Section 25.3

SB1d. Explain the impact of water on life processes (i.e., osmosis, diffusion). **SB3b.** Compare how structures and function vary between the six kingdoms (archaebacteria, eubacteria, protists, fungi, plants, and animals). **Also covers: SCSh9c**

Objectives

- **Evaluate** the importance of the coelom to mollusks.
- **Interpret** the function of the mantle and its adaptive advantage to mollusks.
- **Analyze** 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

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.

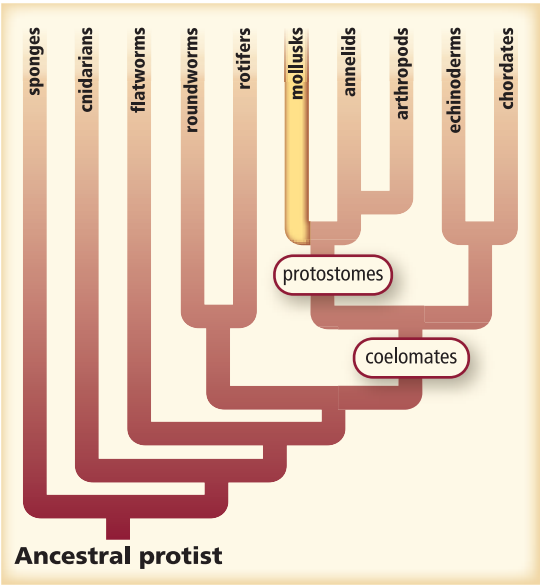
Body Structure

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.

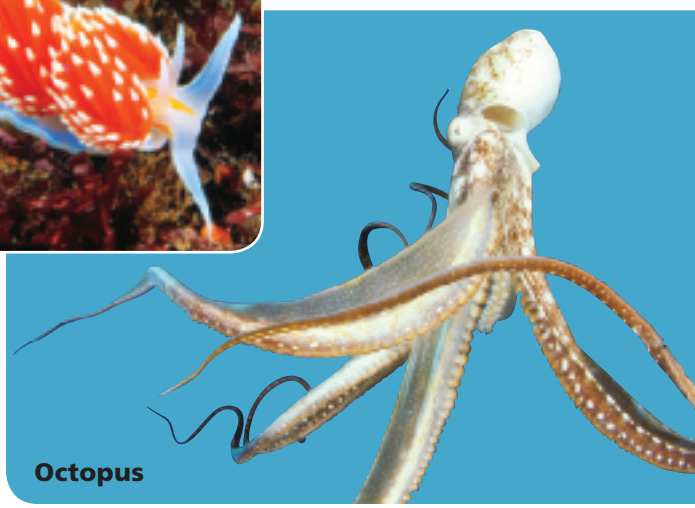
Look at the evolutionary tree in **Figure 25.13.** Mollusks, such as the nudibranch and the octopus in **Figure 25.13,** undergo protostome development and might have been the first animals in the course of evolution to have a coelom, which allowed for the development of more complex tissues and organs. There are more than 110,000 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.

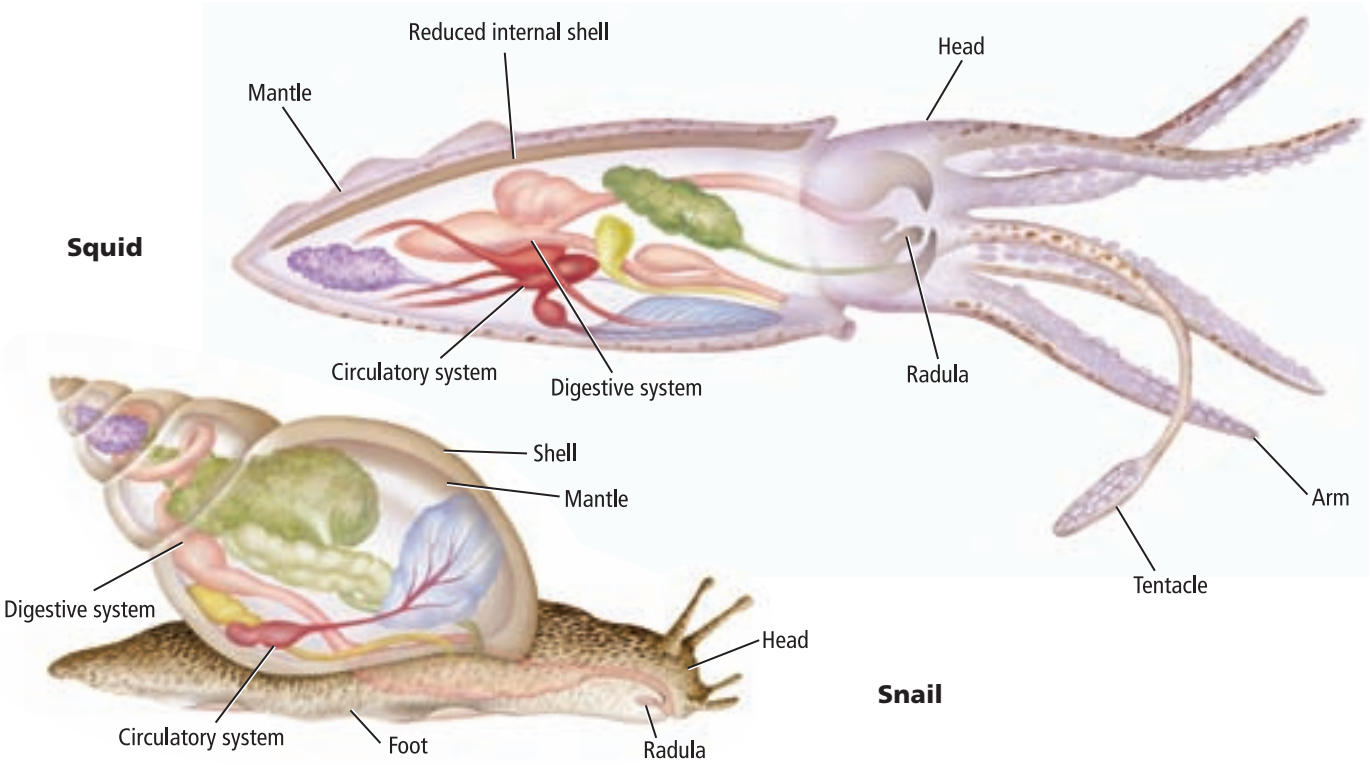
Figure 25.13 Mollusks, like the nudibranch and octopus, have coeloms.
Infer *What is the main difference between mollusks and roundworms based on the evolutionary tree?*




Nudibranch


Octopus

(l)age fotostock/SuperStock, (r)OSF/D. Fleetham/Animals Animals



■ **Figure 25.14** 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.***

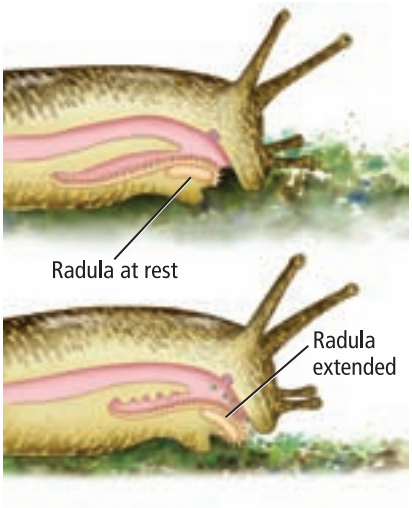
Compare the bodies of the snail and the squid in **Figure 25.14.** Their external features are very different from each other. However, both have coelomate body plans and highly evolved body systems, such as the digestive system, respiratory system, circulatory system, and nervous system.

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 25.15.** 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 25.16.** 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 25.15** Many mollusks feed using a radula. At top, the radula is at rest. At 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 25.16,** are parts of the mantle that consist of a system of filamentous projections 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 the octopus and squid, 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 25.16.** 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 a brain. 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. For more information on biology careers, visit biologygmh.com.

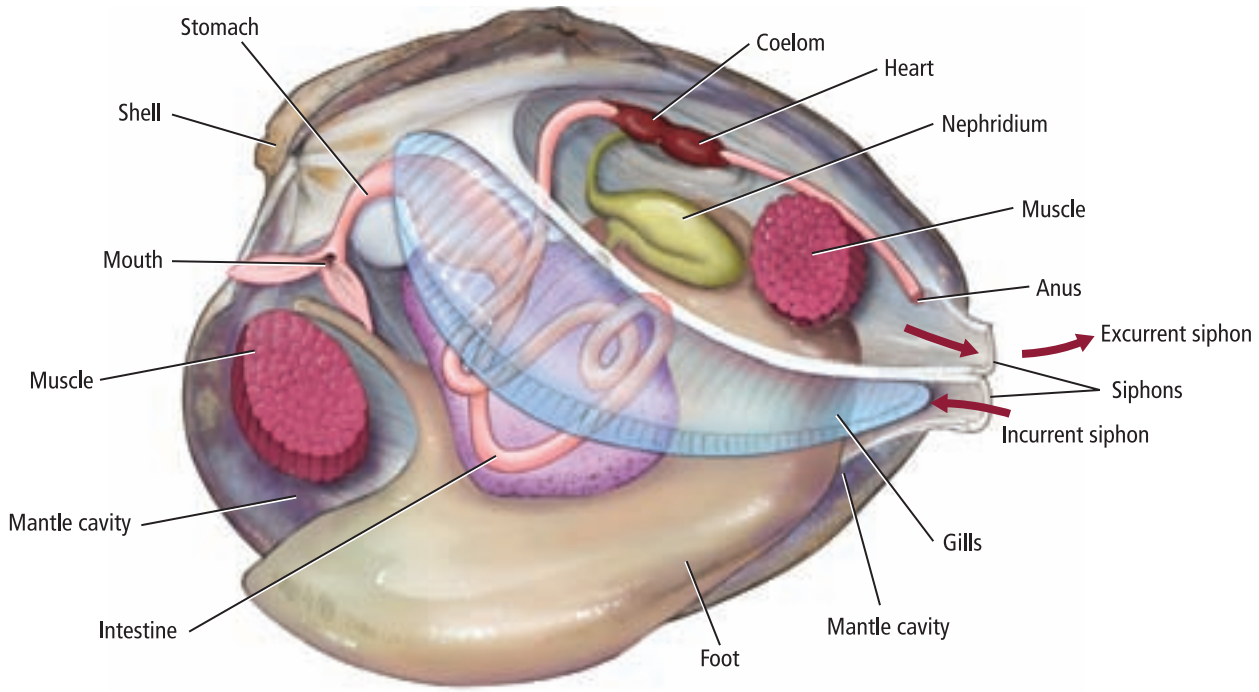


Figure 25.16 The internal anatomy of a clam illustrates the well-developed organ systems in mollusks.

NATIONAL GEOGRAPHIC

Visualizing Movement in Mollusks

Figure 25.17
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.

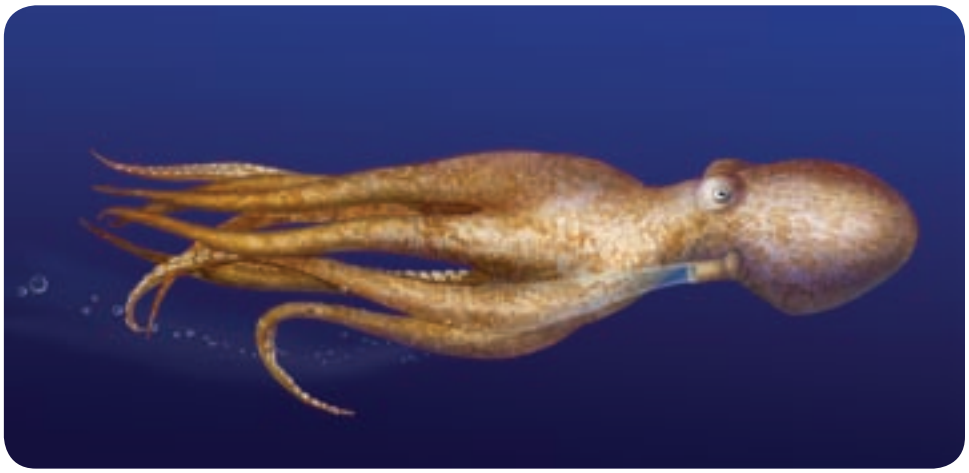
Bivalves

Most bivalves don't 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 Cephalopods, 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.

Interactive Figure To see an animation of mollusk movement, visit biologygmh.com

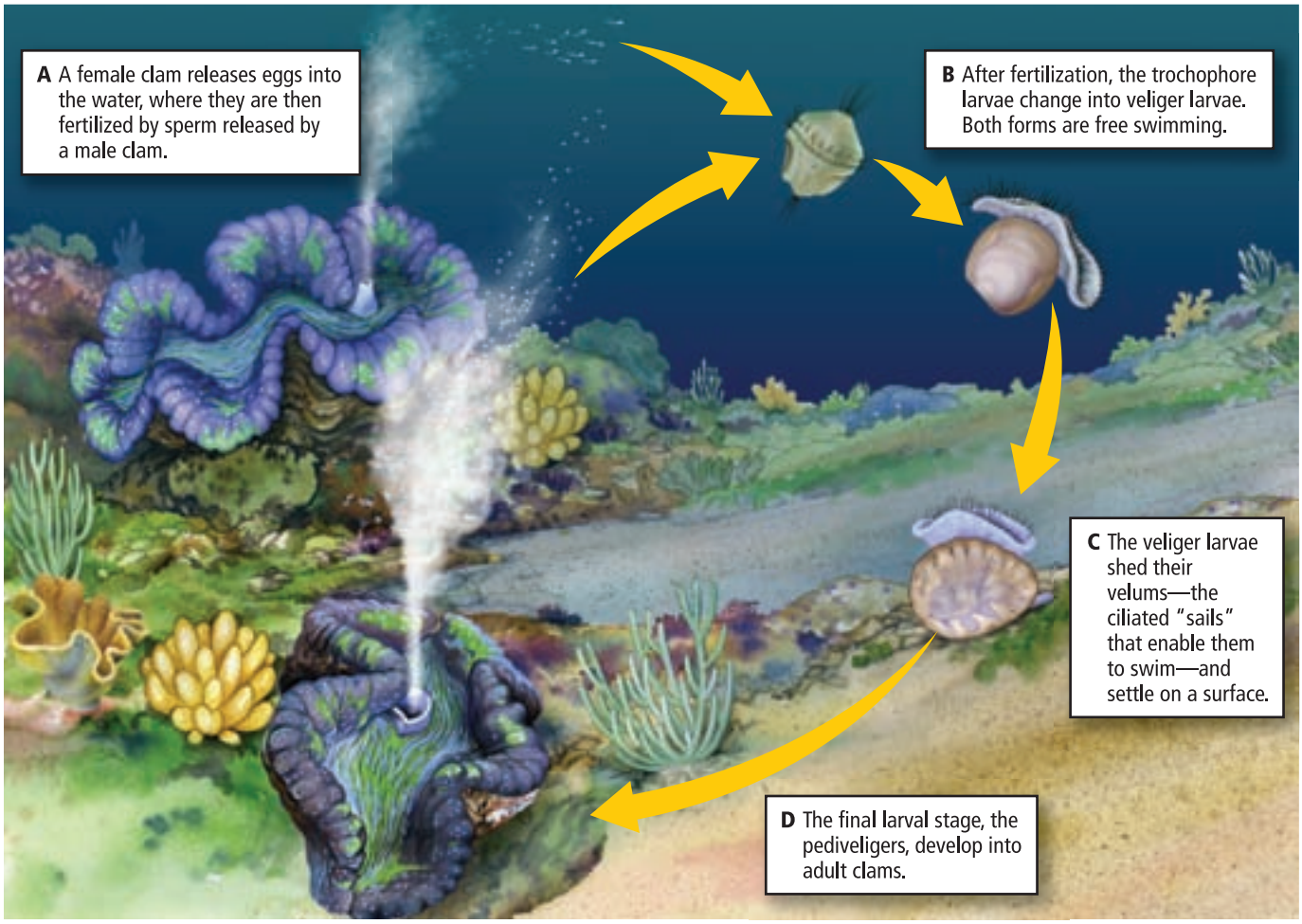
Movement The muscular foot of a clam enables it to burrow into wet sand. Mollusks with two shells can clap their shells together for short bursts of rapid swimming. Most slugs and snails creep along moist areas on a slime trail of mucus secreted by glands in the foot. Octopuses and squids take water 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 25.17** illustrates the ways mollusks move.

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

Reproduction Mollusks reproduce sexually, as illustrated in **Figure 25.18.** 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 (TRAH kuh for)—looks very similar to the larval stage of the next group of animals you will study—the segmented worms. Because the larval forms are similar in both segmented worms and mollusks, scientists hypothesize that segmented worms and mollusks are closely related.

Figure 25.18 The life cycle of a clam illustrates the characteristic developmental stages of all mollusks.



Abalone

Scallop

(l)age fotostock/SuperStock, (r)Andrew J. Martinez/Photo Researchers

■ **Figure 25.19** 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 25.19.** 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 threatened.

Slugs and nudibranchs do not have shells, but 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.

Vocabulary

Word origin

Gastropod

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

–pod suffix; from Greek, meaning *foot.*

Bivalves One word—slow—best describes most behavior of the class Bivalvia—the two-shelled mollusks. Bivalves, such as clams, mussels, oysters, and the scallop shown in **Figure 25.19,** are all aquatic animals. Most are marine, but some are found in freshwater habitats. Bivalves might seem to be inactive even though 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 the 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.

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 the squid, octopus, chambered nautilus, and the cuttlefish in **Figure 25.20.** 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 seen from above, while the white bottom of the shell blends in with the water above when 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 25.2** to study this phenomenon.

Georgette Douwma/Photo Researchers

Cuttlefish

Figure 25.20 Cuttlefish have eight arms and two tentacles. The tentacles often are not visible because they are withdrawn into pouches under the eyes.

Compare *What other differences do you see between cephalopods and gastropods?*

DATA ANALYSIS LAB 25.2

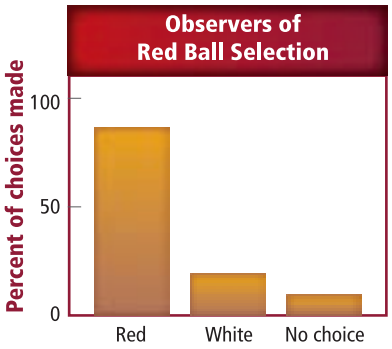
Based on Real Data*

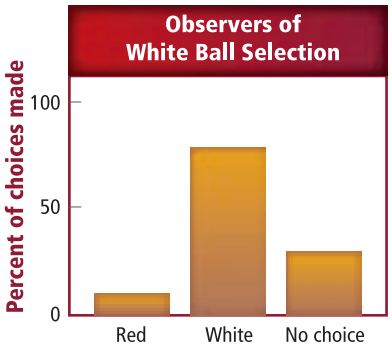
Interpret the Data

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 the Data** How many octopuses selected the red ball or the white ball after observing the red ball being selected?
2. **Analyze the Data** How many 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.

Gary Meszaros/Photo Researchers

■ **Figure 25.21** 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 25.21,** are highly prized by collectors for the beauty of their shells and, as a result, might be close to extinction.

Connection to Health 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. Pearl producers implant pieces of shell or tiny plastic spheres in oysters and harvest cultured pearls in about five to seven years.

Section 25.3 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 well-developed organ systems than roundworms and flatworms.
- Mollusks play important roles in the ecosystems in which they live.

Understand Main Ideas

1. MAIN Idea **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 Scientifically

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.