Section 28–2

1 FOCUS

Objectives

28.2.1 ***Explain*** how arthropods are classified.

28.2.2 ***Identify*** the distinguishing features of the three subphyla of arthropods.

Guide for Reading

Vocabulary Preview

Pronounce each Vocabulary word, and have students repeat the pronunciation as a class. Pay special attention to words that are difficult for English language learners.

Reading Strategy

Have students preview Figures 28–8 and 28–9 and write down questions about any differences they observe. Then, as they read, they should try to answer their questions from the information in the section.

2 INSTRUCT

Crustaceans

Build Science Skills

Observing Display a live lobster in a clear container. Encourage students to examine the lobster closely and make labeled sketches of what they see. Caution students not to touch the lobster. Ask: **What structures does this lobster have that mark it as a crustacean?** *(It has two pairs of branched antennae, two body sections, and chewing mouthparts called mandibles.)* Explain that lobsters are members of the crustacean order Decapoda ("ten feet"), so named because members of this order have five pairs of walking legs. L2

Go Online NSTA SCILINKS

Download a worksheet on crustaceans for students to complete, and find additional teacher support from NSTA SciLinks.

28–2 Groups of Arthropods

Guide for Reading

Key Concepts
- How are arthropods classified?
- What are the distinguishing features of the three major groups of arthropods?

Vocabulary
cephalothorax
thorax
abdomen
carapace
mandible
cheliped
swimmeret
chelicera
pedipalp
spinneret

Reading Strategy: Building Vocabulary
Before you read, preview new vocabulary by skimming the section and making a list of the highlighted, boldface terms. Leave space to make notes as you read.

Go Online NSTA SCILINKS
For: Links on crustaceans
Visit: www.SciLinks.org
Web Code: cbn-8282

You are a naturalist sent to the rain forests of Brazil to bring back a representative sample of arthropods from the region. As you search the forest, your collection grows to include an astonishing array of arthropods—butterflies several centimeters across, armored wormlike animals that move about using dozens of legs, and beetles that defend themselves by shooting out a stream of poisonous liquid. You must organize your collection before you return home, but you do not know how all these arthropod species are related to one another. Where to begin?

This is the challenge that has faced biologists for many decades—how to catalogue all the world's arthropods. The diversity of arthropods is daunting to any biologist interested in understanding the relationships among organisms. As you will see, however, arthropod classification is based on a few important characteristics. **Arthropods are classified based on the number and structure of their body segments and appendages—particularly their mouthparts.** The three major groups of arthropods are crustaceans, spiders and their relatives, and insects and their relatives.

Crustaceans

Animals in subphylum Crustacea, or crustaceans (krus-TAY-shunz), are primarily aquatic. This subphylum includes organisms such as crabs, shrimps, lobsters, crayfishes, and barnacles. Crustaceans range in size from small terrestrial pill bugs to enormous spider crabs that have masses around 20 kilograms. **Crustaceans typically have two pairs of antennae, two or three body sections, and chewing mouthparts called mandibles.** An example of a crustacean is shown in **Figure 28–7.**

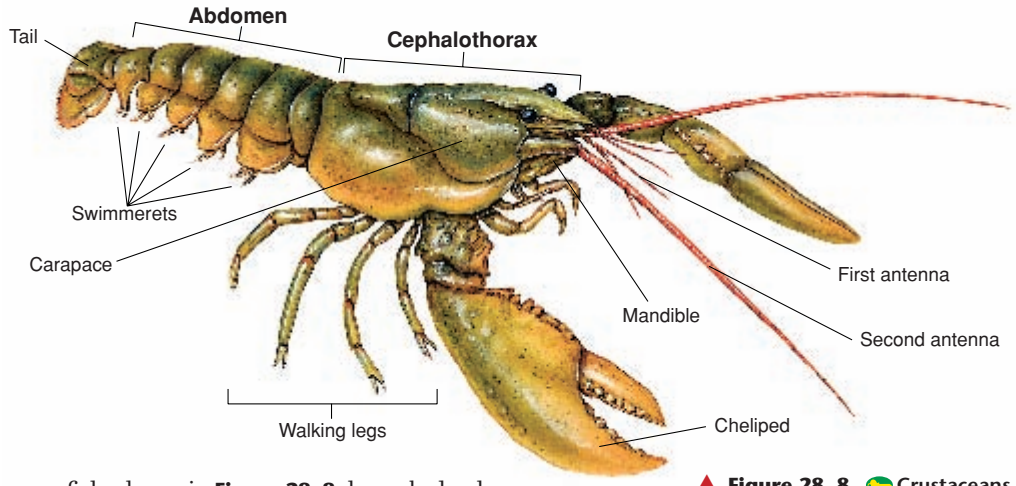
Figure 28–7 Arthropods are classified based on the number and structure of their body segments and appendages. The fiddler crab shown here is an example of a crustacean.

TIME SAVER

SECTION RESOURCES

Print:
- ***Teaching Resources,*** Lesson Plan 28–2, Adapted Section Summary 28–2, Adapted Worksheets 28–2, Section Summary 28–2, Worksheets 28–2, Section Review 28–2
- ***Reading and Study Workbook A,*** Section 28–2
- ***Adapted Reading and Study Workbook B,*** Section 28–2

Technology:
- ***iText,*** Section 28–2
- ***Animated Biological Concepts DVD,*** 36 Crayfish Anatomy
- ***Transparencies Plus,*** Section 28–2



▲ **Figure 28–8** Crustaceans **typically have two pairs of antennae, two or three body sections, and chewing mouthparts called mandibles.** Notice these structures in this illustration of a crayfish, an aquatic crustacean. Each of the smaller antennae has two branches.

The crayfish, shown in **Figure 28–8,** has a body plan that is typical of many crustaceans. Its body is divided into a cephalothorax (sef-uh-loh-THAWR-aks) and an abdomen. The anterior **cephalothorax** is formed by fusion of the head with the **thorax,** which lies just behind the head and houses most of the internal organs. The **abdomen** is the posterior part of the body. The **carapace** is the part of the exoskeleton that covers the cephalothorax.

Crustacean appendages vary in form and function. The first two pairs of appendages are antennae, which bear many sensory hairs. In crayfish, antennae are primarily sense organs. In other crustaceans, they are used for filter feeding or swimming. The third pair of appendages are the mandibles. A **mandible** is a mouthpart adapted for biting and grinding food. Gills are attached to the appendages associated with the cephalothorax.

Crayfishes, lobsters, and crabs are members of the largest group of crustaceans: the decapods. The decapods have five pairs of legs. In crayfishes, the first pair of legs, called **chelipeds,** bear large claws that are modified to catch, pick up, crush, and cut food. Behind these legs are four pairs of walking legs. Along the abdomen are several pairs of **swimmerets,** which are flipperlike appendages used for swimming. The final abdominal segment is fused with a pair of paddlelike appendages to form a large, flat tail. When the abdominal muscles contract, the crayfish's tail snaps beneath its body. This pushes the animal backward.

The barnacles are another group of crustaceans. Unlike the decapods, barnacles are sessile, or attached to a single spot. Barnacles are crustaceans that have lost their abdominal segments and no longer use mandibles. Because of their outer shell-like coverings, barnacles were once classified as mollusks. Barnacles attach themselves to rocks along the shore and in tide pools. They even attach to the surface of marine animals such as whales. Barnacles use their appendages to capture and draw food particles into their mouths.

CHECKPOINT *What are the body sections of a crayfish?*

Word Origins

Decapod comes from the Greek word *deka,* meaning "ten," and the Greek word *podos,* meaning "foot." So, *decapod* means "ten-footed." **If *cephalo* means "head," what do you think the term *cephalopod* means?**

Use Visuals

Figure 28–8 Ask students: **What appendages does this crayfish have?** *(Antennae, chelipeds, mandibles, walking legs, and swimmerets)* Emphasize that all crustaceans have two pairs of branched antennae, as shown in the figure. **How does this aquatic arthropod respire?** *(Through feather-like gills)* **Does a crayfish have two or three body sections?** *(Two. The cephalothorax is a fusion of the head and the thorax, and the abdomen is the posterior part of the body.)* L1 L2

Build Science Skills

Observing Provide each student or pair of students with a whole unshelled, raw shrimp. (Students should wear disposable plastic gloves. Caution students not to place their hands near their face or mouth after handling the shrimp and to wash their hands with soap and warm water when they have completed their observations.) Have each student use a hand lens to observe the crustacean. Then, students should sketch the shrimp's body, note any appendages, and label all parts that can be identified. Once students have finished their sketches, ask: **From your observations, what can you infer about a shrimp's range of motion and the way it moves from place to place?** *(Students might correctly infer that a shrimp contracts its abdominal muscles and spreads its fanlike sections, so that it jerks backward in the water. It also walks and swims with its legs.)* L2

Word Origins

The term *cephalopod* means "head footed." L2

ESL SUPPORT FOR ENGLISH LANGUAGE LEARNERS

Vocabulary: Prior Knowledge

Beginning Write the word *swimmeret* on the board, and say it aloud. Have students repeat the word after you. Then, draw a box around the base word *swim*. Ask students what *swim* means. If they do not know this word, explain the definition and clarify it with pictures of swimmers. Ask students where they expect to find swimming animals (in water). Help students infer that swimmerets are structures that crustaceans use for swimming. Point out the flipperlike structure of swimmerets in Figure 28–8. Repeat this strategy for the word *spinneret* and the base word *spin.* L1

Intermediate Some students may know the word *abdomen* in relationship to human anatomy. Ask students where a crustacean's abdomen is located and how this compares with the human abdomen. L2

Answer to . . .

CHECKPOINT *The cephalothorax and the abdomen are the body sections of a crayfish.*

Spiders and Their Relatives

Build Science Skills

Applying Concepts Show students photographs or slides that illustrate some of the representative kinds of chelicerates, including various spiders, ticks, scorpions, and horseshoe crabs. As you show each example, ask students to identify the organism, or tell them the name if they cannot. Then, ask: **What characteristics do all chelicerates have in common?** *(They have two pairs of appendages attached near the mouth, called chelicerae and pedipalps. Chelicerates also have two body sections and four or five pairs of legs.)* Call on volunteers to point out these characteristics in the photos or slides of chelicerates. L2

Use Visuals

Figure 28–9 Ask students: **What structures does the spider share with some other arthropods?** *(Nervous system, well-developed head with brain and sense organs such as eyes, Malpighian tubules for excretion, heart, open circulatory system, spiracles)* **What structures are characteristic of this spider and some other chelicerates?** *(Book lungs, poison gland, pedipalps and chelicerae, silk gland, four pairs of legs)* L1 L2

Spiders and Their Relatives

Horseshoe crabs, spiders, ticks, and scorpions are members of subphylum Chelicerata, or chelicerates. **Chelicerates have mouthparts called chelicerae and two body sections, and nearly all have four pairs of walking legs.** Locate these structures in the spider in **Figure 28–9.** Note that chelicerates lack the antennae found on most other arthropods. As in crustaceans, the bodies of chelicerates are divided into a cephalothorax and an abdomen. The cephalothorax contains the brain, eyes, mouth, and walking legs. The abdomen contains most of the internal organs.

Chelicerates have two pairs of appendages attached near the mouth that are adapted as mouthparts. One pair, called **chelicerae** (kuh-LIS-ur-ee; singular: chelicera), contain fangs and are used to stab and paralyze prey. The other pair, called **pedipalps** (PED-ih-palps), are longer than the chelicerae and are usually modified to grab prey. Chelicerates respire using either book gills or book lungs. Horseshoe crabs, which are aquatic, move water across the membranes of book gills. In spiders, which are terrestrial, air enters through spiracles and then circulates across the surfaces of the book lung.

Chelicerates are divided into two main classes: Merostomata and Arachnida. Class Merostomata includes horseshoe crabs, and class Arachnida, or arachnids, includes spiders, mites, ticks, and scorpions.

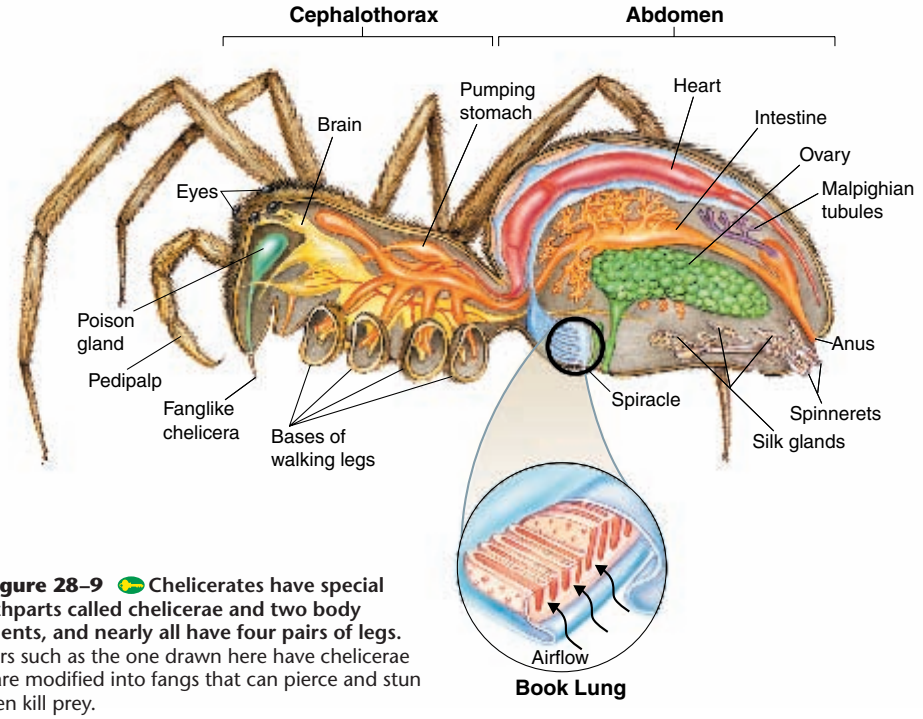


Figure 28–9 Chelicerates have special mouthparts called chelicerae and two body segments, and nearly all have four pairs of legs. Spiders such as the one drawn here have chelicerae that are modified into fangs that can pierce and stun or even kill prey.

BIO INSIGHTS

FACTS AND FIGURES

Ballooning off to new territory

Female spiders usually lay eggs in a small cocoon spun from silk. In some, such as members of the genus *Theridion,* the young live on the mother's web for a month or so after hatching. When the mother captures prey, she signals to the young by strumming the web with her legs. When danger threatens, she rubs the web a different way, and the young scurry for the shelter of their cocoon.

Once they are a few weeks old, most spiders live alone. Some baby spiders leave the nest by climbing onto a tall plant and releasing a long silk thread. When a strong breeze picks up the thread, the spider lets go of its perch and sails off in the wind. This behavior, called ballooning, can carry the baby spider for hundreds of kilometers to a new, possibly less crowded, territory.

Figure 28–10 Horseshoe crabs look a bit like true crabs, but their bodies more closely resemble those of spiders and other chelicerates. The abdomen and cephalothorax of these animals are encased in a hard shell. **Inferring** *From this photograph, what can you infer about the habitat of horseshoe crabs?*

Horseshoe Crabs Horseshoe crabs, such as the one shown in **Figure 28–10,** are among the oldest living arthropods. They first appeared more than 500 million years ago and have changed little since that time. Despite their name, horseshoe crabs are not true crabs at all. They are heavily armor-plated, like crabs, but have an anatomy closer to that of spiders. They have chelicerae, five pairs of walking legs, and a long spikelike tail that is used for movement. Horseshoe crabs grow to about the size—and shape—of a large frying pan. They are common along the marshes and shallow bays of the eastern United States seacoast.

Spiders Spiders, the largest group of arachnids, capture and feed on animals ranging from other arthropods to small birds. They catch their prey in a variety of ways. Some spin webs of a strong, flexible protein called silk, which they use to catch flying prey. Others, including the tarantula shown in **Figure 28–11,** stalk and then pounce on their prey. Other spiders lie in wait beneath a camouflaged burrow, leaping out to grab insects that venture too near.

Because spiders do not have jaws for chewing, they must liquefy their food to swallow it. Once a spider captures its prey, it uses fanglike chelicerae to inject paralyzing venom into it. When the prey is paralyzed, the spider injects digestive enzymes into the wounds. These enzymes break down the prey's tissues, enabling the spider to suck the tissues into a specialized pumping stomach. The stomach forces the liquefied food through the rest of the spider's digestive system. In the digestive system, enzymes break food molecules into smaller molecules that can be absorbed.

Whether or not they spin webs, all spiders produce silk. Spider silk is much stronger than steel! Spiders spin silk into webs, cocoons for eggs, and wrappings for prey. They do this by forcing liquid silk through **spinnerets,** which are organs that contain silk glands. As the silk is pulled out of the spinnerets, it hardens into a single strand. Web-spinning spiders can spin webs almost as soon as they hatch; the complicated procedure seems to be preprogrammed behavior.

CHECKPOINT *How do chelicerates respire?*

Figure 28–11 The tarantula shown here is an example of a chelicerate. The chelicerae, or specialized mouthparts, can inject poison by way of a painful bite. **Applying Concepts** *How might this action be useful to tarantulas?*

Build Science Skills

Using Models Divide the class into pairs, and ask each pair to make a simple two- or three-dimensional model of a chelicerate's body plan. Explain that they can use materials of their choice and also choose the chelicerate they want to model. Students should use written labels or tags to name the chelicerate's body sections and major appendages. L2 L3

Build Science Skills

Classifying Challenge interested students to use a field guide or a library book about spiders to identify spider webs they find around the school or at home. Explain that each kind of spider spins a distinctive web. Some are triangular, others are dome-shaped, and so on. Ask students to make sketches of the webs they find and use books to identify the kind of spider that made each web. L3

Build Science Skills

Comparing and Contrasting Show students how they can "collect" a spider web. After finding a fresh web, spray it with enamel spray paint. Next, spray a sheet of bright white construction paper with hairspray to make it sticky. Then, push the construction paper against the spray-painted web. As one person holds the paper in place, another can use scissors to cut the strands of silk around the web. Once dry, the paper will hold the collected web. After your demonstration, divide the class into pairs and challenge each pair to find a suitable web to collect. Display the collected webs, and have students use field guides to identify the species of spiders that made the webs. L2 L3

BIO INSIGHTS

FACTS AND FIGURES

A great research animal

The horseshoe crab, *Limulus polyphemus,* can survive great changes in temperature and salinity and does not seem to be affected by doses of radiation high enough to kill humans. It can also live for almost a year without eating. For these reasons, *Limulus* has interested biologists for many years. This chelicerate is found only in the eastern part of North America, from Nova Scotia to Mexico. In the spring and summer, great numbers of *Limulus* can be seen in the shallow water of protected bays and estuaries as they prepare for mating. Biologists have studied *Limulus* reproduction extensively. The *Limulus* eye has also been invaluable to researchers who investigate vision. Because it has a relatively simple structure, it provides an excellent model for studies of the way that vision works.

Answers to . . .

CHECKPOINT *Chelicerates respire using book gills or book lungs.*

Figure 28–10 *Horseshoe crabs live in water along the seacoast.*

Figure 28–11 *The ability to inject poison enables the tarantula to capture prey and defend itself against predators.*

Analyzing Data

The name for the disease is derived from a location—Lyme, Connecticut—near where a cluster of cases was first reported in 1975. Lyme disease is caused by the bacterial spirochete *Borrelia burgdorferi.* For the bacterium to be transferred from tick to human, the tick must remain on the human for days, and therefore prompt removal of the tick will prevent the disease. But the deer tick that carries the bacterium in the East, *Ixodus scapularis,* is so small that a person bitten by the tick may not notice it at all. A deer tick feeds three times during its life: usually on field mice as a larva and as a nymph, and then usually on a deer as an adult tick. Deer and other wild animals show no signs of being affected by the disease. In humans, antibiotics are usually effective in treating Lyme disease. L2

Answers

1. The areas where the incidence of Lyme disease is greatest are where there are the most humans.

2. One hypothesis is that climate differences are a major factor: the ticks are less abundant in the dry areas of the Southwest than in the more humid areas of the West Coast. Another hypothesis is that in the warm Southwest, the ticks prefer to feed on reptiles rather than humans.

Insects and Their Relatives

Build Science Skills

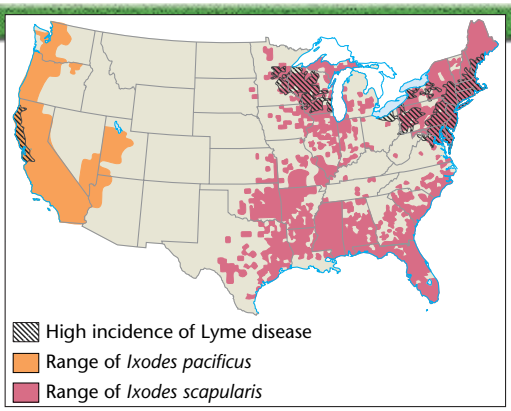
Classifying To reinforce arthropod classification, show the class photographs or specimens of a variety of uniramians, including centipedes, millipedes, and a number of different insects. Ask: **What do all these uniramians have in common?** *(All have jaws, one pair of antennae, and unbranched appendages.)* **What is the difference between a centipede and a millipede?** *(Most body segments of a centipede bear one pair of legs each. Each millipede segment bears two pairs of legs.)* L1 L2

Analyzing Data

Ticks and Lyme Disease

Lyme disease is caused by a bacterium found in two species of small ticks, the deer tick (*Ixodes scapularis*) and the western black-legged tick (*Ixodes pacificus*). Both species are most common in humid, wooded areas. They feed by sucking blood from deer, mice, birds, or humans. In warmer climates where reptiles such as lizards and snakes are most common, deer ticks prefer to feed on reptiles. The disease-causing bacteria are transmitted to the host by the bite of an infected tick. In humans the bacteria can cause a rash, fever, fatigue, joint and muscle pain, and damage to the nervous system. The bacteria do not survive well in reptiles.

The map shows the distribution of the two tick species and areas where there is a high incidence of Lyme disease. Use the map to help you answer the questions that follow.



1. **Interpreting Graphics** How can you explain the differences in the incidence of Lyme disease within the range of deer ticks?
2. **Formulating Hypotheses** What are two possible reasons that Lyme disease is not common in the parts of the dry southwest where western black-legged ticks are found?

▼ **Figure 28–12** Scorpions are easily recognized by their clawlike pedipalps and curved abdomen that bears a stinger at its tip. Although scorpions inflict stings on humans—usually causing as much pain as a wasp sting—they typically prey on other invertebrates, such as insects. **Comparing and Contrasting** *How do scorpions and spiders capture their prey?*

Mites and Ticks Mites and ticks are small arachnids that are often parasitic. Their chelicerae and pedipalps are specialized for digging into a host's tissues and sucking out blood or plant fluids. In many species, the chelicerae are needlelike structures that are used to pierce the skin of the host. The pedipalps are often equipped with claws for attaching to the host. These mouthparts are so strong that if a tick begins to feed on you and you try to pull it off, its cephalothorax may separate from its abdomen and remain in your skin!

Mites and ticks parasitize a variety of organisms. Spider mites damage houseplants and are major agricultural pests on crops such as cotton. Others—including chiggers, mange, and scabies mites—cause itching or painful rashes in humans and other mammals. Ticks can transmit bacteria that cause serious diseases, such as Rocky Mountain spotted fever and Lyme disease.

Scorpions Scorpions are widespread in warm areas around the world, including the southern United States. Scorpions have pedipalps that are enlarged into claws, as shown in **Figure 28–12.** The long, segmented abdomen of a scorpion carries a venomous stinger that can kill or paralyze prey. Unlike spiders, scorpions chew their prey, using their chelicerae.

CHECKPOINT *Where are scorpions usually found?*

BIO INSIGHTS

FACTS AND FIGURES

The sting of a scorpion

Most biologists think that scorpions have undergone little change over their history and are thus representative of the most ancient of land-dwelling arthropods. They probably moved onto land more than 300 million years ago during the Carboniferous Period. Scorpions usually spend most of the day hidden under rocks or logs. All scorpions are predators, and a scorpion first catches prey with its large front claws, or pedipalps. At the tip of a scorpion's abdomen is a stinging apparatus called the aculeus, which has a sharp, barbed point. At the base of the aculeus are venom-producing glands. When a scorpion catches prey, it stings it with the aculeus and ejects venom through the point, paralyzing the catch. Although scorpions are widely feared by people, only a few have venom that is extremely toxic to humans. *Centuroides,* which is native to the Southwest, is one scorpion whose venom can be deadly to humans.

Insects and Their Relatives

Centipedes, millipedes, and insects all belong to the subphylum Uniramia, or uniramians (yoo-nuh-RAY-mee-unz). This subphylum contains more species than all other groups of animals alive today. **Uniramians have jaws, one pair of antennae, and unbranched appendages.** They also have widely varying forms and lifestyles. Centipedes and millipedes have long, wormlike bodies composed of many leg-bearing segments, as shown in **Figure 28–13.** Insects have compact, three-part bodies, and most are adapted for flight. The insects are so diverse and important that they are discussed separately, in the next section.

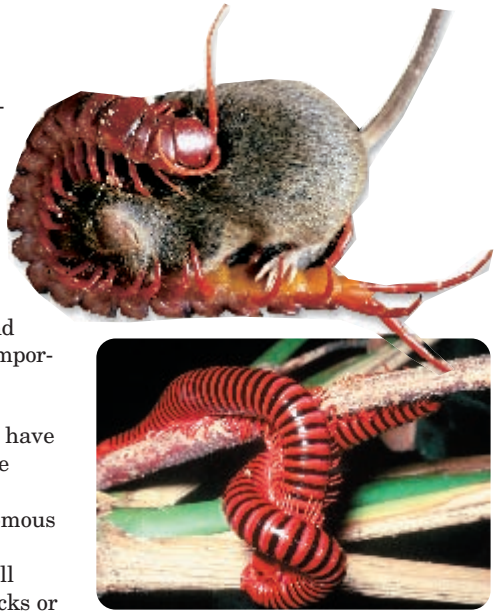


Figure 28–13 **Uniramians such as centipedes and millipedes have jaws, one pair of antennae, and unbranched appendages.** A centipede (top) is a carnivore that feeds on earthworms and other small animals. A millipede (bottom) is a herbivore that feeds on rotting vegetation.

Centipedes Centipedes belong to class Chilopoda. They have from a few to more than 100 pairs of legs, depending on the species. Most body segments bear one pair of legs each. Centipedes are carnivores whose mouthparts include venomous claws. They use these claws to catch and stun or kill their prey—including other arthropods, earthworms, toads, small snakes, and even mice. Centipedes usually live beneath rocks or in the soil. Their spiracles cannot close, and their exoskeleton is not waterproof. As a result, their bodies lose water easily. This characteristic restricts centipedes to moist or humid areas.

Millipedes Millipedes form class Diplopoda. Like the centipedes, millipedes have a highly segmented body. However, each millipede segment bears two, not one, pairs of legs. These two pairs of legs per segment develop from the fusion of two segments in the millipede embryo. Millipedes live under rocks and in decaying logs. They feed on dead and decaying plant material. Unlike centipedes, they are timid creatures. When disturbed, many millipedes roll up into a ball. This behavior protects their softer undersides. Millipedes may also defend themselves by secreting unpleasant or toxic chemicals.

28–2 Section Assessment

1. **Key Concept** What characteristics are used to classify arthropods?
2. **Key Concept** How do the three largest groups of arthropods differ?
3. Describe the process of digestion in spiders.
4. What characteristic of horseshoe crabs is different from most other chelicerates?
5. Compare and contrast the body plans and feeding habits of millipedes and centipedes.
6. **Critical Thinking Applying Concepts** Are insects more closely related to spiders or to centipedes? Explain.

Sharpen Your Skills

Problem Solving
Use information from this section to design a new type of arthropod. Make sure that the arthropod has all the characteristics described in this section. Draw the arthropod and give it a name. Include a brief description of what it eats and where it lives.

3 ASSESS

Evaluate Understanding

Call on students at random to explain the differences in structure among the three major groups of arthropods.

Reteach

Have students make a compare/contrast table to organize the information about the three major groups of arthropods. Headings might include *Group, Characteristics*, and *Examples*. They can use this table as a study aid.

Sharpen Your Skills

Consider working with an art teacher at your school in order to provide students with more options for their drawings. Drawings should be accompanied by a name and a brief description of the fantasy arthropod, including feeding and habitat. All organisms should have a segmented body, an exoskeleton, and jointed appendages. In their drawings, students should pay special attention to the structure of the arthropod's mouthparts.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 28–2.

28–2 Section Assessment

1. Arthropods are classified based on the number and structure of their body segments and appendages—particularly their mouthparts.
2. Students should describe characteristics of crustaceans, chelicerates, and uniramians.
3. Spiders first inject enzymes into prey to liquefy their food, and then suck the tissues into a specialized pumping stomach, which forces the liquid through the rest of the digestive system.
4. The abdomen and cephalothorax of horseshoe crabs are encased in a hard shell, and they use a long, spikelike tail for movement.
5. Most centipede segments bear a pair of legs; each millipede segment bears two pairs of legs. Centipedes use claws on prey; millipedes feed on dead or decaying organisms.
6. Insects are more closely related to centipedes because both belong to the subphylum Uniramia, which does not include spiders.

Answers to . . .

CHECKPOINT *Scorpions are widespread in warm areas around the world.*

Figure 28–12 *Some spiders catch prey in webs. Others stalk, then pounce on their prey. Others lie in wait beneath a camouflaged burrow, leaping out to grab insects that venture too near. Scorpions use a venomous stinger that can kill or paralyze prey.*