



10 Crustaceans

When you have finished this chapter, you should be able to:

LIST the basic characteristics of the crustaceans.

DESCRIBE the structures and functions of lobsters and crabs.

IDENTIFY important features of the smaller crustaceans and other marine arthropods.

10.1 Introduction to Crustaceans: The Lobster

10.2 Another Important Crustacean: The Crab

10.3 Diversity Among Crustaceans: The Shrimp and Others

10.4 Diversity Among the Arthropods

Hiding in the recesses of a rocky shoreline is a northern lobster, ready to grab its next meal with its strong claws. The lobster's claws, and the rest of its body covering, are composed of a tough fibrous material. This outer skeleton is like a suit of armor that protects the lobster.

Other animals with tough outer skeletons include such diverse forms as crabs, shrimps, barnacles, spiders, and insects. These animals also have numerous segmented legs, or appendages, which they use for locomotion and food-getting. Numbering more than a million species, and found both on land and in water, this largest group of animals is classified as the phylum Arthropoda.

With their tough body covering and movable appendages, lobsters and other members of this phylum can move about with some degree of security. In this chapter, you will learn how the marine arthropods have successfully adapted to life in the sea.

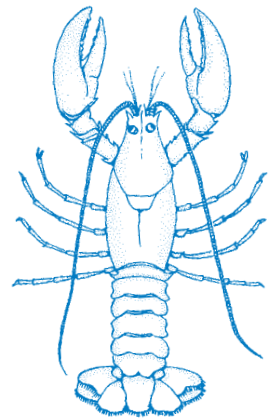
10.1 INTRODUCTION TO CRUSTACEANS: THE LOBSTER

Members of phylum Arthropoda are commonly called the **arthropods** (meaning “jointed feet”). The characteristic movable limbs, which give the phylum its name, are referred to as jointed appendages. The tough body covering, or outer skeleton, is the animal’s **exoskeleton**. It is made of **chitin**, a type of carbohydrate. Chitin varies from flexible to hard in different arthropod species. The exoskeleton functions not only as a protective cover for arthropods but also as a place of attachment for their muscles. The arthropods are so diverse in appearance that scientists differ on whether to divide the group into several classes, subphyla, or completely separate phyla. For our purposes, we refer to the major subdivisions as classes, the most important in marine habitats being the class Crustacea (meaning they have a “crust” or “shell”).

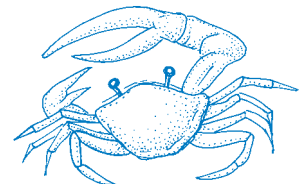
Crustacean Features

Look at the lobster and crab illustrated in Figure 10-1. What do the two animals have in common? These sea creatures are **crustaceans**, animals that have a hard outer covering. The bodies of these crustaceans have bilateral symmetry and are divided into two main segments—the **cephalothorax** (which comprises the head and chest regions) and the abdomen (including a tail, if present). The part of the exoskeleton that covers the head and chest regions is called the **carapace**. Crustaceans such as lobsters, crabs, and shrimps have five pairs of legs located under their carapace. Therefore, they are referred to as the decapods (meaning “ten legs”). The claws, which are used in food-getting, are the first pair of legs; the four other pairs are the walking legs. The head contains two eyes, two pairs of antennae, and special mouthparts used for feeding. The thorax contains the food-getting appendages and the walking legs. Some crustaceans, such as the lobster, can glide along the sea bottom by using their small paddlelike appendages, called **swimmerets**, which are located under the abdomen.

How does a crustacean grow, if it is encased in a rigid exoskeleton? Crabs, lobsters, and shrimps shed their outer covering once or more



Northern lobster



Fiddler crab

Figure 10-1 Typical crustaceans—a lobster and a crab.

each year in a process called **molting**. To molt, the crustacean secretes a new exoskeleton inside the old one, which it splits. The animal then pushes its body out through a gap between the thorax and the abdomen. After molting, the crustacean has a soft new exoskeleton that gradually hardens; but until that time, it is vulnerable to predators. While they are still soft, crabs such as the blue claw crab (*Callinectes sapidus*) are harvested and sold commercially as soft-shell crabs.

The Lobster

Two common lobster species are the northern lobster (*Homarus americanus*) and the spiny lobster (*Panulirus argus*). The northern lobster, also called the Maine lobster, has two large claws, which are absent in the spiny lobster. The northern lobster lives in the rocky subtidal zone, from Labrador to Virginia. The spiny, or rock, lobster is found in the waters of Florida, the Gulf of Mexico, and California. (There is also a European species of spiny lobster.)

Lobsters are aggressive and often fight amongst themselves. If one lobster grabs the claw of another lobster, the latter can escape by releasing its arm from its socket. Lobster trappers can also be left holding just a lobster arm if they make the mistake of grabbing a lobster by its claws. The ability of a lobster to sacrifice a body part to escape from its enemy is an adaptation for survival. The arm grows back, because arthropods can regenerate appendages. This ability is of interest to medical scientists, who are investigating the possibility of limb regeneration in humans.

Structures and Life Activities of Lobsters

Lobsters are predators, able to feed on other invertebrates such as mussels and sea urchins, which they grab with their claws. They also scavenge on the remains of dead animals. Food is digested in a one-way digestive tract consisting of a mouth, esophagus, stomach, and intestines. Wastes are eliminated through the anus. (See Figure 10-2, which shows the internal and external anatomy of a typical northern lobster.)

How does a lobster breathe? Like the mollusks, lobsters use gills for breathing. The gills are featherlike structures located in a water-

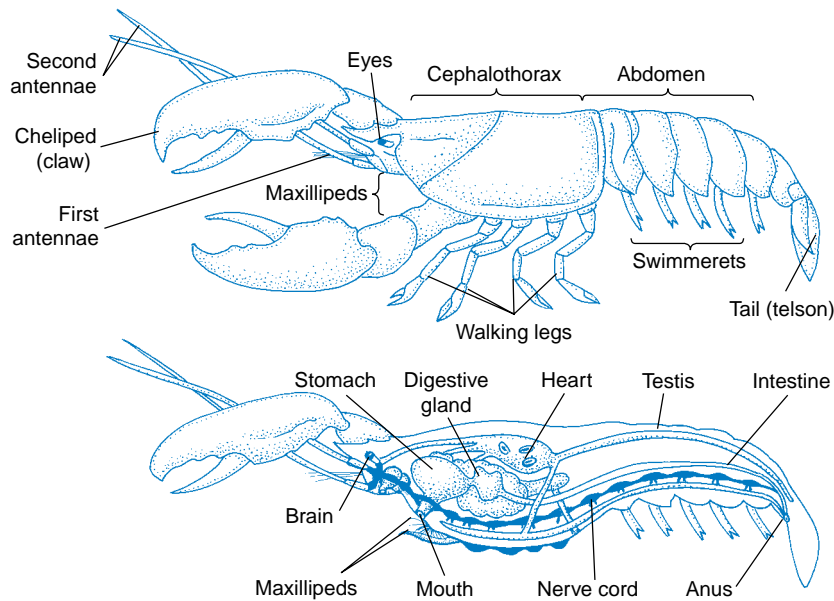


Figure 10-2 External and internal anatomy of a lobster.

filled chamber under the carapace. Each gill is attached to the upper end of a walking leg. The rapid beating of the mouthparts sends currents of water over the gills. Oxygen in the water diffuses into the gills, and carbon dioxide passes from the gills out to the water.

Oxygen and nutrients are transported around the lobster's body in its blood. The blood is blue in color due to the presence of a pigment called hemocyanin. Hemocyanin contains copper, which binds oxygen in much the same way that the iron in our hemoglobin binds oxygen (and imparts a red color to our blood).

Blood is pumped through the body by a one-chambered heart. Veins and arteries carry blood to and from the heart, aided by the body's muscular contractions. However, there are no capillaries connecting the arteries and veins, so the blood just passes through the tissue spaces. Thus, lobsters (and all other arthropods) have an open circulatory system.

The lobster's nervous system enables it to carry out a variety of responses. Its eyes are mounted on movable stalks. Two pairs of antennae actively feel out the environment. The impulses from these receptors are carried by sensory nerves to the brain, or cerebral ganglia. Responses are carried out when the brain sends impulses back via the ventral nerve cord to muscles in the legs and in the abdomen.

Lobsters reproduce sexually. Fertilization is internal, and development is external. The male deposits sperm cells into the female's abdomen, where they are stored in a chamber called the seminal receptacle. As the eggs are released, they are fertilized by the sperm. The female carries the large mass of fertilized eggs on its abdomen, attached to its swimmerets, for nearly a year before they hatch. The embryos go through a larval phase typical of most other crustaceans, floating as part of the plankton population, and molting as they grow and develop into the adult form.

10.1 SECTION REVIEW

1. How can an arthropod grow if it is enclosed in an exoskeleton?
2. How does a lobster carry out the life activity of breathing?
3. Explain why some lobsters may have one claw that is larger than the other claw.

10.2 ANOTHER IMPORTANT CRUSTACEAN: THE CRAB

There are many species of crabs alive in the world today. Look at the three crabs shown in Figure 10-3. They look very different from one another. What do you think is the reason for this? Crabs live everywhere—on land and in the sea, and from surface waters down to the great ocean depths. The great diversity that exists among them is due to the fact that crabs have successfully adapted to these many different habitats. In this section, you will learn about several of these crab species and their unique adaptations.

The Crab

The fiddler crab (*Uca*) digs tunnels in the sand along the shores of bays and inlets. When the tide comes in, fiddler crabs retreat to the tunnels and plug up the entrances with sand. At low tide, the fiddlers leave their tunnels to search for food. If you approach them, they will scurry back into the nearest hole. The fiddler crab is named

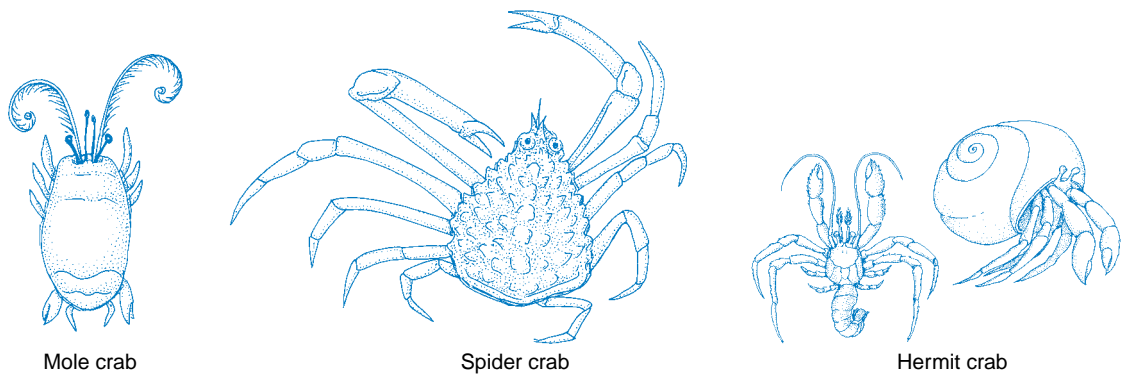


Figure 10-3 Three representative crabs.

for its large claw, which resembles the arm position of a person playing the fiddle. (Refer to Figure 10-1.) The males have the one large claw plus a smaller one, and the females have two small claws. The male uses the large claw to threaten or fight with other males over territory. If a male loses his large claw in a fight, it regenerates a new small claw, while the other claw then grows into a large claw.

The mole crab (*Emertea*) lives in the turbulent surf zone along sandy beaches. How is this animal adapted to live in such an unstable environment? The mole crab has a smooth, streamlined body, which diminishes the impact of waves and lets it burrow and move (by use of its swimmerets) efficiently through swirling mixtures of sand and water. Mole crabs also have featherlike antennae, which they use to capture the microscopic organisms that live between sand grains and in the surf.

The hermit crab (*Pagurus longicarpus*) is born with a soft abdomen that lacks an exoskeleton, making it vulnerable to attack. For protection, the hermit crab finds an empty snail shell to live in. Hermit crabs inhabit shallow coastal waters where they scavenge on particles of food. As the hermit crab increases in size, it outgrows its old snail shell and has to find a larger one. So hermit crabs are always trying on a new shell for a better fit.

Not all crabs are active and aggressive. The spider crab (*Libinia emarginata*) is slow in its movements. Notice that it has no paddle-like appendages for quick swimming or digging in the sand. The pointed legs are used for crawling very slowly along the ocean bottom. As a consequence, organisms such as algae and barnacles have time to attach and grow on the back of the spider crab. The spider crab inhabits Atlantic and Pacific waters, where it scavenges on food

particles. The biggest crab in the ocean is the giant spider crab (*Macrocheira kaempferi*), found in deep waters off the coast of Japan. Some specimens have measured, leg tip to leg tip, up to 4 meters in width.

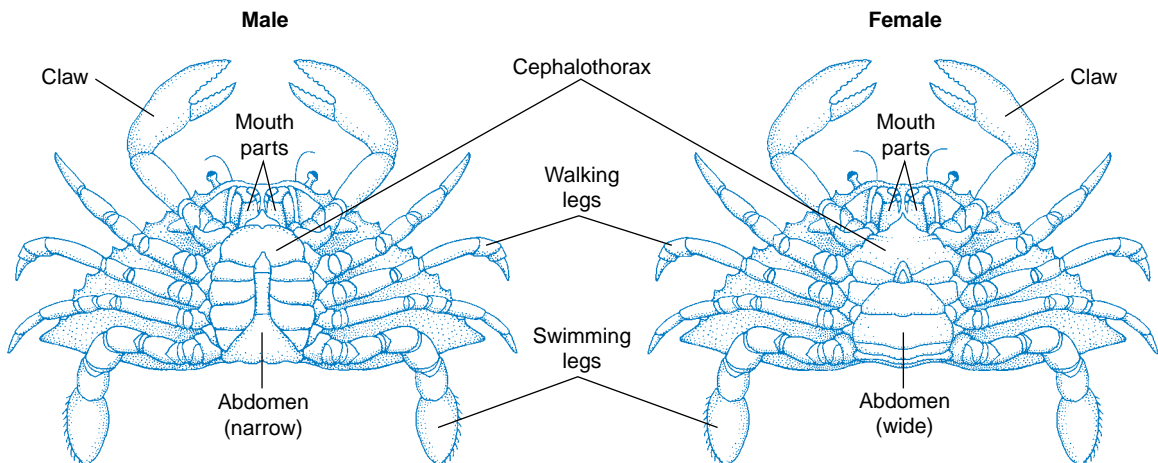
Structures and Life Activities of Crabs

What structures does the crab possess that enable it to carry out its life functions? As mentioned above, the crab's body is divided into segments (the cephalothorax and the abdomen), which are covered by the carapace. (There is no tail.) The abdomen in the crab is small and flat and is folded between the crab's walking legs on its ventral side. You can tell the sex of a crab by the shape of its abdomen; the female has a U-shaped abdomen, and the male has a V-shaped abdomen. (See Figure 10-4.) When you do the lab investigation at the end of this chapter, you will observe the structures of the crab more closely.

Crabs eat mainly dead plant and animal matter, although some graze on algae and others are predatory. They use their two sharp claws to tear and shred food. The food is passed to the mouth, where it is cut into even smaller pieces by the mouthparts. As in the lobster, food is digested in a one-way digestive tract, consisting of the mouth, esophagus, stomach, and intestines. Digestive wastes are eliminated through the anus.

Like the lobster, crabs breathe by means of their gills and they

Figure 10-4 A male and a female crab (ventral view)—they can be distinguished by the shape of the abdomen.



transport nutrients and oxygen through an open circulatory system. Their head region has two eyes (on stalks) and antennae for perceiving touch and temperature stimuli. Their well-developed nervous system enables them to respond to stimuli and control muscular activities, such as locomotion, via the ventral nerve cord.

Crabs produce large numbers of offspring. The female carries a mass of eggs between her abdomen and thorax. Sperm from the male fertilizes the eggs internally. The embryos develop externally, passing through the larval phase that is typical of decapod crustaceans. It is most adaptive for the crab to produce an abundance of fertilized eggs, since so many are eaten during their larval phase in the plankton population.

10.2 SECTION REVIEW

1. How is the mole crab adapted to live in the turbulent surf zone?
2. Why does the hermit crab live inside an empty snail shell?
3. Why might it be particularly beneficial for the giant spider crab to be so large?

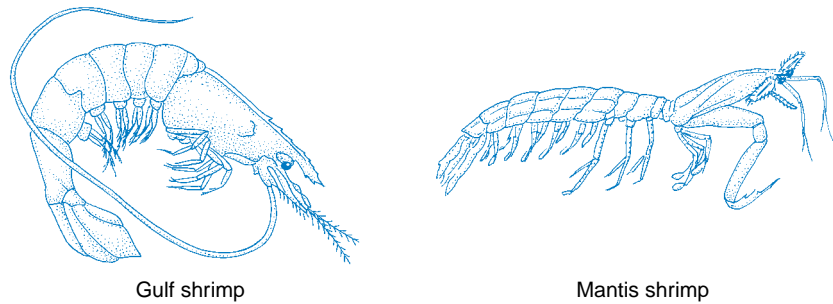
10.3 DIVERSITY AMONG CRUSTACEANS: THE SHRIMP AND OTHERS

Crustaceans range in size from nearly microscopic to absolutely huge. You are more aware of the larger ones, such as the lobster and crab, because they are popular seafood items. In this section, you will learn about the shrimp and some of the smaller crustaceans that may be less familiar to you.

The Shrimp

The shrimp looks somewhat like a small version of the lobster. The pink Gulf shrimp (*Penaeus duorarum*), which grows up to 17 cm long, is caught for the seafood industry by fishing trawlers off the

Figure 10-5 Two species of shrimps.



coast from the Carolinas to the Gulf of Mexico. The smaller common shore shrimp (*Palaemonetes vulgaris*) lives among the grasses and seaweeds in salt marshes, where it scavenges on dead plant matter and other organic debris. One of the smallest shrimps is the cleaning shrimp (*Periclimenes*), several species of which inhabit coral reefs. The cleaning shrimp, which looks like a tiny, colorful version of the shore shrimp, survives by eating parasites that are found on the skin of reef fish—a symbiotic relationship that benefits both fish and shrimp. The mantis shrimp (*Squilla empusa*) is the largest of all shrimp, growing up to 25 cm in length. From its burrow in the sand or mud, the mantis shrimp spears such prey as worms and small fish with its spiny front appendages, which unfold like a jackknife. It is found from Cape Cod down to Brazil. (See Figure 10-5.)

Copepods and Krill

Do you recognize either of the crustaceans in Figure 10-6? The most abundant crustacean in the ocean is actually the tiny **copepod** (*Calanus*)—there are more than 1000 species of copepods in the sea. The copepod, which is less than half a centimeter long, eats mainly diatoms. You may recall from an earlier chapter that the copepod is a very important part of the zooplankton community, because it forms the vast bulk of the base of the oceanic food chain for so many other species. Copepods reproduce sexually; the developing larvae undergo numerous molts before reaching maturity. During the spring and summer, when copepods are abundant, you can catch many of them in a plankton net. For a closer look, you can observe them under a dissecting microscope.

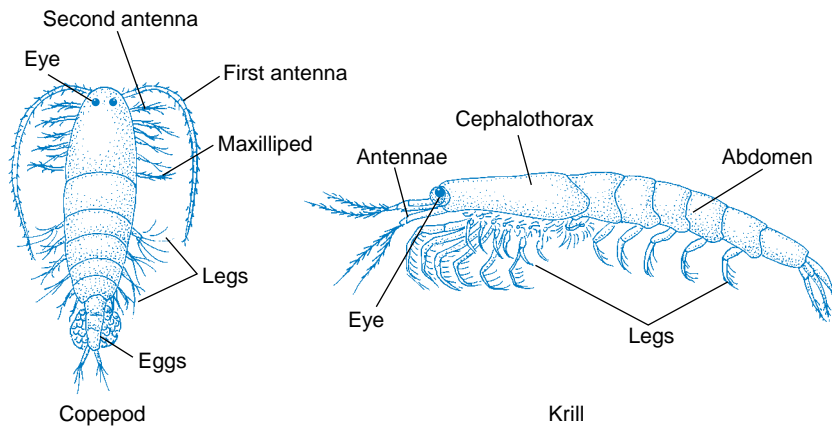


Figure 10-6 Copepods and krill are important members of the zooplankton community.

A cold-water relative of the copepod is a shrimplike animal called **krill** (*Euphausia*). (Although it resembles a shrimp, the krill has more than 10 legs, so it is not classified with the decapods.) Krill grow to about 5 cm in length. Most krill live in Antarctic waters, although some are found in other oceans. Like the copepod, the krill is a planktonic animal that eats diatoms and floats in large masses near the ocean's surface. Krill are the principal food source for the filter-feeding (baleen) whales and, along with the copepod, provide food for countless fish, birds, and seals.

Amphipods and Isopods

Whereas copepods and krill float in the open ocean, other shrimp-like crustaceans are found near the edge of the sea, living in or on a substrate. (See Figure 10-7.) If you turn over a rock or some debris in the intertidal zone, anywhere from the Arctic to the Chesapeake Bay, you are likely to find a bottom-dwelling crustacean called the

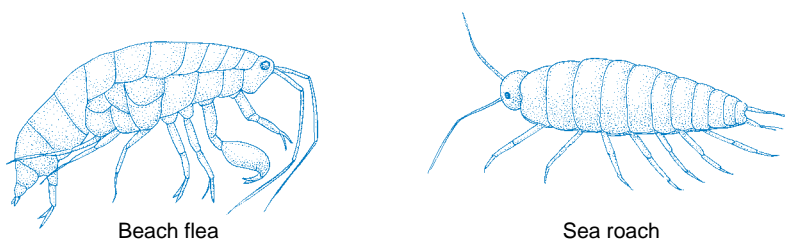


Figure 10-7 Amphipods and isopods live in the intertidal and subtidal zones, respectively.

scud (*Gammarus*). This little crustacean feeds on small invertebrates that live in the wet sand. And on sandy beaches along the East and West coasts, under the moist seaweeds along the strandline, a tiny crustacean called the beach flea (*Talorchestia*) can be found. If you turned over the seaweed, you would see hundreds of these creatures hopping and darting about. The beach fleas use the seaweed both for cover and for food. Crustaceans such as the scud and the beach flea, which look like tiny shrimps that have flattened sides, are called **amphipods**.

Some crustaceans, such as the sea roach (*Ligia*), resemble species of arthropods that live on land. (The pill bug, often found under rotting logs, is related to these crustaceans. Over time, land animals may evolve from sea animals—and vice versa—by first adapting to intertidal conditions.) Sea roaches swim and crawl in coastal waters among the seaweeds; they feed on algae. Like the cockroach, the sea roach is active at night and hides during the day. The sea roach inhabits the shallow coastal waters from California to Central America and from Cape Cod to Canada. Notice that compared with the beach flea, the sea roach's body is flattened from top to bottom (rather than from side to side). These tiny crustaceans, with flattened bodies and seven pairs of legs, are called **isopods**. Other species of isopods are parasitic; they live by attaching to the gills and skin of fish such as cod and halibut.

The Barnacle

An unusual crustacean that is often mistaken for a mollusk is the **barnacle**. The acorn, or rock, barnacle (*Balanus*) lives in the upper intertidal zone, attached to rocks and other hard surfaces. Its overlapping, sharp calcium carbonate plates, which resemble a mollusk's shell, protect the animal inside.

Barnacles attach to almost any substrate, from a ship's hull to a whale's skin. Like the yellow boring sponge described in Chapter 6, the barnacle is a type of encrusting organism. (See Figure 10-8.) Ships must be dry-docked periodically to be scraped clean of barnacles, because they add weight, increase friction, and thus hinder a ship's ability to move smoothly and quickly. In effect, a barnacle-encrusted ship uses more fuel to move through the water.



Figure 10-8 Barnacles are sessile, encrusting organisms; here they have used an empty glass bottle as their substrate.

Structures and Life Activities of Barnacles

How does the barnacle feed? The barnacle's body is actually folded up within its shell, so that its appendages (legs) can protrude from the opening. When the tide comes in and covers it, the barnacle opens its shell plates and extends its six pairs of feathery appendages, called **cirri**. The cirri whip about in rhythmic fashion to catch phytoplankton and other food particles, which are then brought into the mouth. Barnacles are filter feeders because they filter plankton and organic debris from the water. Food is digested in a one-way digestive tract, consisting of the mouth, stomach, and intestine. Wastes are eliminated through the anus. (See Figure 10-9.)

Water that contains dissolved oxygen is swept into a barnacle's shell by the movement of its cirri. The oxygen and carbon dioxide gases are exchanged across the barnacle's skin membrane. At low tide, when the barnacle is exposed to air, its overlapping plates shut tight, thus retaining moisture to keep the animal from drying out.

Notice that the barnacle contains both ovaries and testes; thus it is a hermaphrodite. Although each animal contains both sets of reproductive organs, self-fertilization does not occur. Mating occurs when a penis that is carrying sperm from one barnacle is inserted into a neighboring barnacle. Fertilization occurs inside the barnacle, and the fertilized eggs develop into swimming larvae, which are shed into the water. The barnacle larvae, like those of other crustaceans, are part of the plankton population. When the larvae come

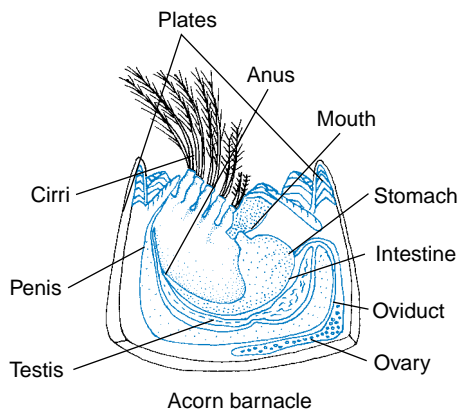


Figure 10-9 The barnacle keeps its body folded up within its shell of overlapping plates; only its cirri extend out of the shell for filter feeding.

RESEARCH

Sticking with the Barnacle



The barnacle is a source of fascination for marine biologists. It can be found attached to a variety of substrates, such as rocks, wood pilings, ships' hulls, and even the bodies of live turtles and whales. Storms and powerful waves cannot dislodge the barnacle from its attachment to these surfaces. How can this tiny arthropod stick so firmly to a substrate? Researchers have found that the barnacle produces natural cement that is more than twice as strong as any factory-made adhesive. This sticky glue, which is produced underwater when the

barnacle is still in its larval stage, does not dissolve in strong acids, alkaline substances, or organic solvents.

How does this strong attachment develop? Once the barnacle larva settles down on a suitable substrate, it secretes a clear liquid adhesive from glands in its body. As the barnacle grows, the glands enlarge to produce more cement, which hardens into an opaque, rubbery solid. Biochemists have determined that the cement is

composed of protein molecules that provide a strong framework to anchor the barnacle.

Scientists are conducting further research to try and unravel various mysteries of the barnacle. Some biologists are focusing on its larval stage in order to understand how it selects a suitable location on which to settle. Medical researchers are interested in the barnacle's adhesive—if scientists can figure out how to manufacture this powerful substance, they might be able to use it to mend broken bones and fill teeth.

QUESTIONS

1. How does a barnacle attach to the shell of a sea turtle?
2. Why are scientists fascinated with the barnacle?
3. Describe two areas of further research on the barnacle.

into contact with a suitable substrate—preferably near other barnacles—they attach to it by secreting glue from special glands, and then develop into adult barnacles.

Barnacles also live in clusters among the mussel beds in the lower intertidal zone along the West Coast. Called gooseneck, or goose, barnacles (*Pollicipes*) for the long stalks by which they are attached to the substrate, they are able to bend with the currents to capture large plankton that drift by. Their six pairs of cirri extend from the shell at the top of the stalk, enabling them to compete with the mussels for living space and food. (See Figure 10-10.)

10.3 SECTION REVIEW

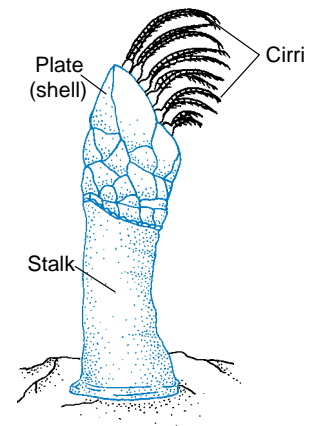
1. Describe three methods of food-getting in shrimps.
2. Why are krill and copepods important members of the plankton population?
3. How do barnacles become encrusted on substrates, such as the hull of a ship?

10.4 DIVERSITY AMONG THE ARTHROPODS

As you have learned, the most important arthropods in the ocean are the crustaceans. However, the arthropods are a very diverse group. In addition to crustaceans, there are other types of arthropods that are adapted to the marine environment. Two unusual groups of arthropods found in or near the sea are the horseshoe crab and the marine insects. In this section, you will learn how these arthropods are uniquely adapted to their marine habitats.

The Horseshoe Crab

An arthropod that is often mistaken for a crab is the **horseshoe crab** (*Limulus polyphemus*). The horseshoe crab is not a true crab; it lacks antennae and mouthparts, and it has six pairs of legs, or appendages. (A true crab has five pairs of legs.) The horseshoe crab is



Gooseneck barnacle

Figure 10-10 The gooseneck barnacle can bend with the ocean currents, extending its cirri to capture drifting plankton.

actually more closely related to spiders and scorpions than to crustaceans. As such, it is placed in its own class, Merostomata.

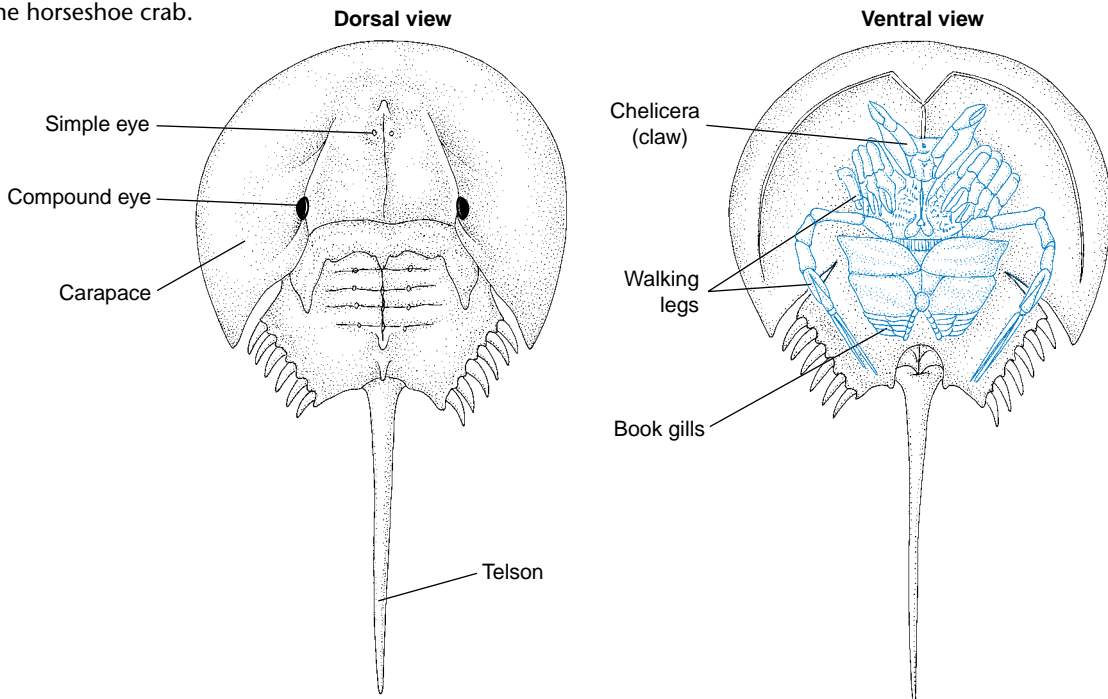
The horseshoe crab inhabits the waters along America's Atlantic and Gulf coasts and along the Asian Pacific coast, where it searches for food in the mud, preying on small mollusks and crustaceans, and scavenging on dead matter. The horseshoe crab has four eyes—two simple eyes and two compound eyes—located on the top of its carapace. The compound eyes contain many visual units, which are grouped together for better vision.

Structures and Life Activities of Horseshoe Crabs

On the underside of the horseshoe crab are its legs. The first pair of appendages is a set of pinching claws (the cheliceras); the five other pairs are the walking legs. In males, the first claw is shaped like a boxing glove. The body and legs are covered by a domed carapace, which is followed by a long spiked tail. (See Figure 10-11.)

Behind the legs are numerous overlapping membranes that

Figure 10-11 External and internal anatomy of the horseshoe crab.



resemble pages in a book. These are the **book gills**, which are used for breathing and locomotion. The movement of the book gills enables larval horseshoe crabs to swim upside down, so that they can feed more easily on suspended food particles and plankton. Like crustaceans, the horseshoe crab has copper-based hemocyanin in its blood for transporting oxygen through its body.

Contrary to what most people think, the horseshoe crab's spiked tail, or **telson**, is not used as a weapon. It is used in locomotion. Also, when tossed on its back by a wave, the horseshoe crab sticks its telson in the sand to use as a lever to flip itself over.

Life Cycle of the Horseshoe Crab

In late spring, when the tide is high, thousands of horseshoe crabs invade the sandy beaches and marshes. The females, carrying the smaller males clutched to their backs, congregate at the high-tide mark where they dig holes in the sand and lay hundreds of tiny pale green eggs. The males, still attached to the females, externally fertilize the eggs, which are then covered with sand. (This abundance of horseshoe crab eggs in the sand provides a feast for shorebirds migrating north in the spring. In fact, the harvest of horseshoe crabs by people is limited, since their eggs are such an important food source for the migrating birds.) About two weeks after fertilization, the eggs hatch into tiny, swimming juvenile horseshoe crabs (unlike crustacean larvae) that are carried out to sea by the tide. Within a month, they develop the spiked tails that are characteristic of the adults.

As the horseshoe crab grows, its outer skin hardens to form the carapace. The young animal settles to the bottom, where it feeds on invertebrates in the sand. The horseshoe crab reaches sexual maturity in about eight years. During this period of growth, the horseshoe crab undergoes many molts, casting off its outer shell each time it grows. These cast-off shells are often found on beaches and mistaken for dead crabs, because they look so complete. Horseshoe crabs can live for as long as 20 years. Fossils of the horseshoe crab show that this animal has not changed very much throughout its more than 400-million-year history. For this reason, the horseshoe crab is often described as a "living fossil."

Marine Insects

Arthropods also include the marine insects. While insects tend not to inhabit water with a high salinity (such as the open ocean), some are found in habitats such as salt marshes. The ones that you are most likely to come into contact with are the biting insects that live in inland bays and marshes. They all possess a chitinous exoskeleton and jointed appendages, the characteristic features of all arthropods. Unlike the crustaceans, insects have only three pairs of legs, and a body made up of three segments (head, thorax, and abdomen). Insects also differ from some other arthropods in that they have just one set of antennae and one pair of eyes. They are placed in their own class, Insecta, which comprises nearly a million known species.

The most familiar of marine insects is the marsh mosquito. Mosquitoes draw blood from their hosts by using a specialized mouthpart, the proboscis, like a hypodermic needle. Another common marine insect is the greenhead fly, which is seen in salt marshes and above sand dunes. One biting marine insect, the sand fly (*Culicoides*), commonly called the “no-see-um,” gets its name from the fact that the insect is so small that you can be bitten by it without even seeing it. This fly can transmit a fever to the people that it bites.

Mosquitoes, and some species of flies, inhabit inland marine habitats (such as estuaries) where the wave impact is slight. These calm waters are less saline than the ocean; and they provide a flat surface on which the insects can lay their eggs. The eggs develop into larvae, which then develop and hatch into the adult insects. The salt-marsh mosquito is a pest to humans, but it is food to the fish and marine invertebrates that feed on its larvae.

10.4 SECTION REVIEW

1. Why is the horseshoe crab not classified as a true crab?
2. Explain why the horseshoe crab is considered a living fossil.
3. Why are mosquitoes classified as arthropods, along with such animals as lobsters?

Laboratory Investigation 10

Adaptations of Crabs

PROBLEM: How is the crab adapted for carrying out its life functions?

SKILL: Observing adaptive features of a crab's external anatomy.

MATERIALS: frozen crabs (thawed), trays, hand lens, probe.

PROCEDURE

1. Put a crab on a tray with the dorsal side facing up. Tap the shell with your pen. Notice the hardness of the shell. The shell is the crab's exoskeleton. Because the exoskeleton is rigid, the crab has to shed it, or molt, several times during its lifetime as its body size increases. (See Figure 10-12.)
2. The body of a crab is divided into segments: the cephalothorax and the abdomen. The cephalothorax is composed of two parts, the head and the chest. The shell that covers the cephalothorax is the carapace. The abdomen is located on the ventral side. Turn the crab over and look at the flat abdomen, located between the legs. In the male, the abdomen is narrow and V-shaped. In the female, it is wide and U-shaped.

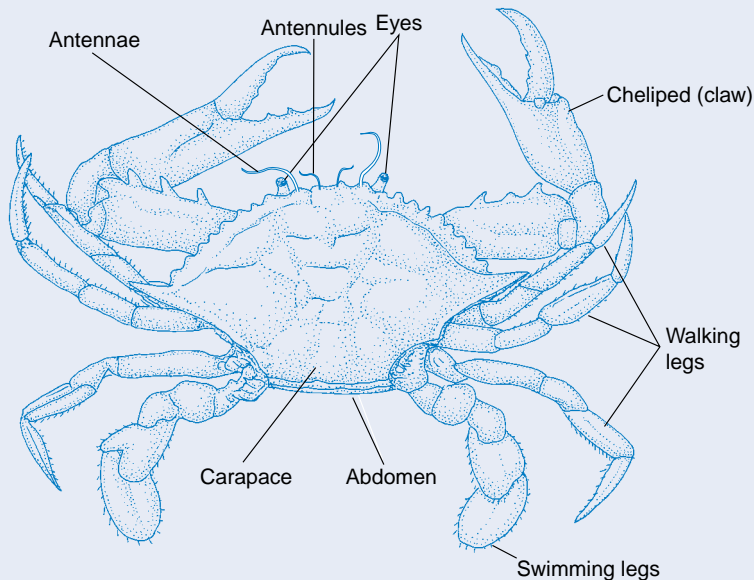


Figure 10-12 External anatomy of a crab.

3. How does the crab move? Crabs use their legs, or appendages, for crawling and swimming. Count the number of legs. There are five pairs (ten legs); hence the name of the order to which crabs and lobsters belong: Decapoda (*deca* meaning “ten”; *pod* meaning “foot”). Why are some of the legs pointed and others flat? The pointed ones are used for crawling, and the flat ones are used like paddles for swimming. Examine the first pair of legs, which are modified as claws, called chelipeds. The chelipeds catch and hold food and bring it to the mouth. Sketch the appendages in your notebook. Identify which ones are used for swimming, crawling, and feeding.
4. How does the crab ingest food? Food is brought to the mouth by the claws. Locate the mouth using your probe and hand lens. The mouth is surrounded by several pairs of mouthparts, which are used for tasting, moving, and shredding the food into smaller pieces.
5. How does the crab sense its environment? Use the hand lens to observe its eyes and its antennae in the head region. The two eyes are mounted on stalks. The two pairs of antennae are used to sense the environment. They function as receptors for touch, temperature, sound, and smell.

OBSERVATIONS AND ANALYSES

1. What are the advantages and disadvantages of an exoskeleton?
2. What body parts does the crab use to ingest food?
3. How is the crab adapted for locomotion?
4. How does the crab sense its environment?

Chapter 10 Review

Answer the following questions on a separate sheet of paper.

Vocabulary

The following list contains all the boldface terms in this chapter.

amphipods, arthropods, barnacle, book gills, carapace, cephalothorax, chitin, cirri, copepod, crustaceans, exoskeleton, horseshoe crab, isopods, krill, molting, swimmerets, telson

Fill In

Use one of the vocabulary terms listed above to complete each sentence.

1. A characteristic of all arthropods is their tough _____.
2. A crustacean's head and chest regions make up the _____.
3. Paddlelike _____ are used for movement by crustaceans.
4. Crustaceans shed their shell in a process called _____.
5. A tiny crustacean at the base of ocean food chains is the _____.

Think and Write

Use the information in this chapter to respond to these items.

6. Compare and contrast feeding in the barnacle and the crab.
7. Identify the important features that are characteristic of all arthropods.
8. Describe a main difference in isopod and amphipod body shapes.

Inquiry

Base your answers to questions 9 to 12 on the experiment described below and on your knowledge of marine science.

A student observed the movement of cirri in three groups of rock barnacles kept at different water temperatures. He recorded the number of cirri beats per minute for one (random) barnacle from

each group in six separate trials. All other conditions in the three groups' environments, such as levels of salinity and sunlight, were kept constant for each group throughout the six trials. The results are shown in the table below.

Trial	Group A Cirri beats per minute at 5°C	Group B Cirri beats per minute at 15°C	Group C Cirri beats per minute at 28°C
1	12	25	25
2	11	26	30
3	14	23	35
4	9	28	26
5	16	19	31
6	10	23	33
Total	72	144	180
Average	12	24	30

9. Which statement is most correct based on the data in the table?
 - a. Barnacles in group A showed the most cirri activity.
 - b. Barnacles in group B were, on average, twice as active as those in group A.
 - c. Barnacles in group C were the least active of all the barnacles.
 - d. All three groups of barnacles showed little or no cirri activity.
10. The results of this experiment show that
 - a. as temperature increases, cirri activity decreases
 - b. as temperature decreases, cirri activity increases
 - c. as temperature increases, cirri activity increases
 - d. there is no relationship between temperature and cirri activity.
11. A tentative conclusion that can be drawn from the data is that
 - a. temperature has an effect on the life activities of barnacles
 - b. food is the only factor that affects cirri activity
 - c. barnacles are warm-blooded animals
 - d. barnacles show no response to changes in their environment.
12. When the student who performed this experiment wrote up his results, he called it "The Effect of Temperature Change on

Cirri Movement in Barnacles.” In one or more complete sentences, describe and provide a reasonable scientific explanation for the results obtained.

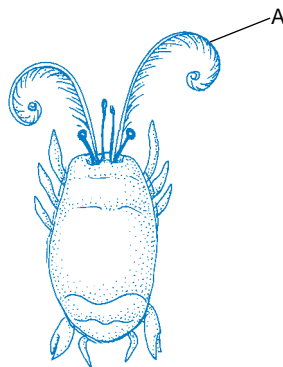
Multiple Choice

Choose the response that best completes the sentence or answers the question.

13. In lobsters, the part of the shell that covers the cephalothorax is the *a. swimmeret b. carapace c. book gills d. telson.*
14. An important food source for filter-feeding whales is the crustacean known as the *a. scud b. krill c. barnacle d. isopod.*
15. The process of molting is related to the life function of *a. growth b. reproduction c. sensitivity d. digestion.*
16. The horseshoe crab’s telson is used in *a. reproduction b. defense c. locomotion d. food-getting.*
17. To escape predators, fiddler crabs will *a. cover themselves with seaweed b. hide in their sand tunnels c. change their shell color d. lie motionless in the water.*
18. Barnacles obtain food by means of appendages called *a. tentacles b. cirri c. swimmerets d. cilia.*
19. Which arthropod is considered to be a living fossil?
a. hermit crab b. copepod c. horseshoe crab d. sea roach

Refer to the following drawing of an arthropod to answer questions 20 and 21.

20. This organism is classified as a type of *a. true crab b. horseshoe crab c. amphipod d. copepod.*
21. The structure labeled “A” is used for *a. swimming b. digging into sand c. mating d. food-getting.*



22. Which statement about crustaceans is true? *a.* All have the same number of appendages. *b.* All have an internal skeleton. *c.* All have an exoskeleton. *d.* Only some have jointed appendages.
23. All of the following arthropods are crustaceans *except* the *a.* lobster *b.* barnacle *c.* horseshoe crab *d.* beach flea.
24. The arthropod that lives as an encrusting organism is the *a.* barnacle *b.* lobster *c.* hermit crab *d.* copepod.
25. The horseshoe crab breathes by means of its *a.* carapace *b.* telson *c.* chelicera *d.* book gills.

Research/Activity

- To find out if the presence of food particles increases feeding response in barnacles, sprinkle some fish food into a container of live barnacles. Count the number of times the cirri move per minute (count beats for 15 seconds; then multiply by 4). Compare with a control group that has not been fed. Record your data in a table and draw a graph.
- Barnacles cause problems when they coat the hulls of ships. Unfortunately, the “antifouling” chemicals that have been used to deter them are toxic to other forms of marine life. Report on what is being done to try to find safer alternatives to these chemicals.