworms

There are three main classes of flatworms: Turbellaria (tur buh LER ee uh), Trematoda (trem uh TOH duh), and Cestoda (ses TOH duh). Class Turbellaria consists of the free-living flatworms. Class Trematoda and class Cestoda consist of parasitic flatworms.

Turbellarians Members of the class Turbellaria are called turbellarians. Most turbellarians, like planarians, live in marine or freshwater habitats, while some live in moist soils. They vary in size, color, and body shape. As shown in **Figure 4,** turbellarians have eyespots that can detect the presence or absence of light. They also have sensory cells that help them identify chemicals and water movement.

The cells sensitive to chemicals are concentrated on small projections called auricles (OR ih kulz) at the anterior end of the worm. When a planarian hunts, it might wave its head back and forth as it crawls forward, exposing the auricles to chemical stimuli coming from food. At the same time, its eyespots might help it perceive light conditions that would protect it from predators.

Trematodes Flukes belong to class Trematoda—the trematodes. They are parasites that infect the blood or body organs of their hosts. The life cycle of the parasitic fluke *Schistosoma* is shown in **Figure 5.** Notice that this parasite requires two hosts to complete its life cycle.

When humans contract schistosomiasis (shihst tuh soh MI uh sis), the fluke eggs clog blood vessels, causing swelling and eventual tissue damage. Schistosomiasis can be prevented by proper sewage treatment and by wearing protective clothing when wading or swimming in infested water. Schistosomiasis infections are not common in the United States.

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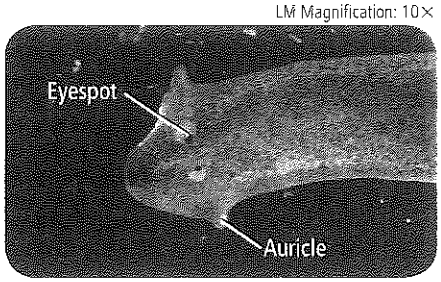
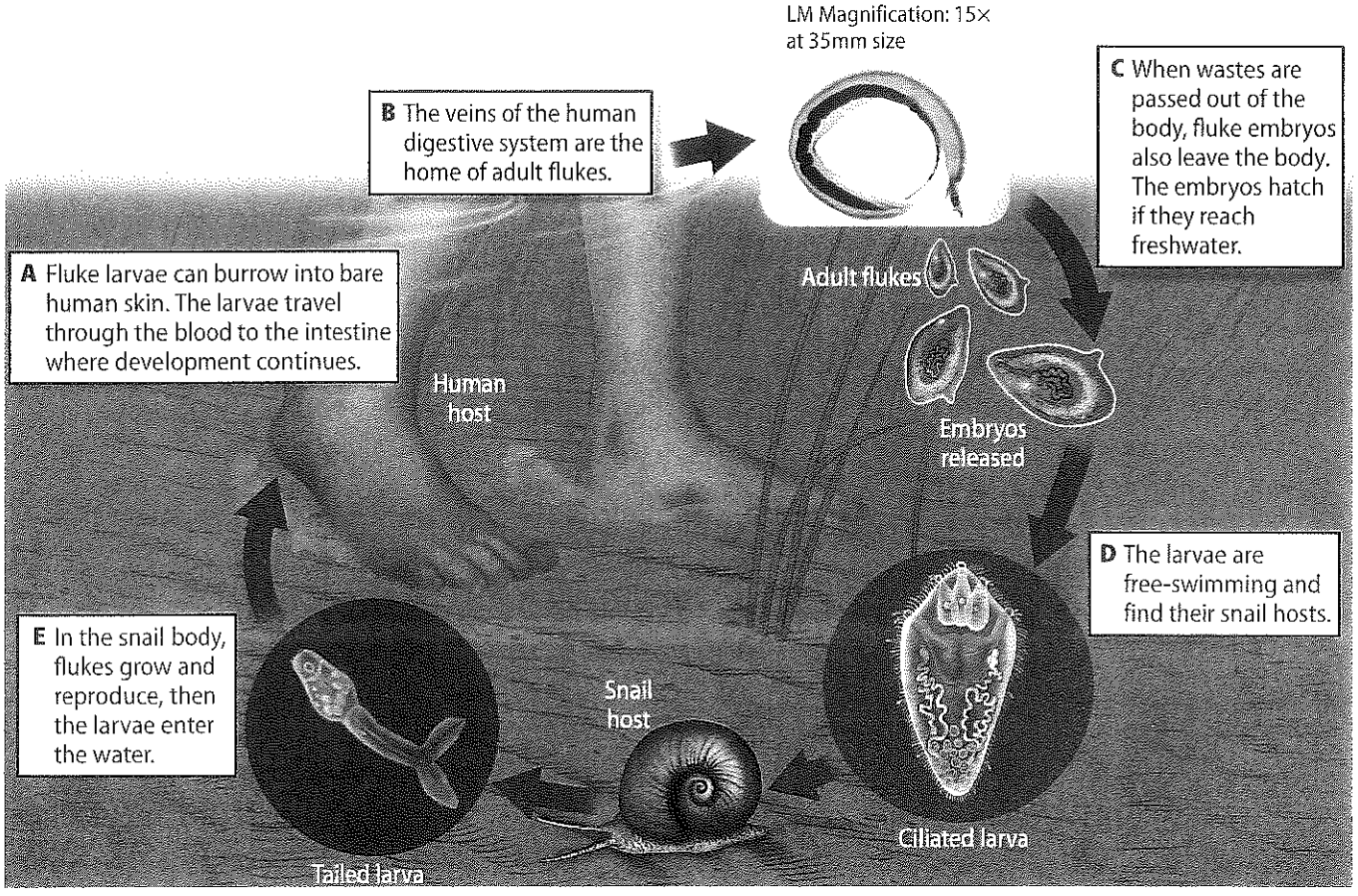


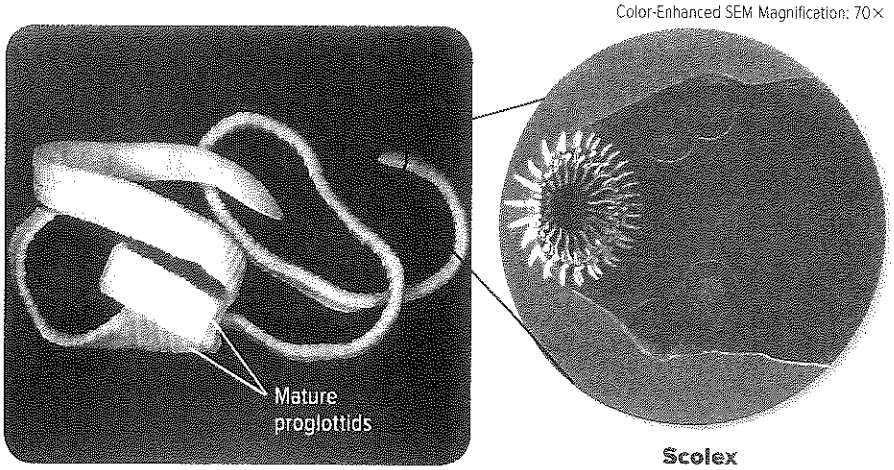
Figure 4 Dark clusters of light-sensitive cells form the eyespots on this planarian. Note the auricles projecting from the same area.

Figure 5 Two hosts—humans and snails—are needed to complete the life cycle of the fluke *Schistosoma.*
Infer ***why the two larval forms of the fluke are different shapes.***



(t)Richard L. Carlton/Photo Researchers; (b)Scott Camazine/Photo Researchers

Figure 6 As the proglottids behind the scolex mature, new proglottids form.



Cestodes All tapeworms are members of class Cestoda–the cestodes. They are parasites adapted to life in the intestines of their hosts. Look at the anterior end, or head, of the tapeworm in **Figure 6.** This is the **scolex** (SKOH leks), a knob-shaped structure with hooks and suckers that attach to the intestinal lining of a host, such as a cow or a human.

Behind the scolex of the worm are a series of individual sections called **proglottids** (proh GLAH tihdz), each of which contains muscles, nerves, flame cells, and male and female reproductive organs. Proglottids form continuously; as new ones form near the scolex, older proglottids move farther back and mature. After eggs in the mature proglottids are fertilized, the last segments with developing embryos break off and pass out of the intestines of their hosts. Animals such as cattle might feed on vegetation or drink water contaminated by the tapeworm proglottids, and then the cycle of tapeworm growth is repeated.

When eaten by cattle, tapeworms burrow through intestinal walls, entering blood and muscle. If undercooked infected beef is eaten, human infection by tapeworms is likely. Tapeworm infections are uncommon in industrialized nations because of beef inspections.

Section 1 Assessment

Section Summary

- Flatworms were among the first animals to exhibit bilateral symmetry.
- Flatworms are acoelomates with limited numbers of organs and systems.
- Some flatworms are free-living, and others are parasitic.
- Flatworms that are parasitic have specialized adaptations for parasitic life.

Understand Main Ideas

1. **Evaluate** the advantages of a flatworm's thin body.
2. **Compare and contrast** the adaptations of free-living flatworms and parasitic flatworms.
3. **Prepare** a chart that compares digestion, respiration, movement, and reproduction in the free-living and parasitic flatworms.
4. **Analyze** the importance of flame cells in a flatworm.

Think Critically

5. **Design** an experiment to determine what habitat conditions planarians prefer.
6. **Evaluate** how the three classes of flatworms are adapted to their habitats. Name the three classes of flatworms in your answer.
7. **Diagram** bilateral symmetry using a planarian as an example. Explain the adaptive advantage of bilateral symmetry to a planarian.

Online Quiz

Reading Preview

Essential Questions

- What are the similarities between the features of roundworms and flatworms?
- How can roundworms be identified based on movement?
- What are the ways humans risk contracting roundworm parasites?

Review Vocabulary

cilia: short, numerous projections that look like hairs

New Vocabulary

hydrostatic skeleton
trichinosis

Multilingual eGlossary

Roundworms and Rotifers

MAIN Idea Roundworms and rotifers have a more highly evolved gut than flatworms.

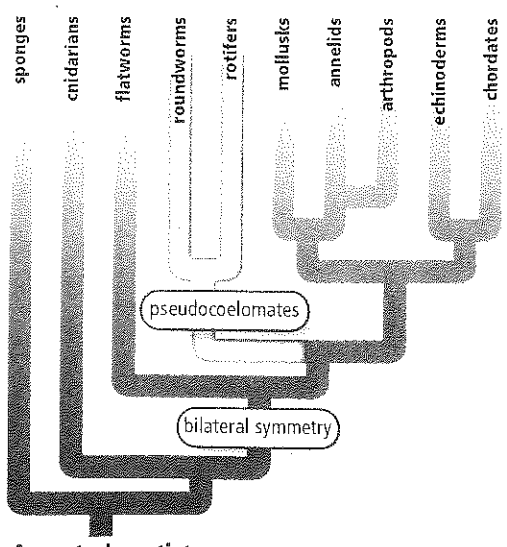
Real-World Reading Link If you were to guess what animal is one of the most common in the world, what animal would you choose? Would you guess a roundworm? With 20,000 species of roundworms known, scientists estimate that there might be 100 times as many more kinds of roundworms still undiscovered.

Body Structure of Roundworms

Roundworms are in phylum Nematoda (ne muh TOH duh) and often are called nematodes. Locate roundworms on the evolutionary tree in **Figure 7.** Notice that they are pseudocoelomates. Recall that pseudocoelomates have a fluid-filled body cavity that is partially lined with mesoderm. Roundworms have bilateral symmetry and are cylindrical, unsegmented worms that are tapered at both ends. Roundworms come in a variety of sizes, as shown in **Figure 7.** Most are less than 1 mm long. However, the longest known roundworm, which lives in certain whales, can grow to 9 m in length.

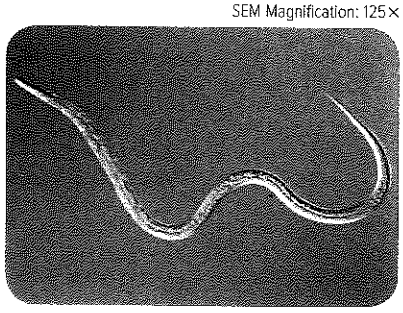
Roundworms are found in both marine and freshwater habitats and on land. Some are parasites that attach to plants or animals. A spadeful of garden soil might contain one million roundworms. One study revealed that a rotting apple contained 1074 roundworms! Dogs and cats can be plagued by roundworms if they are not wormed when they are young and at regular intervals during adulthood. Roundworms have adaptations that enable them to live in many places.

Figure 7 Roundworms are pseudocoelomates with bilateral symmetry.

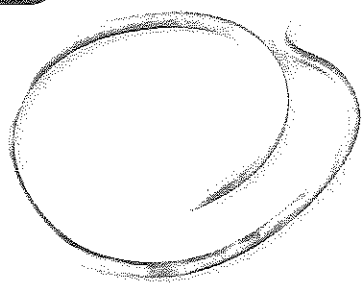


Ancestral protist

SEM Magnification: 125×



Vinegar eel (2 mm in length)



Ascarid worm (10–35 cm in length)

CAREERS IN BIOLOGY

Veterinary Parasitologist As scientists who keep parasites out of the food supply, veterinary parasitologists are responsible for the health of farm and domesticated animals. They determine ways to control and prevent parasites in animals such as cows, pigs, and chickens.

Feeding and digestion Most roundworms are free-living, but some are parasites. Some free-living roundworms are predators of other tiny invertebrates, while others feed on decaying plant and animal matter. Free-living forms have a key evolutionary adaptation in their digestive systems. Recall that in the course of evolution, pseudocoelomate animals were the first to have a body cavity. The pseudocoelom of a nematode separates the endoderm-lined gut from the rest of the body. The movement of food through the gut, or digestive tract, is one-way–food enters through the mouth, and undigested food leaves through an opening at the end of the digestive tract called the anus.

Respiration, circulation, excretion, and response to stimuli Like flatworms, roundworms have no circulatory organs or respiratory organs, and they depend on diffusion to move nutrients and gases throughout their bodies. Most roundworms exchange gases and excrete metabolic wastes through their moist outer body coverings. More complex forms have excretory ducts that enable them to conserve water for living on land, while others have flame cells.

Ganglia and associated nerve cords coordinate nematode responses. Nematodes are sensitive to touch and to chemicals. Some have structures that might detect differences between light and dark.

Movement Roundworms have muscles that run the length of their bodies. These muscles cause the worms' bodies to move in a thrashing manner as one muscle contracts and another relaxes. These muscles also pull against the outside body wall and the pseudocoelom. The pseudocoelom acts as a **hydrostatic skeleton**–fluid within a closed space that provides rigid support for muscles to work against. If you were to observe a roundworm moving, it might resemble a tiny piece of wriggling thread. Learn more about worm movement in **Data Analysis Lab 1.**

DATA ANALYSIS LAB 1

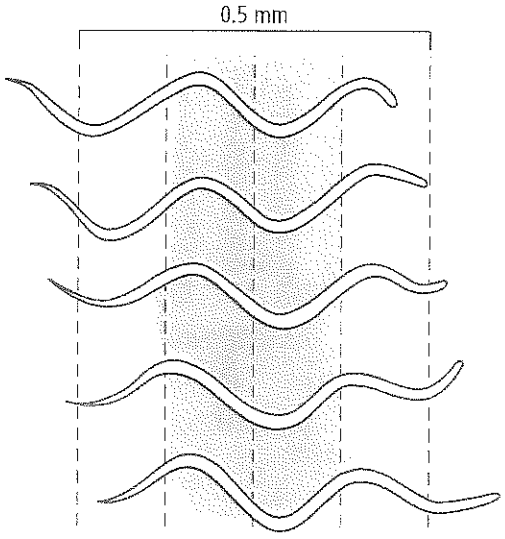
Based on Real Data*

Interpret the Diagram

How does a nematode move? A nematode alternately contracts and relaxes muscles that run lengthwise on each side of its body.

Data and Observations

The diagram sequences the movement of a single nematode. Each segment of time is represented by the space between the dotted lines.



Time between segments is 0.33 s

Think Critically

1. **Interpret** about how long it took the worm to move to its final location.
2. **Calculate** how far the worm could move in 10 min.
3. **Infer** how worm movement might differ if muscles on one side of its body were damaged.

*Data obtained from: Gray, J. and H.W. Lissmann. 1964. The locomotion of nematodes. *Journal of Experimental Biology* 41:135–154.

Reproduction Roundworms reproduce sexually. The females produce eggs, and the males, which often are smaller than the females, produce sperm. Fertilization is internal. In free-living roundworms, larvae hatch from the fertilized eggs, then grow into adults. In parasitic roundworms, development often is more complicated, involving one or more hosts or different locations in the host's body.

The adult roundworm *Caenorhabditis elegans (C. elegans),* shown in **Figure 8,** contains only 959 cells; zygotes mature to adults in just three days. These characteristics make it an extremely important subject of research on development, aging, and genetics. *C. elegans* was the first multicellular organism to have its entire genome sequenced. The *C. elegans* genome contains 97 million DNA bases encoding more than 19,000 different genes.

Reading Check **Explain** why the features of *C. elegans* make it a good subject for research.

LM Magnification: 64×

Figure 8 *C. elegans* is the subject of much genetic research. With comparatively few cells and rapid development, scientists can easily research developmental changes.

Diversity of Roundworms

Of the 20,000 known roundworm species, approximately half are parasites. These parasitic roundworms cause a variety of diseases in plants and animals, including humans. Many of these diseases in humans are the result of carelessness, a lack of personal hygiene, or poor sanitation.

Trichinella worms A disease called **trichinosis** (trih keh NOH sis) can be contracted by eating raw or undercooked pork and pork products, or wild game infected with the larvae of *Trichinella,* like the one shown in **Figure 9.** After ingestion by a host organism, the worms mature in one to two days. Female worms with fertilized eggs burrow into the intestinal walls of humans, pigs, and other mammals. After the eggs hatch, the larvae burrow into muscles where they form cysts, causing muscle pain. Trichinosis can be prevented by cooking meat properly.

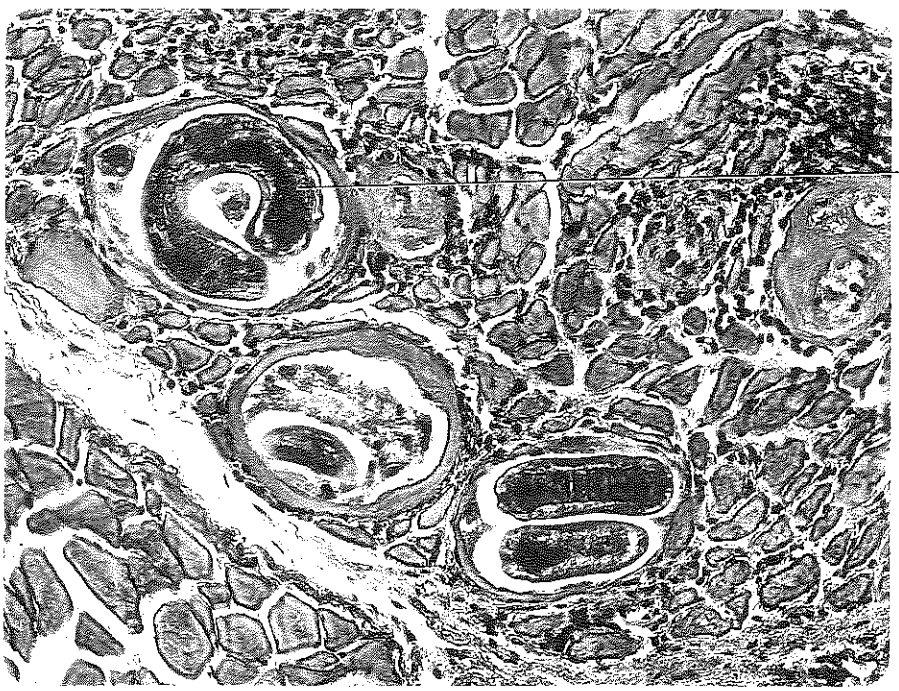


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Figure 9 A trichinella worm larva is seen curled up inside of a cyst in pig muscle.
Infer ***what kind of physical symptoms a person with trichinosis might have.***

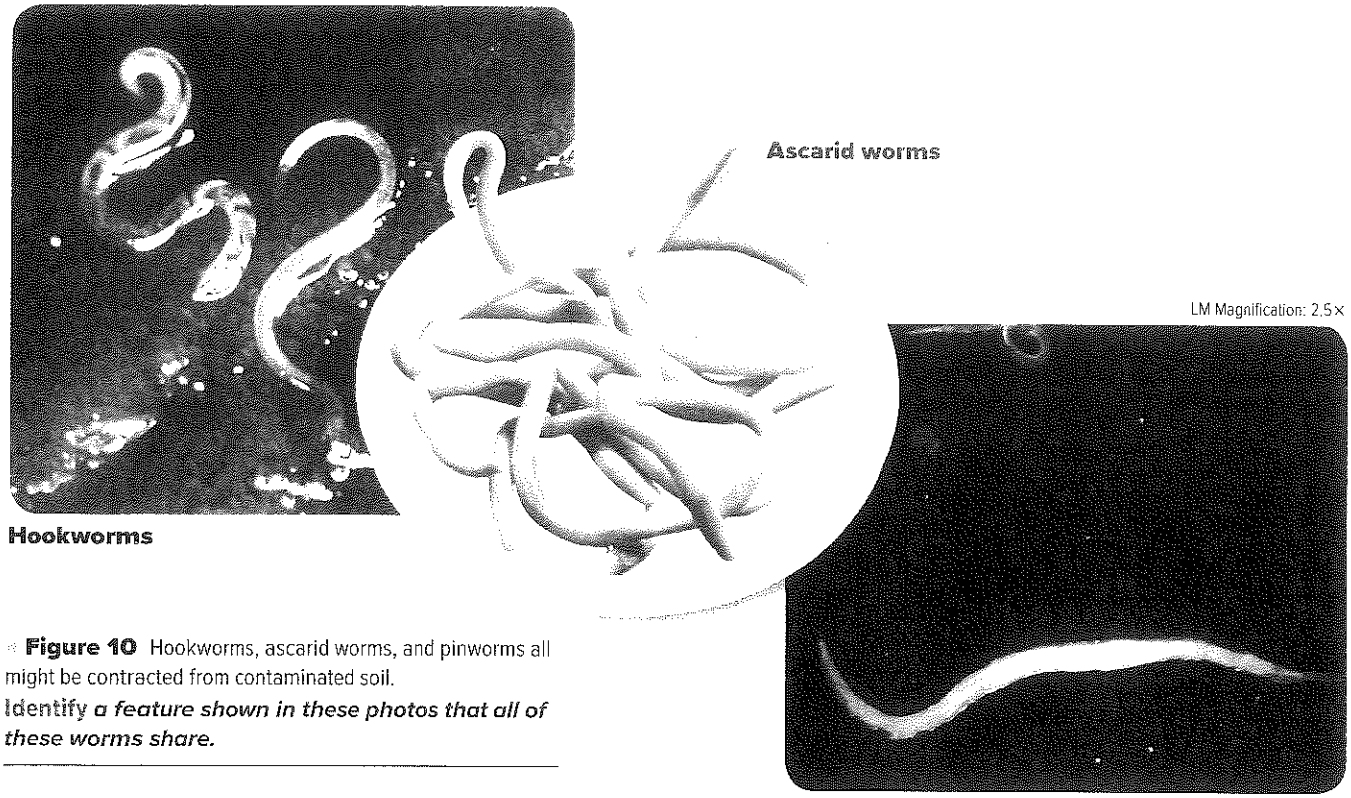


Figure 10 Hookworms, ascarid worms, and pinworms all might be contracted from contaminated soil.
Identify ***a feature shown in these photos that all of these worms share.***

Hookworms Hookworm infections are common in warm climates when people go barefoot on contaminated soil. When a hookworm, shown in **Figure 10,** contacts bare human skin, it cuts its way inside, travels in the bloodstream to the lungs, and then to the windpipe, or esophagus, where it is coughed up and swallowed. The parasite then moves to the small intestine, where it attaches to intestinal walls and feeds on blood and other tissue. Hookworm infection can be prevented by wearing shoes.

Ascarid worms The most common worm infection in humans is ascariasis (AS kuh RI uh sus), which is caused by ascarid (AS kuh rid) worms like the ones shown in **Figure 10.** Eggs of ascarid worms are found in soil in subtropical and tropical areas. They enter the human body through the mouth and live in the intestine. Infection can result when unwashed vegetables from contaminated soil are eaten or when hands contaminated with infected soil are put in the mouth, as young children are likely to do. Infection by ascarid worms can be controlled by carefully washing vegetables and hands.

Reading Check **Explain** how humans can prevent infection from hookworms and ascarid worms.

Pinworms **Figure 10** shows a pinworm, the most common nematode parasite in humans in the United States. The highest incidence of infection occurs in children. At night, female pinworms living in the intestine move out of the anus and lay eggs on nearby skin. When the skin is scratched because of the itching caused by pinworm activity, the eggs are transferred to hands and then to any surface that is touched. These eggs can survive for up to two weeks on surfaces and are ready to hatch if another person ingests them. This infection can spread quickly among children who put toys and other objects in their mouths.

VOCABULARY

Nematode
nemato- prefix; from Greek, meaning *thread*
-ode suffix; from the Greek word *oeides*, meaning *similar to*

(l)Centers for Disease Control; (c)Sinclair Stammers/SPL/Photo Researchers; (r)©Lester V. Bergman/Corbis

Filarial worms Elephantiasis (el uh fun TI uh sus) is a disease caused by filarial (fuh LER ee uhl) worms, which are roundworm parasites that live in tropical areas. A mosquito is the intermediate host of filarial worms. When a mosquito sucks blood from a person who is infected with this roundworm, worm embryos are passed into the insect's bloodstream. The embryos grow into larvae, which then are passed to another person when the mosquito bites again. Adult worms accumulate in the lymphatic system and obstruct the flow of lymph–the tissue fluid in the spaces between cells. This fluid builds up in tissue, causing legs and other body regions to enlarge. Controlling mosquitoes and using mosquito netting at night can aid in preventing this disease.

Another disease caused by a filarial worm–heartworm–is found in dogs and cats throughout the United States. Heartworms are transmitted to dogs and cats through mosquito bites. Once in the bloodstream, the worms travel to the heart and block the flow of blood. Regular doses of oral medications prevent heartworm in dogs and cats.

Reading Check **Identify** In what parts of the human body do pinworms and filarial worms live?

Nematodes in plants Some species of roundworms cause diseases in plants. Nematodes can infect and kill pine trees, soybean crops, and food plants such as tomatoes. When they infect plant roots, as shown in **Figure 11,** they damage the plant.

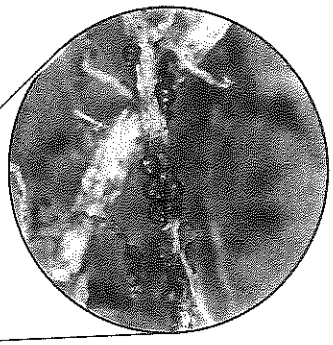
Most species of nematodes are either harmless or beneficial to plants. Certain nematodes are used to control the spread of cabbage worm caterpillars, Japanese beetle grubs, and many other pests of crop plants. Spraying a solution of nematodes and water on areas that are infested with crop pests is most effective when the targeted pest is at the stage in its life cycle when it lives in the soil.

Connection to [illegible] In addition to treating plant pests, nematodes are used to control pests of humans and animals. Nematodes eat flea larvae and thus control the flea population in yards. This reduces or eliminates exposure of humans and animals to traditional chemicals used to treat flea infestations.

Figure 11 The growth of the vascular system of plants can be slowed down when nematodes move into the roots and form cysts.

Potato plant without nematodes

Potato plant with nematodes



Nematode cysts on roots

(l)Michael P. Gadomski/Photo Researchers; (c, r)Nigel Cattlin/Photo Researchers

LM Magnification: 100×

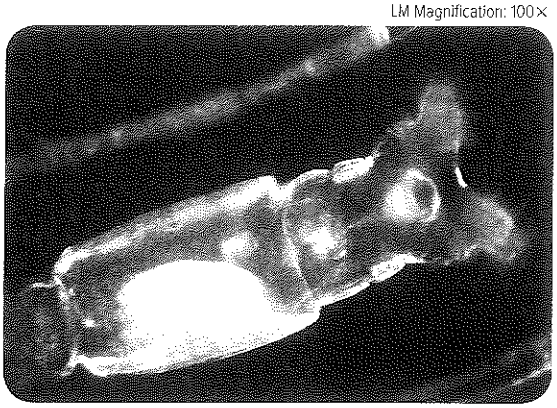


Figure 12 Rotifers have two rings of cilia at their anterior end.

Rotifers

Rotifers are tiny animals only about 0.1 mm to 0.5 mm in length. The phylum Rotifera, meaning *wheel-bearer,* gets its name from the rings of cilia around the mouths of the animals. About 1800 species of rotifers have been studied, mostly from freshwater habitats, including ponds, streams, and lakes. It would not be unusual to find 40 to 500 rotifers in a liter of pond water. A few species are marine. Refer to the evolutionary tree in **Figure 7** and note that although rotifers and roundworms occupy separate branches, both are pseudocoelomates.

Rotifer features and movement Rotifers are similar to roundworms because they have bilateral symmetry and are pseudocoelomates with a gut open at both ends. Unlike roundworms, however, rotifers move through the water by means of their ciliated wheel-like structures, which are shown in **Figure 12.** The posterior end of a rotifer generally has "toes" and glands that secrete an adhesive material that enables a rotifer to attach itself to a surface in the water.

Organ systems of rotifers Rotifers feed by using cilia to gather protists and organic materials into a complete digestive tract, which includes a mouth and an anus. Like other pseudocoelomates, rotifers exchange gases and excrete metabolic wastes by diffusion through body walls. Sensory structures include sensory bristles and eyespots on the head. Some rotifers reproduce sexually, while others have complex life cycles involving diploid eggs producing diploid females and haploid eggs producing haploid males. These life cycles are dependent on environmental conditions, such as spring rains, frost, or the presence of stagnant water.

Section 2 Assessment

Section Summary

- Roundworms are closely related to flatworms.
- Roundworms, like flatworms, have a limited number of organs and systems.
- Roundworms are either free-living or parasitic.
- Roundworms cause many human and plant diseases.
- Rotifers are pseudocoelomates that appear on a different branch of the evolutionary tree from that of roundworms.

Understand Main Ideas

1. **Describe** the evolutionary adaptation of the digestive tract of roundworms.
2. **Compare and contrast** the features of flatworms and roundworms.
3. **Explain** how roundworms make their distinctive thrashing movements.
4. **Compare and contrast** the various ways in which humans might risk contracting roundworm parasites.

Think Critically

5. **Hypothesize** Imagine that you are digging in your garden and find some tiny threadlike animals making thrashing movements. Make a hypothesis about what these animals might be. Explain your answer.

MATH in Biology

6. Make a circle graph that shows the number of roundworm species known compared to the estimated number of roundworm species that might exist.

John Walsh/Photo Researchers

Online Quiz

Reading Preview

Essential Questions

- What is the importance of the coelom to mollusks?
- What is the function of the mantle and what are its adaptive advantages to mollusks?
- What is the importance of mucus and the muscular foot to mollusks?

Review Vocabulary

herbivore: an organism that eats only plants

New Vocabulary

mantle
radula
gill
open circulatory system
closed circulatory system
nephridium
siphon

Multilingual eGlossary

Mollusks

MAIN Idea **Mollusks are coelomates with a muscular foot, a mantle, and a digestive tract with two openings.**

Real-World Reading Link Have you ever watched a rocket blast off into space? The rocket is powered by jet propulsion—a stream of heated gas is forced out of the engine, pushing the rocket in the opposite direction. Some animals, such as octopuses, also move by jet propulsion, forcefully expelling streams of water to push them away from danger.

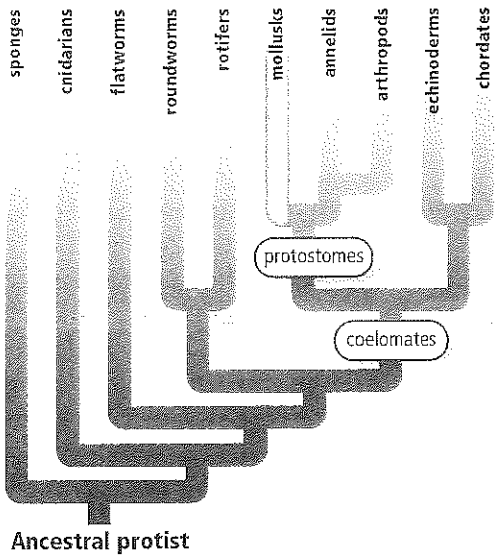
Body Structure

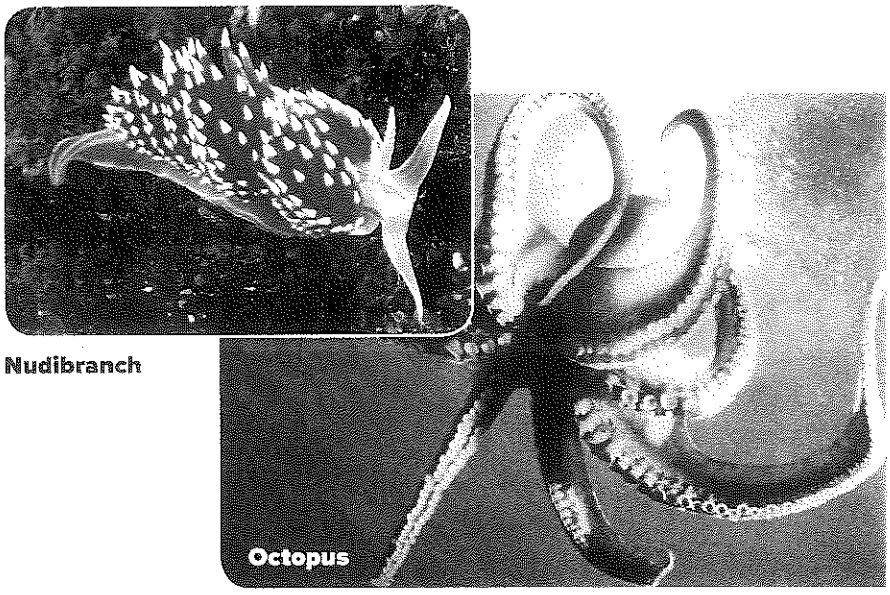
Mollusks are members of the phylum Mollusca. They range from the slow-moving slug to the jet-propelled squid, from scallops and cuttlefish to chitons and nudibranchs. Mollusks range in size from almost microscopic snails to giant squids, which can grow to be 21 m long.

Look at the evolutionary tree in **Figure 13.** Mollusks, such as the nudibranch and the octopus in **Figure 13,** undergo protostome development and might have been the first animals in the course of evolution to have a coelom, which allowed for the development of more complex tissues and organs. There are more than 110,000 known species of mollusks. Many are marine, some live in freshwater, and others live in moist land environments.

Mollusks are coelomate animals with bilateral symmetry, a soft internal body, a digestive tract with two openings, a muscular foot, and a mantle. The **mantle** (MAN tuhl) is a membrane that surrounds the internal organs of the mollusk. In mollusks with shells, the mantle secretes calcium carbonate to form the shell. Other mollusks, including slugs and squids, are adapted to life without a hard outer covering.

Figure 13 Mollusks, such as the nudibranch and octopus, have coeloms.
Infer *what the main difference is between mollusks and roundworms based on the evolutionary tree.*





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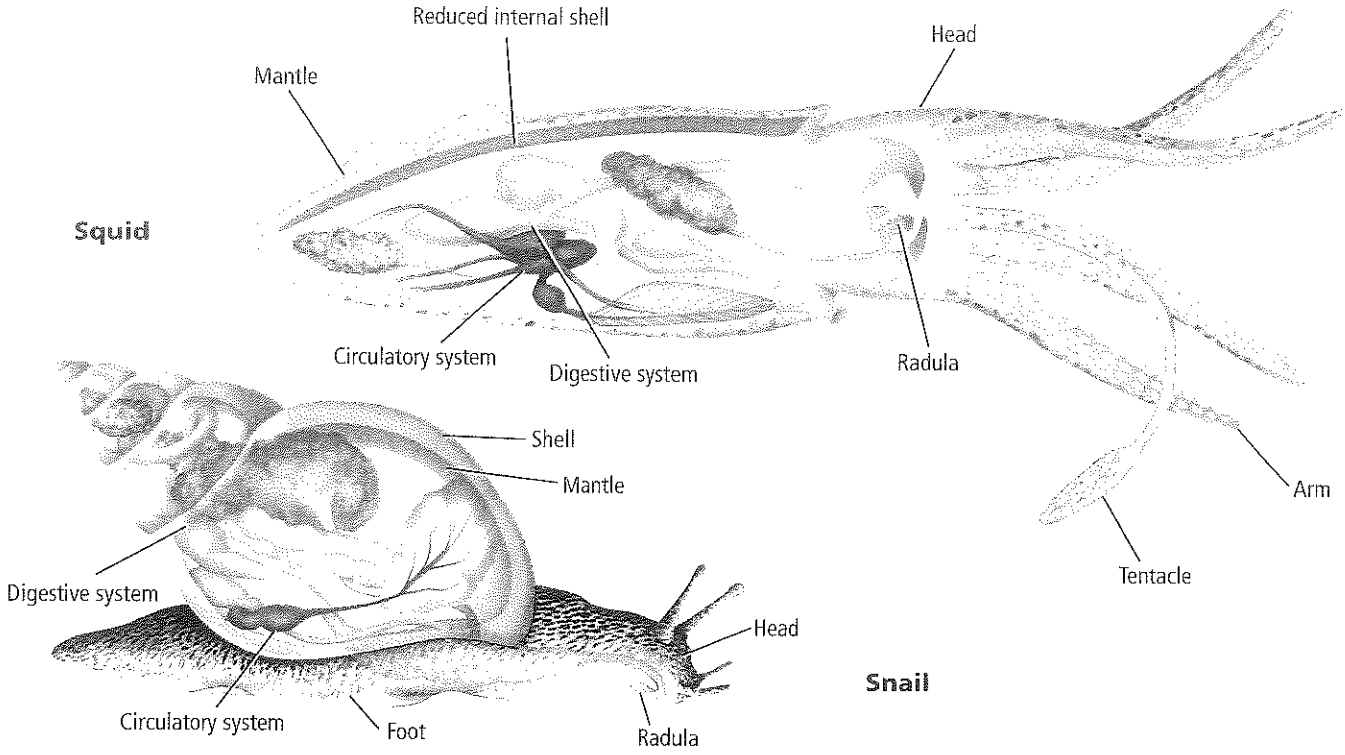


Figure 14 Many mollusks have shells. Inside the shell is a soft body consisting of a foot, organs, and a mantle.
Compare and contrast *the bodies of the snail and the squid.*

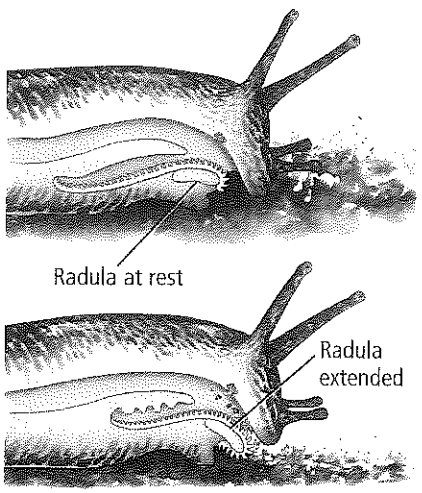
Compare the bodies of the snail and the squid in **Figure 14.** Their external features are very different from each other. However, both have coelomate body plans and highly evolved body systems, such as the digestive system, respiratory system, circulatory system, and nervous system.

Feeding and digestion Many mollusks use a rasping structure called a radula to scrape food into their mouths. Located in a mollusk's mouth, a **radula** (RA juh luh) is a tonguelike organ with rows of teeth, as shown in **Figure 15.** Herbivorous mollusks use their radulas to scrape algae off rocks. Carnivorous mollusks use their radulas to drill into other mollusks and feed on their internal body parts. Some of these predators, such as octopuses and squids, use their radulas to tear up the food they capture with their tentacles. Other mollusks, such as clams, are filter feeders and do not have radulas.

Mollusks have complete guts with digestive glands, stomachs, and intestines, as shown in **Figure 16.** As in roundworms, the digestive system has two openings—a mouth and anus.

Reading Check **Explain** why the evolution of a coelom is important to mollusks.

Figure 15 Many mollusks feed using a radula. At the top, the radula is at rest. At the bottom, you can see the toothlike scraping structures on the radula as it is extended to feed.



Respiration Most mollusks have respiratory structures called gills. **Gills,** shown in **Figure 16,** are parts of the mantle that consist of a system of filamentous projections that are like the fringes of a blanket. Gills contain a rich supply of blood for the transport of oxygen to the blood and for the removal of carbon dioxide from the blood. Gills move water into and through the mantle cavity in a continuous stream. They are highly branched structures, which increase the surface area through which gases can diffuse. This enables the gills to take in more oxygen from water. Land snails and slugs remove oxygen from the air using the lining of their mantle cavities. In some mollusks, the gills also function in filter feeding.

Circulation Mollusks have a well-developed circulatory system that includes a chambered heart. Most mollusks have an **open circulatory system,** in which the blood is pumped out of vessels into open spaces surrounding the body organs. This adaptation enables animals to diffuse oxygen and nutrients into tissues that are bathed in blood and also to move carbon dioxide from tissues into the blood. Slow-moving animals, such as snails and clams, utilize this system effectively because they do not need rapid delivery of oxygen and nutrients for quick movements.

Some mollusks, such as squids, move nutrients and oxygen through a closed circulatory system, which was a major adaptation in the evolution of animals. In a **closed circulatory system,** blood is confined to vessels as it moves through the body. A closed system efficiently transports oxygen and nutrients to cells, where they are converted to usable forms of energy. Mollusks that move quickly, such as octopuses and squids, need more energy than slow-moving mollusks, and the closed circulatory system quickly delivers nutrients and oxygen. A closed circulatory system is like the heating ducts in some houses. A furnace is efficient at delivering warm air to the rooms in a house because the air travels through a series of ducts or pipes. Rooms of a house would not be evenly heated if the furnace did not have a delivery system.

Excretion Most mollusks get rid of metabolic wastes from cellular processes through structures called **nephridia** (nih FRIH dee uh), shown in **Figure 16.** After nephridia filter the blood, waste is passed out through the mantle cavity. Nephridia are an evolutionary adaptation enabling mollusks to efficiently maintain homeostasis in their body fluids.

Response to stimuli Mollusks have nervous systems that coordinate their movements and behavior. Mollusks that are more highly evolved, such as octopuses, have brains. In addition, octopuses have complex eyes similar to human eyes with irises, pupils, and retinas. Most mollusks have simple structures in the eyes that reflect light.

CAREERS IN BIOLOGY

Laboratory Assistant Marine biologists depend on laboratory assistants to help collect specimens, such as mollusks, and to maintain databases. These entry-level workers also set up equipment and prepare samples for testing.

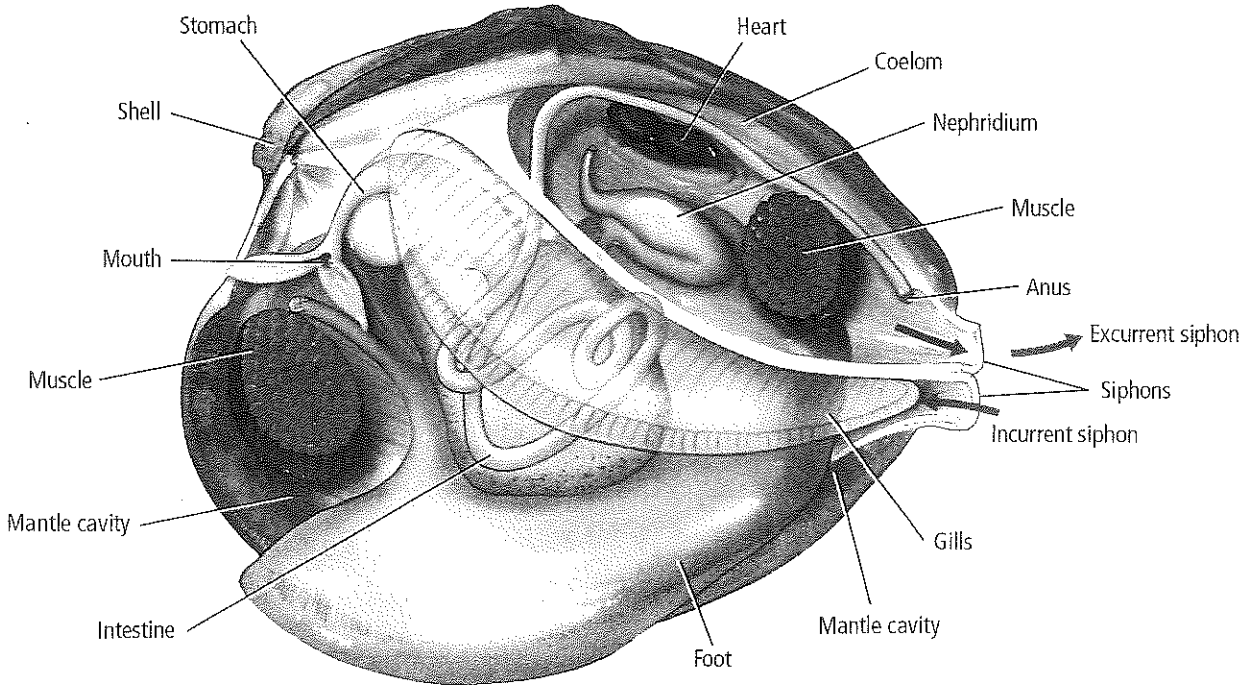


Figure 16 The internal anatomy of a clam illustrates the well-developed organ systems in mollusks.

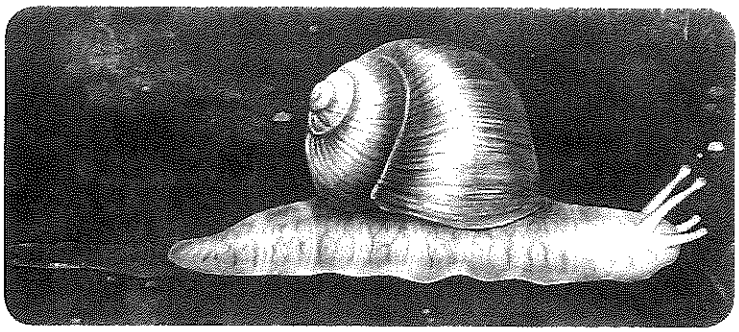
Visualizing Movement in Mollusks

Figure 17

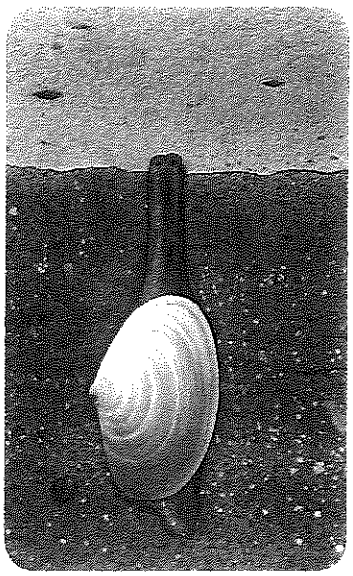
Mollusks move in a variety of ways. The type of movement used often depends on a mollusk's unique adaptations.

Gastropods

A gastropod moves by sending waves of contractions along its muscular foot. A film of mucus lubricates the foot and helps propel the animal forward.



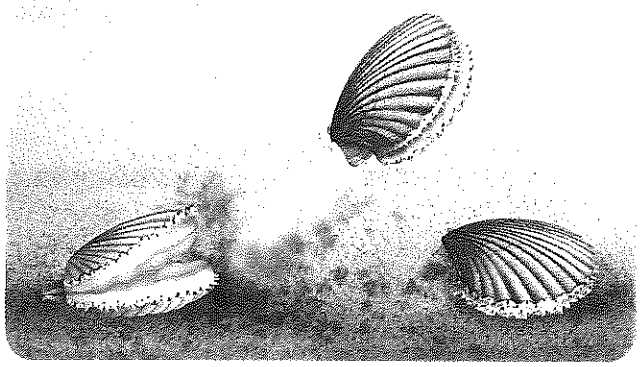
Note the waves of muscle contractions as the snail moves along its mucous trail.



A clam can rapidly bury itself in sand using its muscular foot.

Bivalves

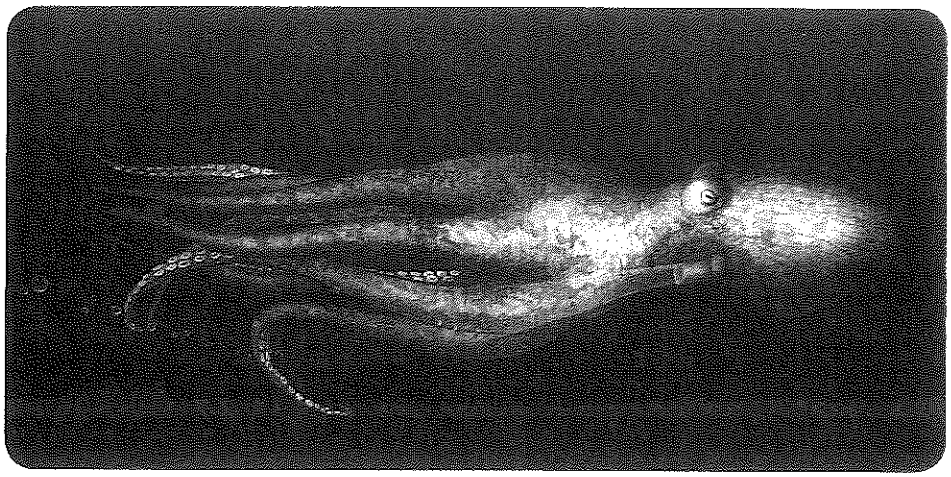
Most bivalves do not move much, unless they are threatened by a predator. Then, a bivalve either uses its muscular foot to burrow into sediment, as shown on the left, or uses jet propulsion to flee, as shown at right.



A scallop pulls its shells together, forcing jets of water toward the shell hinge. The force of the water pushes the scallop in the direction of the shell opening.

Cephalopods

Members of class Cephalopoda, such as octopuses and squids, move by jet propulsion. To avoid predators, a cephalopod draws in water through slits in the body wall. Then the water is pumped rapidly through the siphon, jet-propelling the cephalopod away from danger.



An octopus changes the direction it moves by alternating the direction of its siphon.

Animation

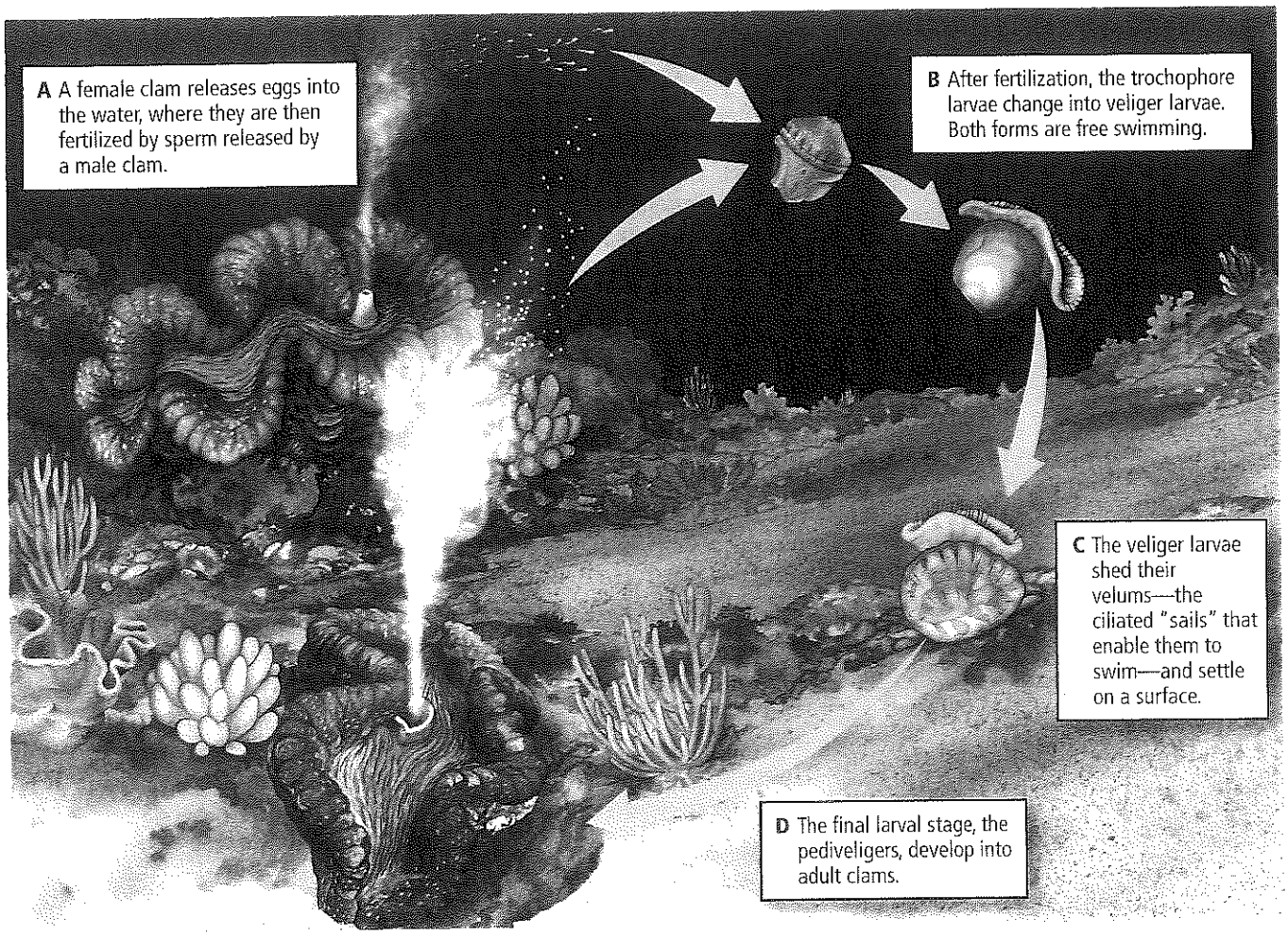
Movement The muscular foot of a clam enables it to burrow into wet sand. Mollusks with two shells can clap their shells together for short bursts of rapid swimming. Most slugs and snails creep along moist areas on a slime trail of mucus secreted by glands in the foot. Octopuses and squids take water into the mantle cavity and expel it through a tube called a **siphon.** When threatened, they can eject the water so rapidly that they appear to be jet-propelled. **Figure 17** illustrates the ways mollusks move.

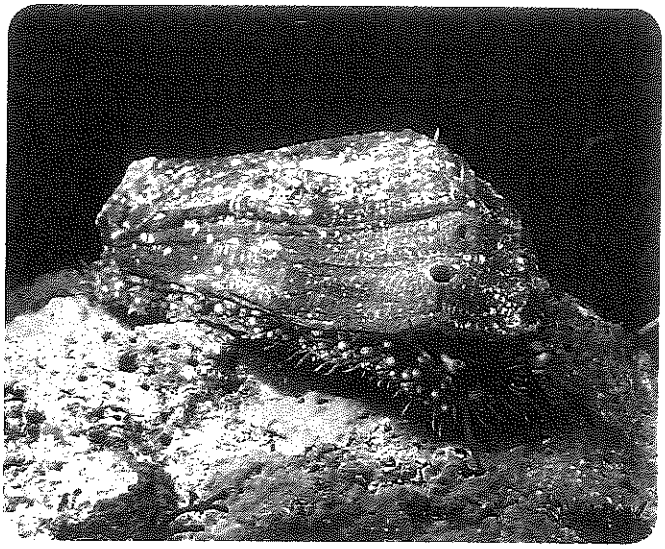
Reading Check **Compare** movement in two-shelled mollusks, snails, and squids.

Reproduction Mollusks reproduce sexually, as illustrated in **Figure 18.** The males and females of most aquatic species release their eggs and sperm into the water at the same time, and fertilization is external. A few bivalves and many gastropods that live on land are hermaphrodites, in which fertilization takes place internally.

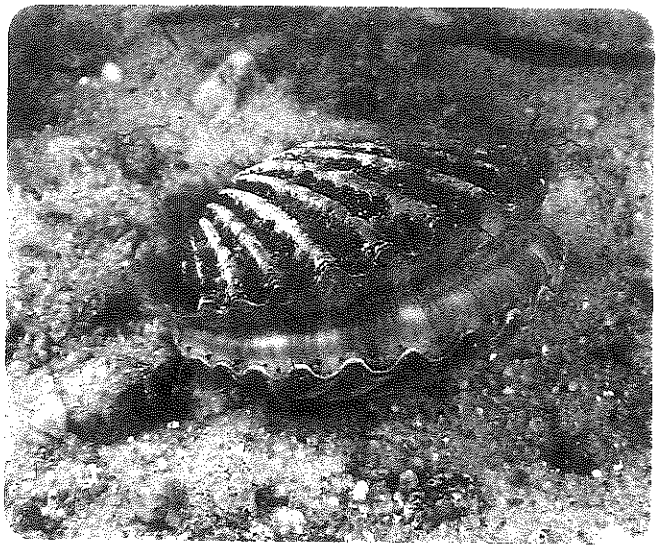
All members of the phylum Mollusca share similar developmental patterns, even though their adult forms vary widely. One larval stage of most mollusks, the trochophore (TRO kuh for), looks very similar to the larval stage of segmented worms, which you will study in Section 4. Because the larval forms are similar in both segmented worms and mollusks, scientists hypothesize that segmented worms and mollusks are closely related.

Figure 18 The life cycle of a clam illustrates the characteristic developmental stages of all mollusks.





Abalone



Scallop

Figure 19 Most gastropods, such as the abalone, have single shells for protection. Bivalves, such as the scallop, have two shells.

Diversity of Mollusks

Animals in the three major classes of mollusks–gastropods, bivalves, and cephalopods–are grouped based on differences in their shell and foot structures.

Gastropods The largest class of mollusks is Gastropoda, the stomach-footed mollusks. The name comes from the way the animal's large foot is positioned under the stomach on the ventral surface. Most species of gastropods have a single shell, like the abalone in **Figure 19.** Single-shelled gastropods also include snails, conches, periwinkles, limpets, cowries, whelks, and cones. They can be found in aquatic habitats and in moist terrestrial habitats, and they can quickly draw their bodies into their shells for protection when they are threatened.

Slugs and nudibranchs do not have shells. They secrete a thick mucus that covers their bodies. To protect themselves, land slugs hide in dark locations under forest or garden litter. Nudibranchs incorporate into their own tissues the poisonous nematocysts of the jellyfishes they eat. The presence of nematocysts is advertised to predator fishes by the bright colors of the nudibranchs.

Bivalves One word–*slow*–best describes most behavior of the class Bivalvia, which are the two-shelled mollusks. Bivalves, such as clams, mussels, oysters, and the scallop shown in **Figure 19,** are all aquatic animals. Most are marine, but some are found in freshwater habitats. Bivalves might seem to be inactive, but they are continuously filter feeding and carrying on all bodily functions.

If you have ever been clamming or have seen people clamming, you know that you might have to dig deeply to find clams because they use a muscular foot to burrow far down into wet sand. Mussels attach to rocks with a sticky, gluelike substance called byssal threads. Scallops are more active than other bivalves because they can clap their shells together to move more quickly through water.

Reading Check **Compare** the foot and shell of a snail with those of a clam.

VOCABULARY

WORD ORIGIN

Gastropod

gastro- prefix; from the Greek word *gaster,* meaning *belly*

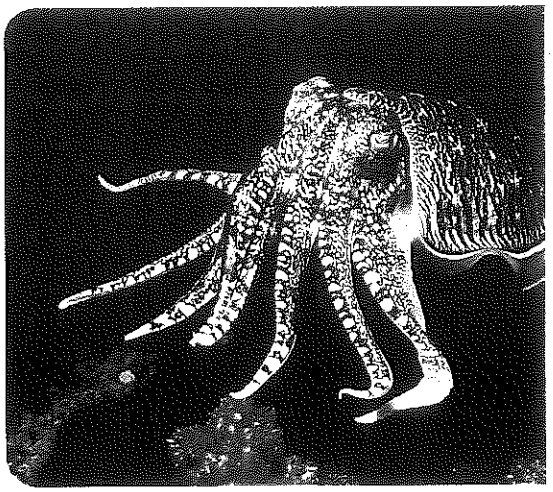
-pod suffix; from Greek, meaning *foot*

Cephalopods *Quick* is a word that best describes some behaviors of the class Cephalopoda. Cephalopods are the head-footed mollusks (from the Greek word *cephalo,* meaning *head,* and from *pod,* meaning *foot*), which includes squids, octopuses, chambered nautiluses, and the cuttlefish shown in **Figure 20.** The chambered nautilus is the only cephalopod with an external shell. Squids and cuttlefishes have an internal shell, while octopuses do not have a shell. The foot of a cephalopod is divided into arms and tentacles with suckers, which are used to capture prey.

Protection Although most cephalopods don't have a hard external shell, they have evolved other protective mechanisms. Octopuses forcefully expel water to propel themselves away from threat. They hide in crevices or caves in the daytime. At night, they creep about in search of prey.

When threatened, an octopus shoots out an inky substance that forms a cloud. Scientists hypothesize that the ink visually confuses predators, and it also might act as a narcotic. Octopuses can change color to blend in with their surroundings. Squids and cuttlefishes also use ink and camouflage to escape predators. A chambered nautilus can pull into its shell for protection. It also uses its shell as camouflage. The dark top of the shell blends in with the ocean bottom when it is seen from above, while the white bottom of the shell blends in with the water above when it is seen from below.

Learning Octopuses are considered to be the most intelligent mollusks. They are capable of complex learning, such as being trained to select an object of a certain shape, color, or texture. See **Data Analysis Lab 2** to study this phenomenon.



Cuttlefish

Figure 20 Cuttlefish have eight arms and two tentacles. The tentacles often are not visible because they are withdrawn into pouches under the eyes.

Compare *the differences between cephalopods and gastropods.*

DATA ANALYSIS LAB 2

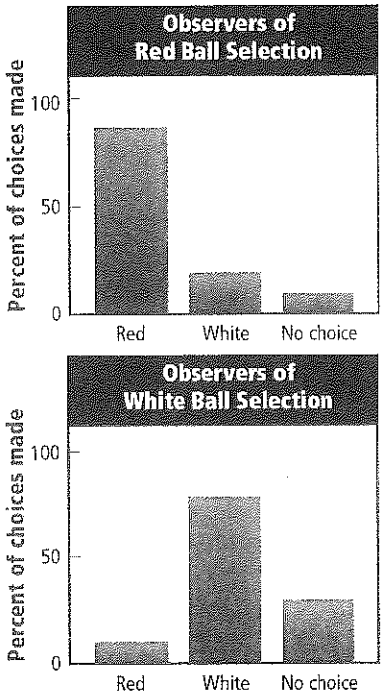
Based on Real Data*

Interpret the Data

Can untrained octopuses learn to select certain objects? Two groups of octopuses were trained to select either a red ball or a white ball. Each trained group was observed by different groups of octopuses that were not trained.

Data and Observations

The graphs show the results of untrained octopus selection of white or red balls.



Think Critically

1. **Analyze** What percentage of octopuses selected the red ball or the white ball after observing the red ball being selected?
2. **Analyze** What percentage of octopuses selected the red ball or the white ball after observing the white ball being selected?
3. **Draw Conclusions** Can untrained octopuses learn by observation? Explain.

*Data obtained from: Fiorito, G. and P. Scotto. 1992. Observational learning in *Octopus vulgaris*. *Science* 256: 545–547.

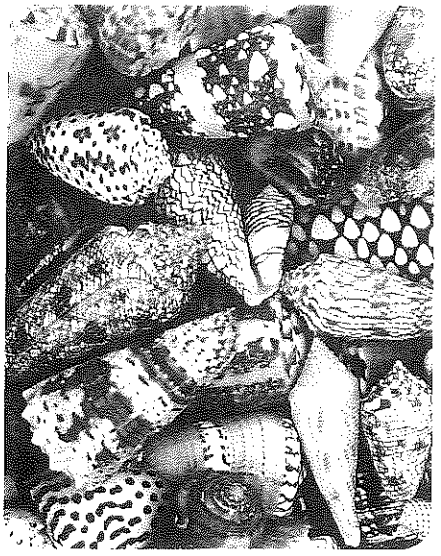


Figure 21 Cone snails are prized for their beauty.

Ecology of Mollusks

Mollusks play important roles in aquatic and terrestrial food chains as herbivores, predators, scavengers, and filter feeders. In many areas, certain mollusks are considered keystone species. A keystone is the stone at the top of an arch that holds the arch together, so a keystone species is one whose health influences the health of the entire ecosystem. For example, the hard clam is a keystone species for the Great South Bay in Long Island, New York. These clams filter water, which cleans the ecosystem. If the hard clam population declines, the water isn't filtered. This disrupts the food web, causing algal blooms and a decline in water quality.

The ability of some mussels to accumulate toxins in their body tissues can be useful to scientists who are monitoring water quality. By examining these mollusks, scientists can find out more about water quality than they could by testing the water alone.

Cone snails, as shown in **Figure 21,** are highly prized by collectors for the beauty of their shells. As a result, they might be close to extinction.

Connection to Certain cone snails produce powerful venom to kill prey. These venoms are being studied as potential treatments for pain, heart disease, clinical depression, and brain diseases, such as Alzheimer's disease, Parkinson's disease, and epilepsy.

Some mollusks cause damage, while others benefit humans. Some marine bivalve species, such as the shipworm, burrow into wood, causing much damage to wooden marinas and boats. On the other hand, people enjoy beautiful pearls that come from oysters. Pearls result when a grain of sand or a tiny parasite becomes trapped in an oyster. The mantle of the mollusk secretes a coating around the object to protect the mollusk, resulting in a pearl. Cultured-pearl producers implant pieces of shell or tiny plastic spheres in oysters and harvest the cultured pearls in about five to seven years.

Section 3 Assessment

Section Summary

- Mollusks were the first animals in the course of evolution to develop a coelom.
- Mollusks are divided into three main classes based on different characteristics.
- Mollusks have two body features that no other animals have—a mantle and a muscular foot.
- Mollusks have more-developed organ systems than those of roundworms and flatworms.
- Mollusks play important roles in the ecosystems in which they live.

Understand Main Ideas

1. **Summarize** the main features of the three classes of mollusks.
2. **Evaluate** the ways in which the development of the coelom allowed for adaptations in mollusks that were not possible in earlier animals.
3. **Draw** a diagram of a representative mollusk and show the main evolutionary adaptations common to mollusks.
4. **Analyze** the importance to mollusks of the following adaptations: the mantle, mucus, and the muscular foot.

Think Critically

5. **Design an experiment** A species of bivalves on one beach is a pale color compared to the same species that is a much darker color on a beach 1100 km to the north. Design an experiment that might explain the differences in shell color.
6. **Classify** Make a dichotomous key that would distinguish the differences among the three classes of mollusks.

Online Quiz

Reading Preview

Essential Questions

- What are the similarities among segmented worms, flatworms, and roundworms?
- What is the importance of segmentation as an adaptation for survival in segmented worms?
- What are the features of the three main classes of annelids that make them well-suited for their habitats?

Review Vocabulary

protostome: an animal with a mouth that develops from the opening in the gastrula

New Vocabulary

crop
gizzard
seta
clitellum

Multilingual eGlossary

Segmented Worms

Segmented worms have segments that allow for specialization of tissues and for efficiency of movement.

Real-World Reading Link Suppose that you watch a train as it roars around a curve. The train will follow the curve of the track because it is made up of individual cars that are linked together. The links give the train the flexibility it needs to stay on the track. In the same way, the individual segments that make up a segmented worm enable it to be flexible.

Body Structure

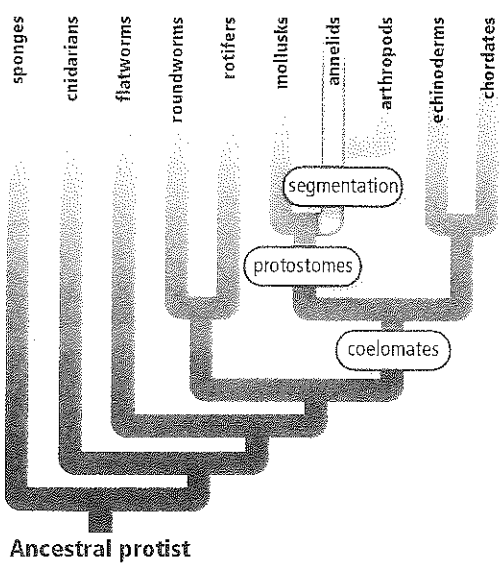
Earthworms are annelids and belong to phylum Annelida, which is characterized by animals with a body plan consisting of segments. As shown on the evolutionary tree in **Figure 22,** both mollusks and annelids undergo protostome development and therefore are considered close relatives.

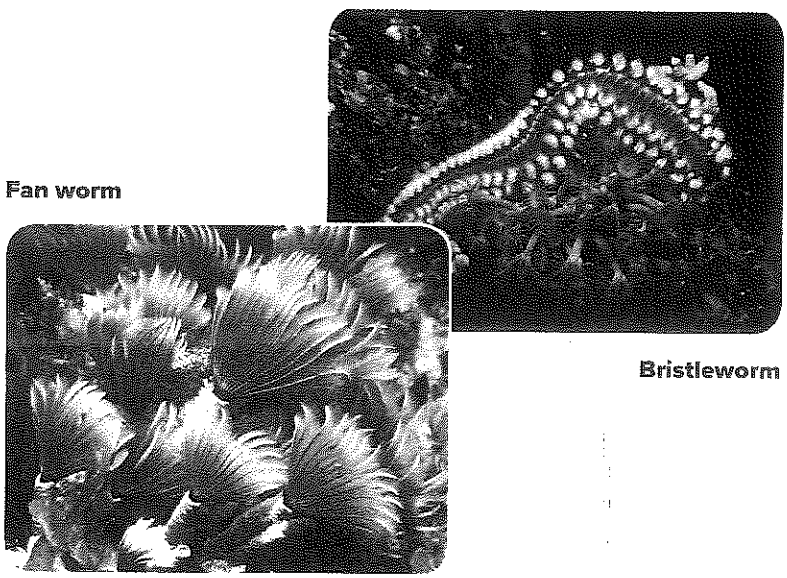
There are more than 11,000 known species of annelids, most of which live in the oceans. Most of the remaining species are earthworms. Annelids live almost everywhere, except in the frozen soil of the polar regions and in the sand of dry deserts.

Annelids include earthworms, marine worms, such as the ones shown in **Figure 22,** and parasitic leeches. These worms are different from flatworms and roundworms because they are segmented and have a coelom. Most annelids also have a larval stage that is similar to those of certain mollusks, suggesting a common ancestor. Annelids have bilateral symmetry, like flatworms and roundworms, and have two body openings, like roundworms.

Reading Check **Describe** two important ways in which segmented worms are different from flatworms and roundworms.

Figure 22 Annelids, like these marine worms, show protostome development, have coeloms, and are segmented.





(l)Georgette Douwma/Science Source; (r)Franco Banfi/Waterframe/Getty Images

Even though annelids have the same cylindrical body shape as roundworms do, annelid bodies are divided into segments. Externally, the segments look like a stack of thick coins or a stack of donuts. Inside the worm, the segments are divided almost completely from each other by walls of tissue, similar to the way that walls separate the segments of a submarine. Each segment contains structures for digestion, excretion, and locomotion. The fluid within the coelom of each segment makes a rigid support system for the worm similar to the rigidity of a filled water balloon.

This rigidity in annelid segments creates a hydrostatic skeleton that muscles can push against. Segmentation also permits segments to move independently of each other and enables a worm to survive damage to a segment, because other segments with the same functions exist.

Virtual Lab

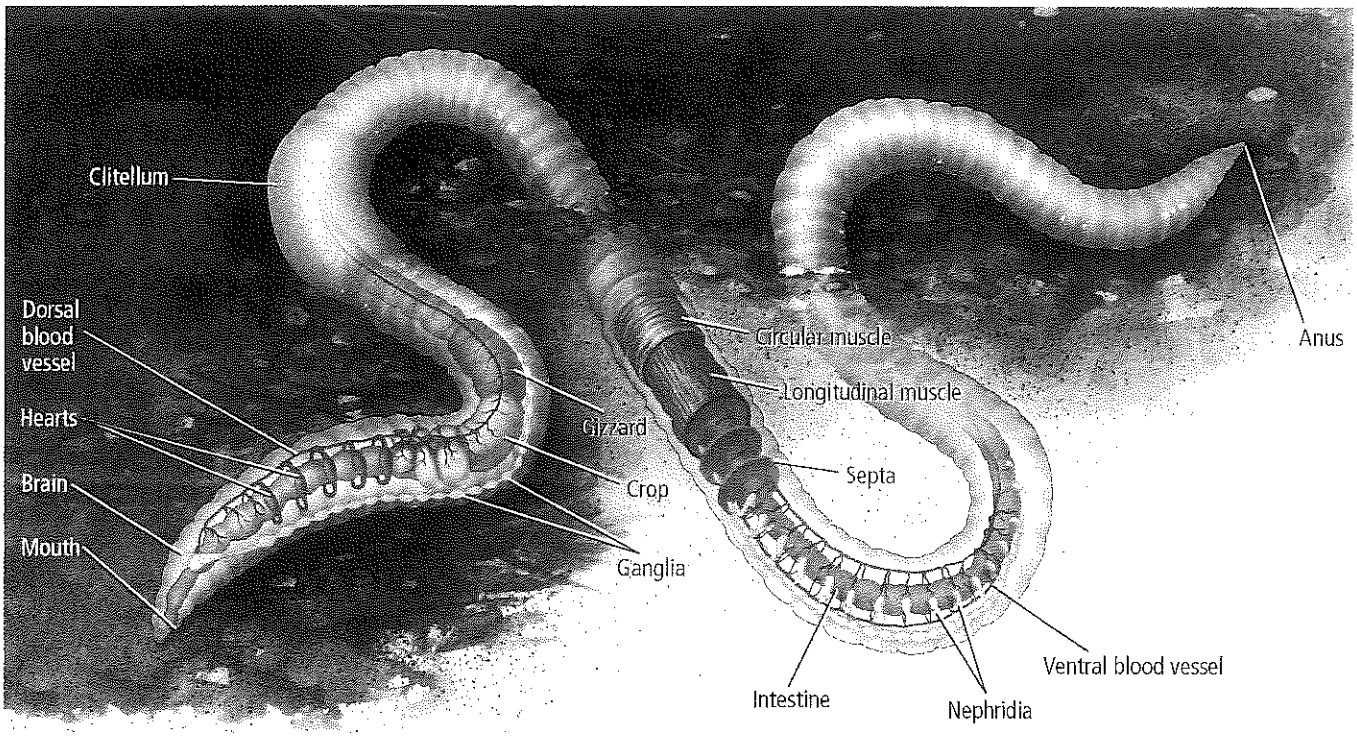
Segments can be specialized, and groups of segments might be adapted to a particular function. For example, some segments might be adapted to sensing, while others are adapted to reproduction. As you continue to study annelids, earthworms will be used to show examples of typical annelid features.

Reading Check **Explain** how segments relate to a hydrostatic skeleton.

Feeding and digestion Running through all earthworm segments from the mouth to the anus is the digestive tract, a tube within a tube. Locate the digestive tract in the earthworm in **Figure 23.** Food and soil taken in by the mouth pass through the pharynx into the **crop,** where they are stored until they pass to the gizzard. The **gizzard** is a muscular sac containing hard particles that help grind soil and food before they pass into the intestine. Nutrients are absorbed in the intestine, then undigested material passes out of the worm's body through the anus. Parasitic annelids have pouches along the digestive tract that hold enough food to last for months.

Figure 23 As an earthworm pushes through the soil, it takes soil into its mouth. Nutrients are absorbed from the organic matter in the soil as it passes through the intestine.

Animation



Circulation Unlike most mollusks, most annelids have a closed circulatory system. Oxygen and nutrients move to various parts of their bodies through their blood vessels. At the same time, carbon dioxide and metabolic wastes are removed from the blood and excreted. Some of the vessels at the anterior end, or head, are large and muscular, as shown in **Figure 24,** and serve as hearts that pump the blood. The blood moves toward the anterior end of the worm in the dorsal blood vessel and toward the posterior end in the ventral blood vessel.

Respiration and excretion Earthworms take in oxygen and give off carbon dioxide through their moist skin. Some aquatic annelids have gills for the exchange of gases in the water. Segmented worms have two nephridia–similar to those in mollusks–in almost every segment. Cellular waste products are collected in the nephridia and are transported in tubes through the coelom and out of the body. Nephridia also function in maintaining homeostasis of the body fluids of annelids, ensuring that the volume and composition of body fluids are kept constant.

Response to stimuli In most annelids, such as the earthworm, the anterior segments are modified for sensing the environment. The brain and nerve cords, composed of ganglia, are shown in the earthworm in **Figure 23.** You might have seen an earthworm quickly withdraw into its burrow when you shine a flashlight on it or step close to it. These observations show that earthworms can detect both light and vibrations.

Movement When an earthworm moves, it contracts circular muscles surrounding each segment. This squeezes the segment and causes the fluid in the coelom to press outward, like paste in a tube of toothpaste being squeezed. Because the fluid in the coelom is confined by the tissues between segments, the fluid pressure causes the segment to get longer and thinner. Next, the earthworm contracts the longitudinal muscles that run the length of its body. This causes the segment to shorten and return to its original shape, pulling its posterior end forward and resulting in movement.

Many annelids have setae on each segment. **Setae** (SEE tee) (singular, seta), as shown in **Figure 25,** are tiny bristles that push into the soil and anchor the worm during movement. By anchoring some segments and retracting others, earthworms can move their bodies forward and backward, segment by segment.

Reading Check **Describe** how longitudinal and circular muscles work together to enable an earthworm to move.

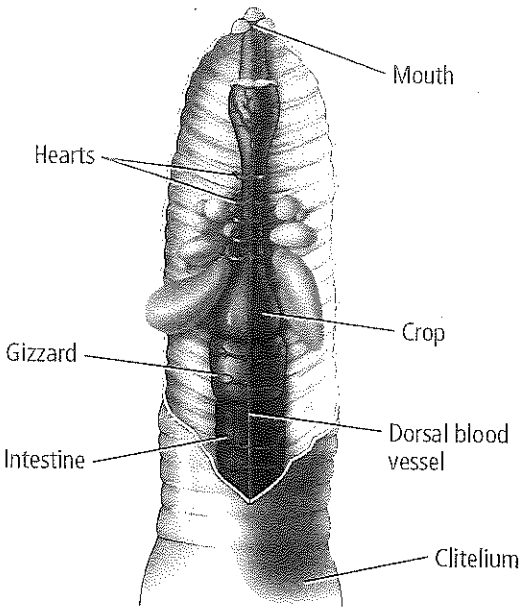


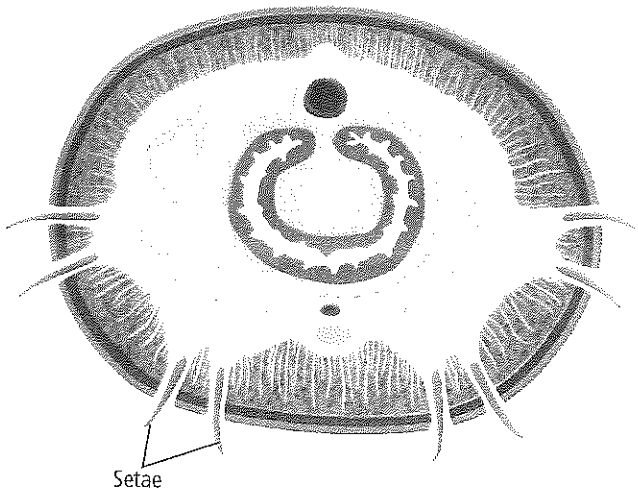
Figure 24 An earthworm has five hearts that pump blood through its circulatory system.

Launch Lab

Review **Based on what you've read about earthworm movement, how would you now answer the analysis questions?**

Figure 25 This earthworm cross section shows how the setae extend from the body. Setae dig into soil and anchor the worm as it pushes forward.

Evaluate ***whether an earthworm would move faster on a rough or a smooth surface.***



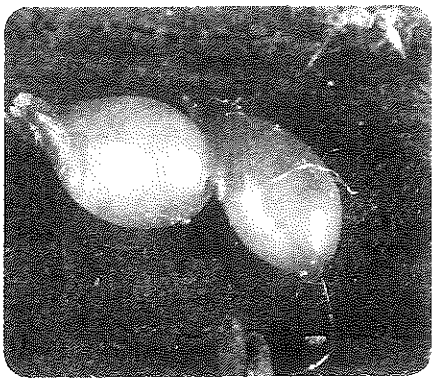


Figure 26 After developing in the cocoon for two to three weeks, a young earthworm hatches.

Reproduction Annelids can reproduce both sexually and asexually. Most annelids have separate sexes, but some, such as earthworms and leeches, are hermaphrodites. Sperm are passed between two worms near segments called the clitella (singular, clitellum). Refer to **Figure 23** and notice that the **clitellum** is a thickened band of segments. It produces a cocoon, like the one shown in **Figure 26,** from which young earthworms hatch. Sperm and eggs pass into the cocoon as it slips forward off the body of the worm. After fertilization, the young are protected in the cocoon as they develop. Some annelids reproduce asexually by fragmentation. If a worm breaks apart, the missing parts can be regenerated.

Diversity of Annelids

The phylum Annelida is divided into three classes: class Oligochaeta (ohl ih goh KEE tuh)–the earthworms and their relatives, class Polychaeta (pah lih KEE tuh)–the bristleworms and their relatives, and class Hirudinea (hur uh DIN ee uh)–the leeches.

Earthworms and their relatives Earthworms probably are the best-known annelids. They are used as bait for fishing and are found in garden soil. An earthworm can eat its own mass in soil every day. Earthworms ingest soil to extract nutrients. In this way, earthworms aerate the soil–they break up the soil to allow air and water to move through it.

FOLDABLES
Incorporate information from this section into your Foldable.

In addition to earthworms, class Oligochaeta–the oligochaetes (AH lee goh keetz)–includes tubifex worms and lumbriculid worms. Tubifex worms are small, threadlike aquatic annelids that are common in areas of high pollution. Lumbriculid (lum BRIH kyuh lid) worms are freshwater oligochaetes that are about 6 cm long and live at the edges of lakes and ponds. You can observe a feature common to oligochaetes in **MiniLab 2.**

MiniLab 2

MiniLab

Observe Blood Flow in a Segmented Worm

How does blood flow in a segmented worm? The California blackworm has a closed circulatory system and a transparent body. Its blood can be viewed as it flows along the dorsal blood vessel.

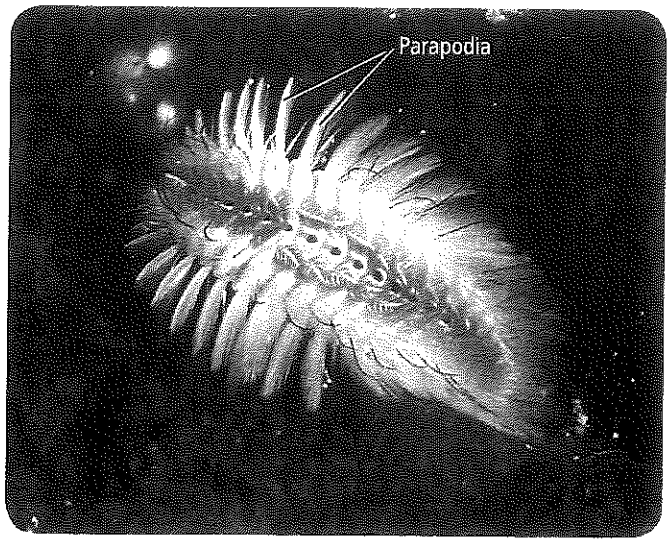
Procedure

1. Read and complete the lab safety form.
2. Moisten a piece of **filter paper** with **spring water** and place it in a **Petri dish.**
3. Examine a **blackworm** on the moist paper using a **stereomicroscope.**
4. Locate the dorsal blood vessel in a segment near the midpoint of the worm. Observe how blood flows in each segment.
5. Use a **stopwatch** to record how many pulses of blood occur per minute. Repeat this for two more segments, one near the head and one near the anus of the worm. Record your data in a table.

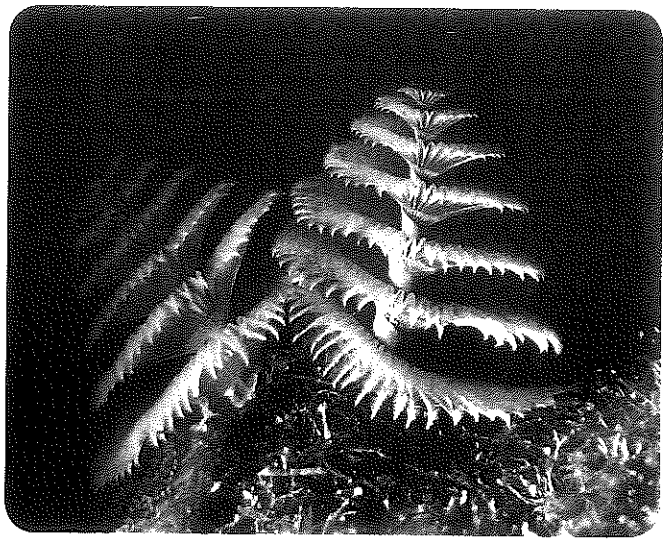
Analysis

1. **Summarize** how blood moves through each segment, including the direction of blood flow.
2. **Compare and contrast** the rate of blood flow near the head, at the midpoint, and near the anus of the worm.

blickwinkel/Alamy



Bristleworm



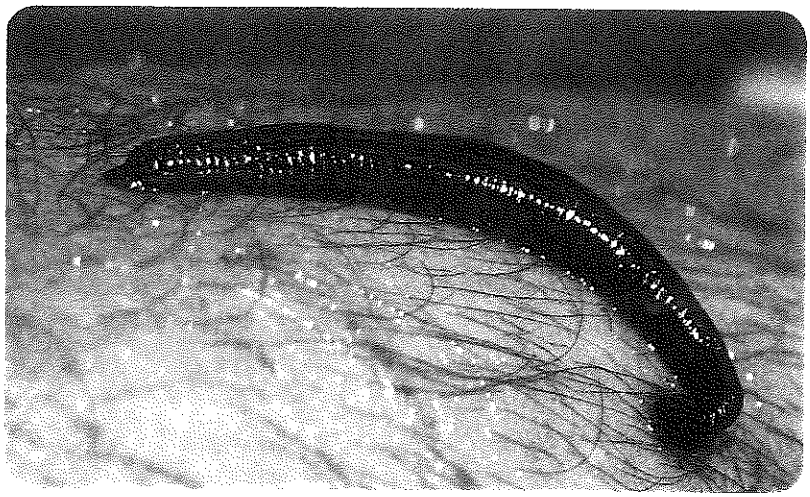
Fan worms

Figure 27 Note the paddlelike parapodia on the bristleworm, which are used for swimming and crawling. Fan worms withdraw quickly into their tubes when there is a disturbance in the water.

Marine annelids Polychaetes (PAH lee keetz), which belong to class Polychaeta, mainly are marine animals. They include bristleworms and fan worms, shown in **Figure 27.** Polychaetes have head regions with well-developed sense organs, including eyes. Most body segments of polychaetes have many setae. Most body segments also have a pair of appendages called parapodia, shown in **Figure 27,** which are used for swimming and crawling. Fan worms are sessile—they stay in one place—and are filter feeders. They trap food in the mucus on their fan-shaped structures. If there is a threat nearby, fan worms retreat into their tubes.

Leeches As shown in **Figure 28,** leeches in class Hirudinea are external parasites with flattened bodies and usually have no setae. Most leeches live in freshwater streams or rivers, where they attach to the bodies of their hosts—including fishes, turtles, and humans. Leeches attach to their hosts using front and rear suckers. When a leech bites, its saliva contains chemicals that act as an anesthetic. Other chemicals in the saliva reduce swelling and prevent the host's blood from clotting.

Reading Check **Describe** the habitats of the three classes of annelids.



Leech

Figure 28 A leech uses its suckers to attach to its host and feeds by drawing blood into its muscular pharynx.
Compare and contrast *the feeding methods of leeches and tapeworms.*

Ecology of Annelids

Segmented worms play important roles in the ecology of ecosystems. Some are beneficial to plants and animals, while others benefit humans.

Earthworms Many different animals, including frogs and birds, eat earthworms as a part of their diets. Earthworms also mix leaf litter into soil, aerating it so that roots can grow easily and water can move through the soil efficiently. Both functions are important for healthy ecosystems. However, nonnative earthworms are moving into areas, especially northern forests, where they are altering ecosystems in harmful ways. The consumption of leaf litter on forest floors by nonnative earthworms removes the shelter and moisture needed by many native plants and animals. Earthworms can be introduced into new habitats inadvertently by fishers and gardeners when the earthworms left from a day's fishing are dumped on the ground, or when a nursery plant from another part of the country is planted in a home garden.

Polychaetes Marine polychaetes help convert the organic debris of the ocean floor into carbon dioxide. Marine plant plankton take in carbon dioxide and use it during photosynthesis. Marine polychaetes are an important part of the diet of many marine predators.

Hirudinea Leeches have been used as medical treatments for centuries. They were used to suck blood out of patients who were believed to be ill because of an excess of blood. Today, leeches are used after microsurgical procedures to prevent blood from accumulating in the surgical area. However, there are drawbacks to using leeches. They have a small feeding capacity and must be replaced often. They can cause bacterial infections, and many people cringe at the thought of having a leech attached to them. To solve these problems, a nonliving mechanical leech has been designed to do the work of the animal. **Table 1** summarizes the ecological benefits of earthworms, polychaetes, and leeches.

Reading Check **Evaluate** the effects of removing polychaetes from oceans.

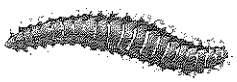
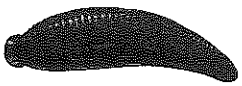
VOCABULARY

ACADEMIC VOCABULARY

Convert
to change from one form to another
Through photosynthesis, plants convert water and carbon dioxide to sugar and oxygen.

Table 1 Ecological Importance of Annelids

Interactive Table

Type of Annelid	Example	Characteristics	Habitat	Ecological Benefit
Earthworms		• Few setae on most body segments	Terrestrial	• They aerate soil so roots can grow more easily and water can move efficiently. • They are food for many different animals.
Polychaetes		• Well-developed sense organs • Many setae on most body segments • Parapodia	Mainly marine	• They convert organic debris in oceans into carbon dioxide, which is used by marine plankton for photosynthesis.
Leeches		• Usually no setae on body segments • Front and rear suckers	Mainly freshwater	• They maintain blood flow after microsurgery.

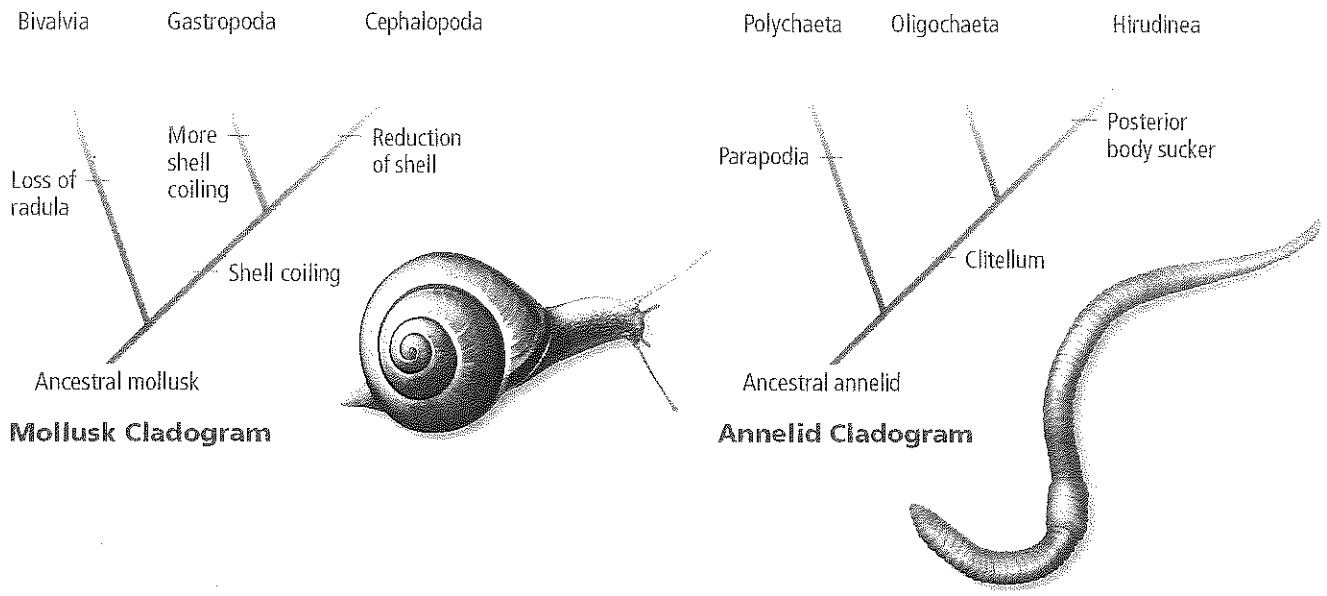


Figure 29 These cladograms show how mollusks and annelids might have evolved.

Evolution of Mollusks and Annelids

In **Figure 29,** the cladogram on the left is one interpretation of the evolution of mollusks. As shown, gastropods have more shell coiling than cephalopods do. In shell coiling, the shell grows in a circular manner, making it more compact and more stable than an uncoiled shell. Cephalopods have a reduced shell. Bivalves are considered to have evolved later than gastropods and cephalopods because they lack a radula.

The cladogram on the right in **Figure 29** is one interpretation of the evolution of annelids. In this interpretation, early segmented worms–the polychaetes–developed parapodia in the course of their evolution. Later annelids–the oligochaetes and leeches–developed clitella. Leeches developed posterior body suckers even later.

Section 4 Assessment

Section Summary

- Two main body features characterize annelids and distinguish them from roundworms and flatworms.
- There are three main classes of annelids based on distinctive features.
- Segmentation is an adaptation important to evolution.
- Annelids are important parts of terrestrial and marine habitats.

Understand Main Ideas

1. MAIN IDEA **Summarize** how segmentation was an important evolutionary milestone.
2. **Compare and contrast** earthworms to flatworms and roundworms.
3. **Model** Using clay or salt dough, make models of typical examples from the three classes of annelids. Describe the adaptations that enable each annelid to live in its environment.
4. **Summarize** how earthworm muscles interact to cause movement.

Think Critically

5. **Hypothesize** Form a hypothesis about what might happen to a farm field if earthworms suddenly disappeared.
6. **Compare and contrast** circulation in annelids and mollusks.

WRITING in Biology

7. Write a paragraph explaining why leeches might be used after microsurgical procedures based on what you know about leech saliva.

Online Quiz

In the Field

Career: Marine Biologist

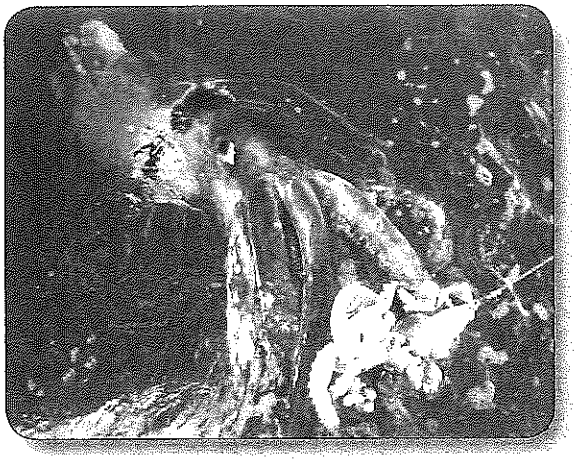
The Search for the Giant Squid

For centuries, sailors told stories of encounters with fearsome monsters while on long sea voyages. Today, scientists acknowledge that two species of squid might be the real-life animals lurking behind the old sailors' tales. The giant squid *(Architeuthis dux)* and colossal squid *(Mesonychoteuthis hamiltoni)* are rarely seen in the wild because they live at extreme depths. Most specimens studied by scientists were washed up on beaches or caught in deep-sea fishing nets.

Marine biologist Steve O'Shea discovered that giant squid can grow up to 12.8 meters in length. They are thought to be the largest invertebrates in the world. Colossal squid are shorter but often weigh more than giant squid. Both species have eight arms and two tentacles covered with sucker rings or hooks for catching prey.

On a research expedition in 2000-2001, O'Shea sailed the waters around South Island, New Zealand. He searched for larval giant squid, which are 9 to 13 mm in size. He intended to raise the squid in captivity to study its life cycle. Although he caught several larval giant squid, none have survived in captivity.

Other scientists have made breakthroughs in the study of giant squid. In September 2004, a ship crewed by two Japanese scientists followed a group of sperm whales, known predators of giant squid, to a spot about 600 miles southeast of Tokyo. The scientists, Tsunemi Kubodera and Kyoichi Mori, lowered a baited fishing line into the ocean and waited.



This image, taken by Japanese scientists in 2006, shows a giant squid as it is hauled on board a research vessel.

Koji Sashara/AP Images

When a giant squid took the bait, they raised the line and took photos of the squid as it struggled to free itself. The 25-foot-long squid eventually tore itself free, but it left behind one of its tentacles, which scientists later studied.

As O'Shea, Kubodera, and other scientists continue to search for and study giant and colossal squid, they likely will add to our knowledge of these animals. This new knowledge will bring them from the realm of myths into the light of scientific inquiry.

VISUAL COMMUNICATION

Make a Model Research the structure of either the giant squid or the colossal squid. Create a model that accurately shows prey-catching structures and body proportions. Present your model to the class.

WebQuest

BIOLAB

HOW DO WORMS AND MOLLUSKS MOVE?

Background: **The worm and mollusk phyla display wide diversity in behavior and physical characteristics. Throughout this chapter, you have been introduced to some of the various species that make up these phyla. In this lab, you will compare the form of movement used by a flatworm (a planarian), a roundworm (a vinegar eel), a mollusk (a land snail), and a segmented worm (a blackworm).**

Question: *What kind of motion do worms and mollusks display?*

Materials

plastic droppers (2)
petri dish (1 or 2)
microscope slide (1 or 2)
coverslip (1 or 2)
500-mL beaker
magnifying lens
dissecting microscope
light microscope
spring water or aged tap water (500 mL)
live cultures of planaria, vinegar eels, land snails, and blackworms

Safety Precautions

WARNING: ***Be sure to treat live animals in a humane manner at all times. Use caution when working with a microscope, glass slides, and coverslips.***

Procedure

1. Read and complete the lab safety form.
2. Create a data table to record your observations.
3. Observe the movement of a flatworm by placing it in a drop of water in a petri dish or on a slide with no coverslip.
4. Make a wet mount of a vinegar eel and observe its movement under low-power magnification.
5. Place a land snail on a petri dish. Gently tip the dish to observe the snail's movement from underneath.
6. Place a blackworm on a moist paper towel and observe it with a magnifying lens.
7. Place the blackworm in a beaker of aged tapwater and observe its movement.
8. Record your observations in your data table.
9. **Cleanup and Disposal** Wash reusable materials and place them where your teacher directs. Return all live specimens to the cultures provided by your teacher.

Analyze and Conclude

1. **Compare and contrast** the movements of the flatworm, roundworm, land snail, and segmented worm.
2. **Infer** how the forms of the flatworm, roundworm, land snail, and segmented worm are designed to enable the animals to move.
3. **Describe** what happens to each segment of the blackworm as it crawls on land.
4. **Compare** the forward and backward motion of the blackworm on land. How might this be an adaptation for survival?
5. **Infer** how the blackworm might be able to escape from predators in the water.

APPLY YOUR SKILL

Experiment Design an experiment that you could perform to investigate how temperature affects worm and mollusk movement. If you have all the materials you will need, you might want to conduct the experiment.

Chapter 25 Study Guide

THEME FOCUS Energy and Matter All worms obtain energy from other organisms, though some worms are parasitic and others are free-living.

BIG Idea Worms and mollusks have evolved to have a variety of adaptations for living as parasites or for living in water or soil.

Section 1 Flatworms

pharynx (p. 727)
flame cell (p. 727)
ganglion (p. 728)
regeneration (p. 728)
scolex (p. 730)
proglottid (p. 730)

BIG Idea Flatworms are thin, flat, acoelomate animals that can be free-living or parasitic.

- Flatworms were among the first animals to exhibit bilateral symmetry.
- Flatworms are acoelomates with limited numbers of organs and systems.
- Some flatworms are free-living, and others are parasitic.
- Flatworms that are parasitic have specialized adaptations for parasitic life.

Section 2 Roundworms and Rotifers

hydrostatic skeleton (p. 732)
trichinosis (p. 733)

BIG Idea Roundworms and rotifers have a more highly evolved gut than flatworms.

- Roundworms are closely related to flatworms.
- Roundworms, like flatworms, have a limited number of organs and systems.
- Roundworms are either free-living or parasitic.
- Roundworms cause many human and plant diseases.
- Rotifers are pseudocoelomates that appear on a different branch of the evolutionary tree from that of roundworms.

Section 3 Mollusks

mantle (p. 737)
radula (p. 738)
gill (p. 738)
open circulatory system (p. 739)
closed circulatory system (p. 739)
nephridium (p. 739)
siphon (p. 741)

BIG Idea Mollusks are coelomates with a muscular foot, a mantle, and a digestive tract with two openings.

- Mollusks were the first animals in the course of evolution to develop a coelom.
- Mollusks are divided into three main classes based on different characteristics.
- Mollusks have two body features that no other animals have--a mantle and a muscular foot.
- Mollusks have more developed organ systems than those of roundworms and flatworms.
- Mollusks play important roles in the ecosystems in which they live.

Section 4 Segmented Worms

crop (p. 746)
gizzard (p. 746)
setae (p. 747)
clitellum (p. 748)

BIG Idea Segmented worms have segments that allow for specialization of tissues and for efficiency of movement.

- Two main body features characterize annelids and distinguish them from roundworms and flatworms.
- There are three main classes of annelids based on distinctive features.
- Segmentation is an adaptation important to evolution.
- Annelids are important parts of terrestrial and marine habitats.

Vocabulary eGames

Chapter 25 Assessment

Section 1

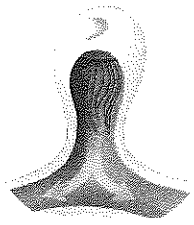
Vocabulary Review

Use what you know about the vocabulary terms found on the Study Guide page to answer the following questions.

1. What is a group of nerve cell bodies that coordinates ingoing and outgoing messages?
2. What is a tubelike muscular organ that releases digestive enzymes?
3. What structure attaches to the intestinal lining of a host with hooks and suckers?

Understand Main Ideas

Use the diagram below to answer question 4.



4. What function does the structure in the diagram perform?
   - A. digestion
   - B. movement
   - C. maintains homeostasis
   - D. provides support
5. Which animals have proglottids?
   - A. flukes
   - B. planarians
   - C. tapeworms
   - D. roundworms
6. Which classification fits a flatworm that is free-living?
   - A. Turbellaria
   - B. Cestoda
   - C. Trematoda
   - D. Nematoda
7. Which is not involved in planarian movement?
   - A. cilia
   - B. muscles
   - C. mucus
   - D. flame cells

Constructed Response

8. **Open Ended** A certain tapeworm secretes a chemical that slows the intestinal pulsations of its host. This helps to ensure that the tapeworm is not expelled from the body of the host. Explain how adding this chemical to a drug for humans might increase the drug's effectiveness.
9. Design a parasitic worm for an animal that lives in the desert. Remember to consider how the animal will contract the parasite and how the parasite will stay within its host.

Think Critically

10. **THEME FOCUS Energy and Matter** Design an experiment that could determine what a planarian prefers to eat.

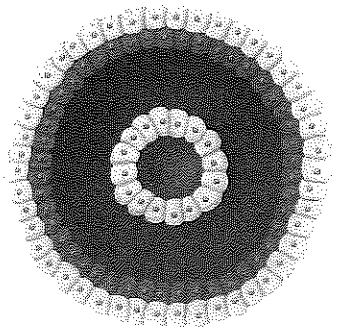
Section 2

Each of the following sentences is false. Make each sentence true by replacing the italicized word with a vocabulary term from the Study Guide page.

11. Roundworms are bilaterally symmetrical, cylindrical, and have *segmented bodies.*
12. *Schistosomiasis* can be prevented by cooking meat properly.
13. A fluid-filled space that provides rigid suppor for muscles to work against is an exoskeleton.

Understand Main Ideas

Use the diagram below to answer questions 14 and 15.



14. Which feature of roundworms is illustrated in the diagram above?
   - A. pseudocoelom
   - B. scolex
   - C. circulatory system
   - D. nervous system
15. The feature in the diagram led to which adaptation in roundworms?
   - A. a coelom
   - B. a gut
   - C. a mantle
   - D. segments

Chapter 25 Assessment

Constructed Response

16. **Short Answer** Make a diagram that shows the life cycle of a beef tapeworm.

17. **Open Ended** Select a human parasite and indicate with a key on a map of the world where the parasite is most common. Research online to find information.

Think Critically

18. **Concept Mapping** Make a concept map that uses the following words: nematode, pseudocoelomate, digestive tract with two openings, parasitic, free-living, lengthwise muscles, host.

19. **Key Idea** Suppose that you find a tiny worm in the garden. How could you determine whether it is a flatworm or a roundworm?

Section 3

Vocabulary Review

An analogy is a comparison relationship between two pairs of words and can be written in the following manner: A is to B as C is to D. In the analogies that follow, one of the words is missing. Complete each analogy with a vocabulary term from the Study Guide page.

20. Kidney is to metabolic waste as _____ is to cellular waste.

21. Tongue is to candy as _____ is to algae.

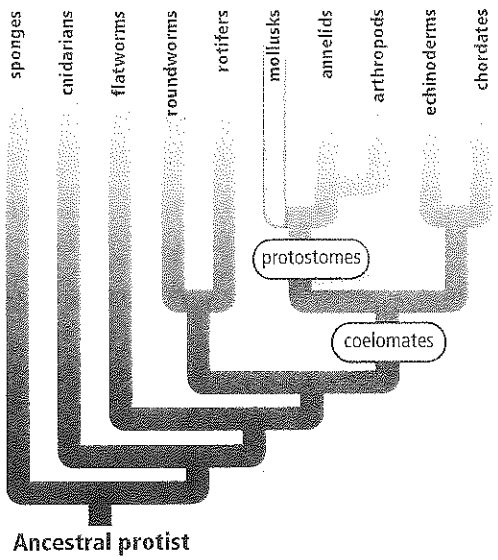
22. Legs are to running as _____ is to jet-propelled swimming.

Understand Main Ideas

23. If the mantle of a bivalve was damaged, the bivalve would not be able to perform which function?
   A. maintain its shell
   B. digest food
   C. circulate blood
   D. excrete wastes

24. Which word pair is related most closely?
   A. shell, circulation
   B. radula, feeding
   C. jet-propelled swimming, bivalve
   D. open circulatory system, octopus

Use the diagram below to answer questions 25 and 26.



25. **Key Idea** The phylogenetic tree of animals shows that mollusks have which feature?
   A. a pseudocoelom
   B. a coelom
   C. a solid body
   D. shells

26. Which group is related most closely to mollusks?
   A. nematodes
   B. enchinoderms
   C. annelids
   D. chordates

Constructed Response

27. **Open Ended** Make a dichotomous key to identify mollusk shells that you find in pictures in books about animals, shells that you have collected, or shells that your teacher supplies.

Think Critically

28. **CAREERS IN BIOLOGY** Marine biologists know that zebra mussels are pests in many aquatic ecosystems. They form ultradense colonies and can clog pipes leading to water-treatment and industrial plants. However, some marine biologists hypothesize that because the mussels live in such dense groups, they might serve as water-purification systems in places such as zoo ponds and other park ponds that have excessive algal blooms in the summer. Design an experiment that would determine whether zebra mussels could be used to purify water.

Online Test Practice

Section 4

Vocabulary Review

An analogy is a comparison relationship between two pairs of words and can be written in the following manner: A is to B as C is to D. In the analogies that follow, one of the words is missing. Complete each analogy with a vocabulary term from the Study Guide page.

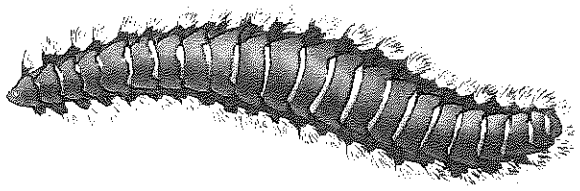
29. Teeth are to human as _____ is to earthworm.

30. Cocoon is to butterfly as _____ is to earthworm.

31. Vacuole is to protist as _____ is to earthworm.

Understand Main Ideas

Use the diagram below to answer questions 32 and 33.



32. Which animal is illustrated in the diagram?
   A. roundworm
   B. leech
   C. polychaete
   D. earthworm

33. What feature is characteristic of this animal?
   A. foot
   B. parapodia
   C. sucker
   D. shell

Constructed Response

34. THINK IDEA If global warming continues, predict how earthworms might change as a result of natural selection.

Think Critically

35. CAREERS IN BIOLOGY Rheumatologists, doctors who treat arthritis, have observed that when leeches are applied for a short time to the skin near joints of people affected with arthritis, pain is relieved for up to six months. Design an experiment that could explain this phenomenon.

Summative Assessment

36. BIG IDEA Worms have evolved to have a variety of adaptations for living as parasites or for living in water or soil. Give an example of a worm that is parasitic, a worm that lives in soil, and a worm that lives in water. Then, describe a characteristic of each that makes it well suited for that environment.

37. Draw diagrams of a typical example from each of the three classes of mollusks and label the distinctive characteristics.

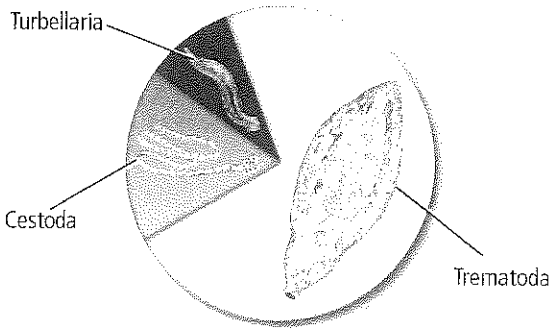
38. Suggest ways to avoid becoming the host of a flatworm.

39. WRITING IN Biology Research mollusks that live in areas of hydrothermal vents. Write a report emphasizing the differences between hydrothermal vent mollusks and those that live in the habitats you studied in this chapter.

DBQ Document-Based Questions

The data below represent the percentages of the three main classes of flatworms.

Data obtained from: Pechenik, J. 2005. *Biology of the Invertebrates.* New York: McGraw-Hill.



40. Approximately what percentage of flatworms are flukes?

41. Which group of flatworms has the least number of species?

42. Infer why there might be so many more of one kind of flatworm than any other kind.

Online Test Practice

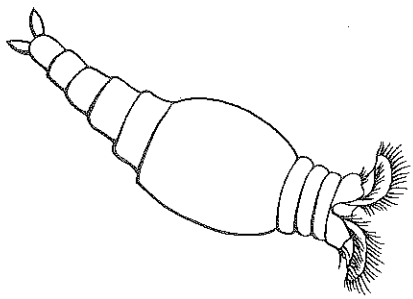
Standardized Test Practice

Cumulative

Multiple Choice

1. During dry weather, pieces of a moss might be scattered by the wind. When it rains, these pieces can grow into new plants. Which process does this display?
   A. alternation of generations
   B. gametophyte reproduction
   C. sporophyte generation
   D. vegetative reproduction

Use the diagram below to answer questions 2 and 3.



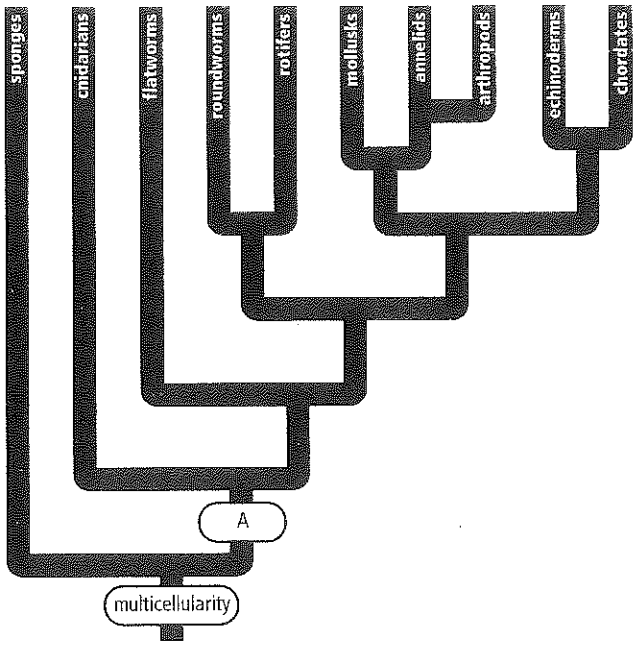
2. In which phylum does the animal shown in the figure belong?
   A. Annelida
   B. Nematoda
   C. Platyhelminthes
   D. Rotifera

3. Roundworms differ from the organism shown above because roundworms have which characteristic?
   A. a complete digestive tract
   B. the inability to live in freshwater
   C. a smaller body size
   D. a body surface covered with cilia

4. Which is one characteristic of all cnidarians?
   A. Their tentacles contain cnidocytes.
   B. Their tentacles contain fibroblasts.
   C. They live only in freshwater environments.
   D. They spend some time as sessile animals.

5. Which is an example of a nastic response?
   A. bamboo plants growing toward a light
   B. corn plant roots growing downward
   C. sunflowers tracking the Sun
   D. vines growing up a tree

Use the diagram below to answer question 6.



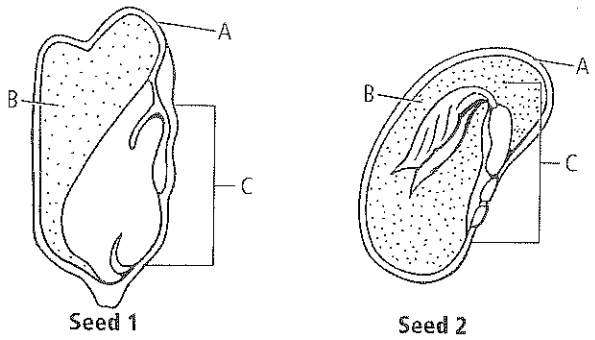
6. Which body structures are typical of all the animals above Point A on the evolutionary tree?
   A. cell walls
   B. coeloms
   C. tentacles
   D. tissues

7. How does an aggregate fruit, such as a blackberry or strawberry, form?
   A. when a flower has multiple female organs that fuse together
   B. when a fruit has multiple seeds that fuse together
   C. when multiple flowers from the same plant fuse together
   D. when multiple simple fruits fuse together

8. How do hornworts differ from other nonvascular plants?
   A. Their cells allow nutrients and water to move by diffusion and osmosis.
   B. Their cells can contain a type of cyanobacteria.
   C. They can be classified as either thallose or leafy.
   D. They have chloroplasts in some of their cells.

Short Answer

Use the diagram below to answer questions 9 and 10.



Seed 1 Seed 2

9. Name the parts of these seeds.

10. Which seed is a monocot and which is a eudicot? How do you know?

11. Explain why squids and clams are both included in phylum Mollusca even though they appear to be very different kinds of animals.

12. What is one thing that humans can do to preserve reefs? Explain your reasoning.

13. Specify an example of an ancestral character and a derived character that angiosperms have.

14. Describe the alternation of generations in plants.

15. Describe how cellular slime molds reproduce. Identify whether this process is sexual or asexual. Assess how this form of reproduction is beneficial for cellular slime molds.

Extended Response

16. List two reasons why animals benefit from segmentation. Assess the importance of these benefits.

17. Suppose that you are a scientist trying to determine the water quality of a river where mussels live. What data could you collect from the mussels to determine the quality of the river water?

Essay Question

Schistosomiasis is caused by flukes, which have complex life cycles involving specific freshwater snail species as intermediate hosts. Infected snails release large numbers of minute, free-swimming larvae (cercariae) that are capable of penetrating the unbroken skin of a human host. Even brief exposure to contaminated freshwater, such as wading, swimming, or bathing, can result in infection. Human schistosomiasis cannot be acquired by wading or swimming in salt water (oceans or seas). The cercariae of birds and aquatic mammals can penetrate the skin of humans who enter infested freshwater or salt water in many parts of the world, including cool, temperate areas. The cercariae die in the skin but may elicit a puritic rash ("swimmer's itch" or "clam-digger's itch").

Using the information in the paragraph above, answer the following question in essay format.

18. Schistosomiasis is a disease that is most common in sub-Saharan Africa, the Philippines, Northern China, and Brazil. Propose a plan to control this disease in a specific area. What steps would need to be taken to keep people from getting the disease? Develop a plan and explain it in a well-organized essay.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Review Section . . .	23.1	25.3	25.2	24.3	22.3	24.3	23.3	21.2	23.3	23.3	25.3	24.3	18.2	23.1	19.4	24.2	15.2	25.1