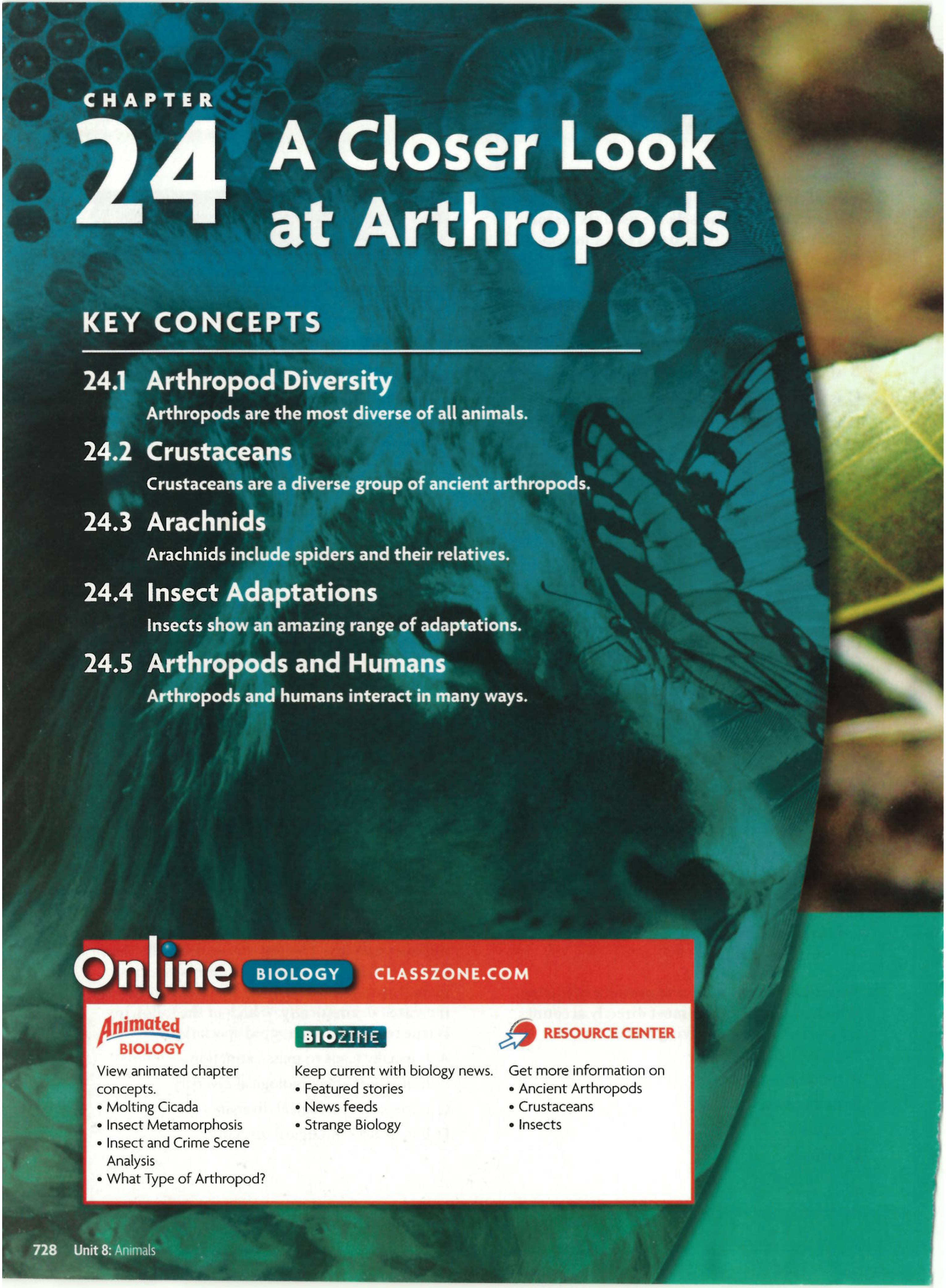

CHAPTER

24 A Closer Look at Arthropods

KEY CONCEPTS

24.1 Arthropod Diversity
Arthropods are the most diverse of all animals.

24.2 Crustaceans
Crustaceans are a diverse group of ancient arthropods.

24.3 Arachnids
Arachnids include spiders and their relatives.

24.4 Insect Adaptations
Insects show an amazing range of adaptations.

24.5 Arthropods and Humans
Arthropods and humans interact in many ways.

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STANDARDS-BASED ASSESSMENT

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1. The earliest classification system divided all animals into two main groups. Linnaeus' original classification scheme used six major groups of animals. Now, based on hundreds of years of scientific research, over 30 animal groups, or phyla, are recognized. This progression supports the idea that scientific evidence

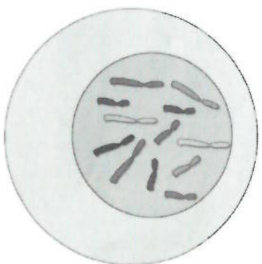
A changes frequently.

B should be disregarded after 100 years.

C is cumulative.

D is often incorrect.

2.



This illustration shows the chromosomes within the egg cell of a snail. If this egg cell unites with a sperm cell of the same snail species, the offspring will have

A 6 chromosomes from each parent.

B 6 pairs of chromosomes from each parent.

C 12 chromosomes from each parent.

D 12 pairs of chromosomes from each parent.

THINK THROUGH THE QUESTION

Recall that each egg and sperm cell has a single set of chromosomes.

3. Two roundworms mate and produce offspring. Which of the following most directly accounts for each offspring receiving half of its DNA from each parent?

A mutation

B maturation

C mitosis

D meiosis

4.

Appearance of Early Animals in Fossil Record

Organism Type	Appearance in Fossil Record
Sponges	570 million years ago
Mollusks	545 million years ago
Echinoderms	500 million years ago

Choanoflagellates are animal-like protists that do not leave behind fossil evidence. They are considered the most likely ancestors to sponges and all other animals. Given this information, when did choanoflagellates likely evolve?

A less than 500 million years ago

B between 545 and 500 million years ago

C between 570 and 545 million years ago

D more than 570 million years ago

5. Over one million species of animals have been described by scientists. Which of the following *best* accounts for the incredible diversity in the animal kingdom, given that all animals are thought to be descendants of a common ancestor?

A The DNA of the common animal ancestor had no mutations.

B New mutations are constantly generated in the gene pools of animal populations.

C Collagen has allowed animal populations to diversify rapidly.

D Heterotrophs are able to diversify more rapidly than autotrophs.

6. The "Cambrian Explosion" occurred about 500 million years ago. During this geologically short period of time, the number of animal species, including mollusks, arthropods, and chordates, increased dramatically. Which of the following is true regarding such rapid speciation?

A It usually leads to mass extinction.

B It does not affect biological diversity.

C It increases biological diversity.

D It decreases biological diversity.

What is the relationship between these two insects?

Connecting CONCEPTS

Arthropod predators such as this digger wasp help to keep an important balance among Earth's invertebrates. This digger wasp has captured a meal not for itself but for its young. The wasp will deposit the live, but paralyzed, grasshopper into a burrow she has constructed. She will then lay a single egg next to the grasshopper so when the egg hatches the larva will have a fresh meal.

Animal Behavior Unlike the solitary digger wasp, many insects live in large social colonies. This paper wasp nest has been carefully constructed of wood pulp mixed with the insects' saliva. Within the colony, all insects are related to one another. A single queen lays eggs, which are raised by workers. Wasps will aggressively defend their nests from predators to ensure that the colony survives.

24.1 Arthropod Diversity

KEY CONCEPT Arthropods are the most diverse of all animals.

MAIN IDEAS

- Arthropod features are highly adapted.
- Arthropod exoskeletons serve a variety of functions.
- Arthropod diversity evolved over millions of years.

VOCABULARY

arthropod, p. 730
exoskeleton, p. 730
chitin, p. 730
appendage, p. 730
segmentation, p. 730

Review
cuticle

REVIEW AT CLASSZONE.COM

Connect Earth is truly ruled by bug-eyed monsters. In just about every way, arthropods are the most successful animal phylum on Earth. More than three-fourths of all known animals—more than 1 million species—are arthropods. They play an important role in every ecosystem on the planet. What makes this phylum so interesting? Arthropods are as diverse in shape and size as any life form on Earth, and are the result of millions of years of adaptation.

MAIN IDEA

Arthropod features are highly adapted.

Without knowing it, almost everywhere you go, you are interacting with arthropods. They can be found in the carpet you walk on and in the bed where you sleep. An **arthropod** is an invertebrate animal with an exoskeleton made of chitin; a series of paired, jointed appendages; and segmented body parts.

Arthropod Characteristics

The entire surface of an arthropod's body is covered by a protective exoskeleton. An **exoskeleton** is an external skeleton that supports the animal's tissues against gravity. Arthropods, such as the rhino beetle in **FIGURE 24.1**, have exoskeletons made of proteins and chitin. **Chitin** (KYT-uhn) is a long organic molecule made of sugars—similar to plant cellulose—that is arranged in layers. In each layer, fibers are laid out parallel to one another. But fibers in different layers point in different directions, forming a biological "plywood" that is very tough and strong. Like armor, chitin also protects the animal from predators.

Jointed appendages were an important adaptation during the evolution of arthropods. An **appendage** is an extension of an organism's body. It can be used for walking, swimming, sensing, manipulating food, or chewing. Arthropods can have six, eight, ten, or even hundreds of appendages. The appendages can be shaped like rakes, tweezers, nutcrackers, hammers, or paddles.

Arthropods have an incredible variety of body forms. Some are microscopic, while others are quite large. For example, some tropical stick insects and millipedes can reach 30 centimeters (1 ft) in length, and spider crabs can have an arm span of 3.6 meters (12 ft). But all arthropod bodies are segmented for specific functions. **Segmentation** describes how an arthropod's body parts are divided into similar sections that have each evolved for a different function.

FIGURE 24.1 The hard exoskeleton of this rhino beetle is constructed of layers of chitin that help protect it from predators.

Arthropod Groups

Classifying animals with so many differences might seem difficult, but most fossil and living arthropod species can be placed into one of five groups.

- **Trilobites** Trilobites are now extinct but were an important part of Paleozoic marine ecosystems for nearly 300 million years. As you can see in **FIGURE 24.2**, their bodies were divided into three long vertical sections, or lobes. A central body and outgrowths of shell on each side covered their many delicate legs. Most of the 4000 known species were bottom feeders, sucking up muck, algae, or soft animals from the sea floor.
- **Crustaceans** Among the most familiar arthropods, crustaceans (kruh-STAY-shuhnz) are found in all of the oceans, freshwater streams, and even on land. Crustaceans are a diverse group that includes huge king crabs and lobsters, microscopic copepods, oysterlike barnacles, and armored pill bugs.
- **Chelicerates** The group known as chelicerates (kih-LIHS-uh-RAYTS) includes horseshoe crabs, scorpions, spiders, mites, ticks, and the extinct sea scorpions. These animals share a set of specialized daggerlike mouthparts that are used for tearing their food.
- **Insects** Insects account for 80 percent of all known animal species. Familiar animals such as ants, bees, butterflies, moths, cockroaches, flies, and mosquitoes are all insects. Though this group is very diverse, most insects are terrestrial and have six legs.
- **Myriapods** The most commonly known myriapods (MIHR-ee-uh-PAHDS) are centipedes and millipedes. Their long bodies and many pairs of legs are the most distinctive characteristics of the myriapods. The largest species can grow up to a foot long. They generally live in humid environments, such as leaf litter, decaying wood, or moist soil. The first pair of legs in centipedes bear poisonous fangs for capturing prey.

Infer How did the evolution of jointed appendages lead to the wide variety of arthropods we see today?

FIGURE 24.2 Trilobite fossils such as this one show the exoskeleton, segmentation, and jointed appendages. These features led scientists to suggest that trilobites were one of the first marine arthropods.

TAKING NOTES

Use a main idea diagram to outline the unique features of each arthropod group.

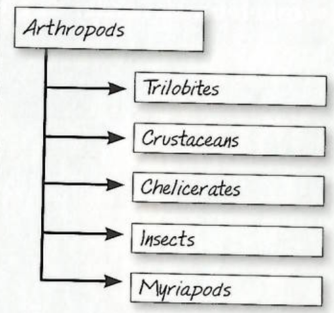


FIGURE 24.3 Arthropod Diversity

Arthropods are a diverse group of animals. Millions of years of evolution has led to many different body forms and functions.

CRUSTACEANS

Crab As aquatic arthropods, crabs have appendages adapted for both swimming and walking.

CHELICERATES

Scorpion The carnivorous scorpions have sharp appendages for tearing apart their prey.

INSECTS

Butterfly Insects have three pairs of jointed appendages that are used for many different functions.

MYRIAPODS

Centipede Many pairs of legs make centipedes suited to a wide variety of biomes.

MAIN IDEA

Arthropod exoskeletons serve a variety of functions.

Connecting CONCEPTS

Chemistry of Life Recall that in **Chapter 2**, you learned about the plant structure cellulose. The molecular structure of chitin forms a polymer similar to plant cellulose. This rigid structure contributes to the strength of an insect's exoskeleton.

All arthropods have an exoskeleton and its structure determines how an arthropod lives. Recall that an exoskeleton is made of many layers of chitin. Chitin is not living tissue, and having a living body crammed into a hard exoskeleton is similar to how a medieval knight would wear a suit of armor. Despite the protective benefits, an exoskeleton makes important functions, such as movement, growth, and maintaining internal and external equilibrium, difficult. Over millions of years, arthropods have developed ways of managing normal functions that are both efficient and effective.

Movement and Growth

Movement Two types of cuticle plates assist in movement. Stiff cuticle plates of the exoskeleton are separated by sections of more flexible cuticle that form joints in the hard armor. When muscles stretching across exoskeleton joints contract, they bend the joint so the arthropod can move. The cuticle supporting arthropod legs acts as a spring, efficiently storing and releasing energy as the animal moves.

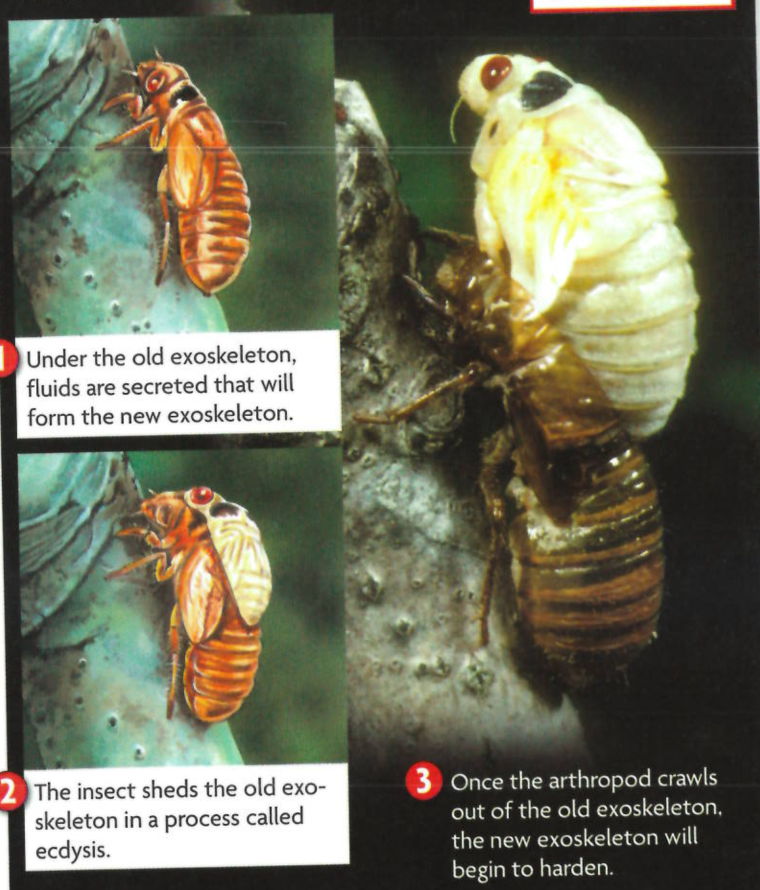
Molting Arthropod cuticle cannot grow along with the animal, so an arthropod must shed its exoskeleton in a process called molting. This process of shedding and reforming a new exoskeleton is illustrated in **FIGURE 24.4**.

1. Before molting, the animal secretes a new layer of cuticle underneath its exoskeleton. The new cuticle layer will actually be larger than the layer of cuticle covering it.
2. The animal secretes enzymes that begin to digest and weaken the old cuticle, allowing the exoskeleton to split open and the animal to crawl out of it. This is as extreme as it sounds—the animal must shed every surface of its body, including the entire lining of its gut and tracheae. Some animals die in the process.
3. The new exoskeleton is filled with fluid while it is still soft, making the animal larger than it was before the molt. However, the exoskeleton takes time to harden. During this time, the animal is very vulnerable to predators.

FIGURE 24.4 Molting

Arthropods must molt their old exoskeletons in order to grow.

Animated BIOLOGY Watch a cicada molt at ClassZone.com.



1 Under the old exoskeleton, fluids are secreted that will form the new exoskeleton.

2 The insect sheds the old exoskeleton in a process called ecdysis.

3 Once the arthropod crawls out of the old exoskeleton, the new exoskeleton will begin to harden.

Apply **What are the advantages and disadvantages of going through the process of molting?**

Managing Internal and External Functions

Circulation Arthropods have an open circulatory system, in which blood is pumped through a tubelike heart and out into the body cavity. In comparison, vertebrates have a closed circulatory system, in which blood is contained inside a system of arteries, veins, capillaries, and a heart. In an open circulatory system, blood is pumped through the heart and into the body, where it comes in direct contact with organs and tissues. The stiff exoskeleton of arthropods also helps control blood pressure. Because an exoskeleton does not change shape, when the heart pumps blood out into the body, the exoskeleton keeps the blood contained, while body movements keep it circulating.

Senses Most arthropod sensory organs, including antennae, are made of modified cuticle. Hard cuticle would otherwise block environmental stimuli. Antennae and body hairs allow an arthropod to sense its surrounding environment, including temperature, touch, sound, and smell.

Most arthropods also have compound eyes. Unlike mammalian eyes, which have a single lens that collects all visual information, arthropod eyes have thousands of tiny individual lenses that interpret only a small portion of the field of view. The image in **FIGURE 24.5** gives an idea of how many individual eyes form a single compound eye. When all of these individual images come together, they form a rough mosaic of an object that resembles a newspaper or magazine image.

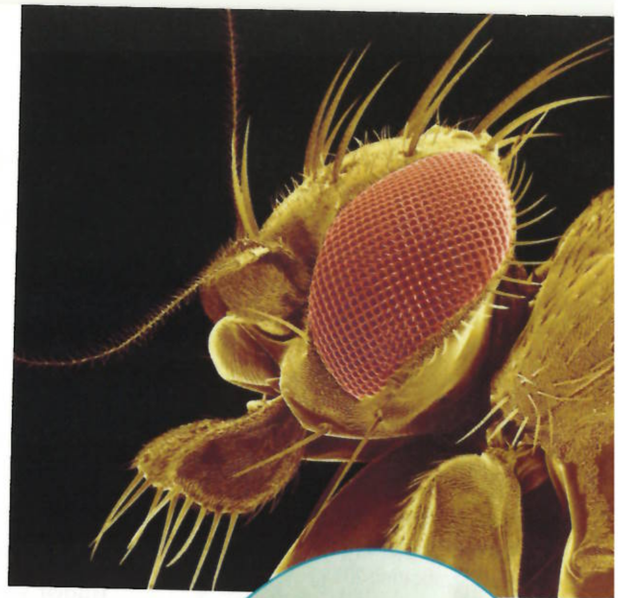


FIGURE 24.5 The compound eye of this fruit fly contains 800 individual eye units. These eyes are highly sensitive to movement and can also determine colors.

Summarize **How does an exoskeleton make functions such as movement and growth difficult?**

QUICK LAB **COMPARING**

Comparing Arthropods

In this lab you will examine and compare the structures of different arthropods.

PROBLEM How do arthropods differ from one another?

PROCEDURE

1. Choose one of the four arthropod slides. Observe one organism under low power. Switch to high power and draw and label the structures of each organism.
2. Repeat the process with a second slide and compare features such as appendages, antennae, and body segments between the two organisms.
3. Find another group who viewed different specimens. View and note any differences between their specimens and yours.

MATERIALS

- slide of tick
- slide of mite
- slide of spider
- slide of mosquito
- microscope

ANALYZE AND CONCLUDE

1. **Observe** What unique structures did you notice on the slide specimens? Predict what uses these structures may have for the survival of each organism.
2. **Evaluate** What similar features do the organisms share? Based on your observations, how closely related do you think the specimens are?

MAIN IDEA

Arthropod diversity evolved over millions of years.

FIGURE 24.6 The velvet worm (top) and the water bear (below) belong to two phyla thought to be the closest relatives of arthropods. (colored SEM water bear; magnification 200×)

All of the major arthropod groups are incredibly old. The oldest arthropod fossils are trilobites from the early Cambrian period, about 540 million years ago. The oldest known chelicerates and crustaceans appeared a few million years later, during the Cambrian explosion. The oldest known myriapod fossils are younger—about 415 million years old—but trace fossils from rocks in Pennsylvania suggest myriapods are older than this. During the next 100 million years, rapid diversification of arthropod species resulted in the appearance of all the major groups of arthropods. Many of today's arthropods are very similar to the arthropods that lived hundreds of millions of years ago. Because the major groups of arthropods appeared so long ago, relationships between them are difficult to determine, and many questions about classification still exist.

Based on similarities in body structures, some scientists think that arthropods are most closely related to annelid worms. Because both groups have segmented bodies, some scientists hypothesize they share a similar ancestry. Recent molecular evidence indicates that annelids and arthropods may have evolved segmentation independently. Two other members of the Ecdysozoa, velvet worms and water bears, are thought to be the closest living relatives of the arthropods. You can see these animals in **FIGURE 24.6.**

- **Velvet worms** (phylum Onchyophora) are soft-bodied carnivorous invertebrates that can grow up to 10 centimeters in length and are covered with a thin cuticle layer. They roam about the tropical forest floor on many unjointed legs, hunting for termites and small mollusks.
- **Water bears** (phylum Tardigradia) are microscopic invertebrates, less than one millimeter in length. Water bears are commonly found in the mud of marine, freshwater, and terrestrial environments. They are omnivores, feeding on plants, algae, dead organic matter, and other organisms.

Analyze Explain how ancient fossils can be used to determine relationships between modern arthropods.

24.1 ASSESSMENT

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REVIEWING MAIN IDEAS

1. What are the five main groups of **arthropods**?
2. What characteristics make the phylum Arthropoda unique?
3. Why are the relationships between arthropod families so difficult to determine?

CRITICAL THINKING

4. **Contrast** How are the structures used for supporting organs different in arthropods and humans?
5. **Synthesize** Fossils reveal that arthropods have been walking the planet for nearly 500 million years. How have arthropods survived for so long? What features have allowed them to be so successful?

Connecting CONCEPTS

6. **Anatomy** In contrast to arthropods, humans have an internal skeleton. What advantages and disadvantages does this type of support system have, as compared with an **exoskeleton**?

24.2 Crustaceans

KEY CONCEPT Crustaceans are a diverse group of ancient arthropods.

MAIN IDEAS

- Crustaceans evolved as marine arthropods.
- Crustacean appendages can take many forms.
- There are many different types of crustaceans.

VOCABULARY

crustacean, p. 735
cephalothorax, p. 735
abdomen, p. 735
carapace, p. 735
mandible, p. 737

Review
filter feeding, sessile

REVIEW AT CLASSZONE.COM

Connect If you have ever eaten a shrimp, you may have an idea of what a crustacean looks like. But this large group of arthropods is surprisingly diverse. Shrimp and lobsters are crustaceans, but so are the tiny brine shrimp better known as "sea monkeys." Tadpolelike copepods, oysterlike barnacles, and the pill bugs that live under damp rocks in your garden are also crustaceans.

MAIN IDEA

Crustaceans evolved as marine arthropods.

Crustaceans are a group of arthropods that have two distinct body sections, a hard exoskeleton, two pairs of antennae, and one pair of appendages per segment. Crustaceans evolved in the oceans, and today most crustaceans still live in saltwater environments. But there are also many freshwater species, and a few have evolved to survive on land.

Crustaceans come in a variety of shapes and sizes. They are vital to the stability of aquatic ecosystems. Some species, such as the violet-spotted reef lobster in **FIGURE 24.7,** are predators of marine fish, mollusks, and worms, while others scavenge dead animals and plants. Most importantly, crustaceans are a significant food source for larger animals. Large crustaceans such as shrimp, lobsters, and crabs are a primary food source for fish, birds, seals, and even humans. But there are also numerous species of microscopic crustaceans. Zooplankton, krill, and copepods are very small as adults but are so abundant that they constitute an important food source for fish, whales, and many species of filter-feeding crustaceans.

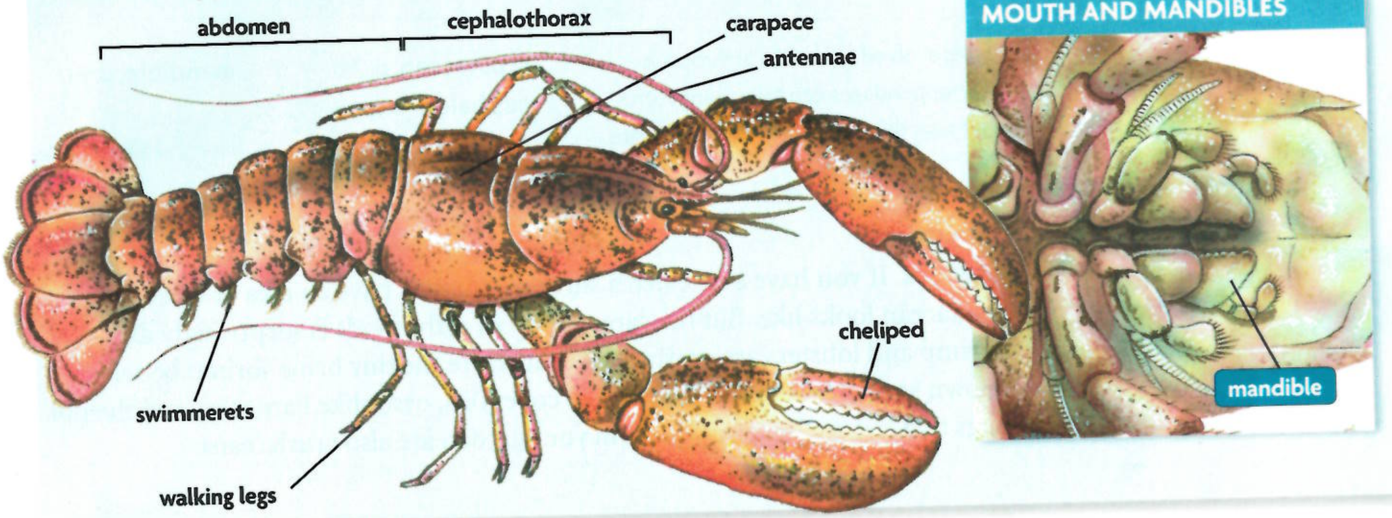
FIGURE 24.7 Crustaceans such as this violet-spotted reef lobster can be found in all of Earth's oceans. They play an integral role in marine ecosystems.

Crustacean bodies are made up of two distinct body sections, a cephalothorax and an abdomen. The **cephalothorax** (SEHF-uh-luh-THAWR-aks) is the region of an organism in which the head and trunk region are combined into one long section. The **abdomen** refers to the rear portion of the organism. The cephalothorax is covered by a shieldlike section of cuticle called the carapace. The **carapace** (KAR-uh-PAYS) covers the sides of the body and protects the gills. The largest crustaceans have a cuticle layer with calcium deposits that make the carapace a hard shell.

Connect Describe how a decrease in marine crustacean populations could affect an ocean ecosystem.

FIGURE 24.8 Crustacean Anatomy

The anatomy of a crustacean is well suited to its underwater habitat. Crustacean appendages are adapted for many different purposes.



MAIN IDEA

Crustacean appendages can take many forms.

All crustacean appendages are homologous structures. Anatomical structures are homologous when they share a common origin. For example, your arm is homologous to a bat wing because long ago, humans and bats shared a common ancestor. As the ancestors of bats and humans evolved, different uses for the same appendage structures developed. In bats, the appendage evolved into a winglike structure, while in humans, the appendage evolved into the arm structure we have today.

Long ago, crustacean appendages probably all looked the same. Today, crustacean appendages have been modified for a variety of different functions. Crustacean appendages are used for sensing the environment, defending against predators, walking, feeding, and even attracting mates.

FIGURE 24.9 The mantis shrimp is a crustacean that spends most of its time scavenging for food. Many species of shrimp and prawn inhabit the coastlines of every continent.

Crustacean appendages are adapted to an underwater habitat and are essential for survival. The illustration in **FIGURE 24.8** shows many of the different types of crustacean appendages. Probably the best known of crustacean appendages are the large claws that are found on many species of crabs and lobsters. Lobsters' claws, or chelipeds (KEE-luh-PEHDZ), are used for collecting and manipulating food. But chelipeds can be specialized for other jobs. Male fiddler crabs have large claws that are used to attract females. Some hermit crabs use their claws to block the entrance to the shells in which they live. There are also some mantis shrimp, such as the one shown in **FIGURE 24.9**, that have hunting claws shaped like clubs. The clubs are attached to spring-loaded limbs that can strike at more than 22 meters per second (50 mph), letting the shrimp break through snail shells to feed.

All crustaceans have two pairs of antennae on their head. These appendages have a covering of tiny hairs packed with chemical sensors. As antennae flick through the water, crustaceans use these appendages to smell food, locate mates, and avoid predators. Some crustaceans, such as the tiny water flea *Daphnia,* use the hairy antennae as oars to move around. Many species of spiny lobsters rub antennae against their cephalothorax to make loud calls that are thought to startle predators.

Crustaceans, like other arthropods, have mouths composed of a pair of hard appendages called mandibles. **Mandibles** are highly adapted appendages that crush and bite food before ingestion. Other appendages near the mouth can act as additional jaws and tear food into bits. In copepods, they can collect food from the water and push it toward the animal's mouth.

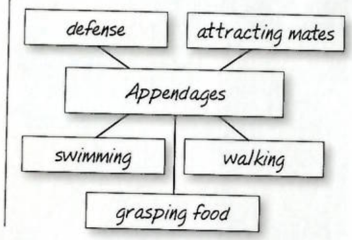
Appendages such as walking legs allow a crustacean to move along the ocean floor as it scavenges for food. Swimming requires additional specialized appendages called swimmerets, which move in wavelike motions to propel the crustacean through the water.

As their appendages changed shape over time, crustaceans were able to use them for more than movement. This diversification of appendages allowed crustaceans to specialize and move into different ecological niches. The speciation of crustaceans through changes to their appendages is a good illustration of the process of natural selection.

Summarize Give three examples of crustacean appendages and how they are used.

TAKING NOTES

Use a main idea web to describe the many ways arthropods use jointed appendages.



MAIN IDEA

There are many different types of crustaceans.

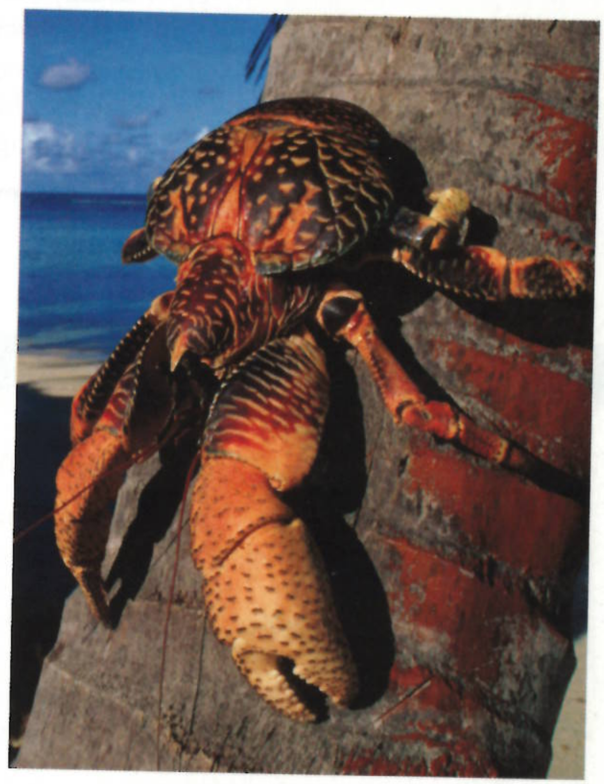
Crustaceans vary in both anatomy and structure. However, they are all similar in how they develop into the adult form.

Decapods

When you think of a crustacean, you are probably thinking of a decapod. This familiar group includes lobsters, crabs, and shrimp, as well as hermit crabs, their cousins the king crabs, and many others. Decapods live primarily in saltwater environments, but species such as crayfish have invaded fresh water. Some crabs, such as the coconut crab shown in **FIGURE 24.10,** even venture onto land to look for food.

Decapods have characteristic features that distinguish them from other crustaceans. The name *decapod* means "ten legs," so all decapods have five pairs of jointed appendages that are used for many different purposes. Decapods also have fused body segments that contain two regions, the cephalothorax and abdomen.

FIGURE 24.10 This coconut crab is the largest terrestrial arthropod in the world, and can have a leg span of almost 1 meter. Primarily a nocturnal creature, this arthropod feeds on coconuts it cracks open using a powerful cheliped.



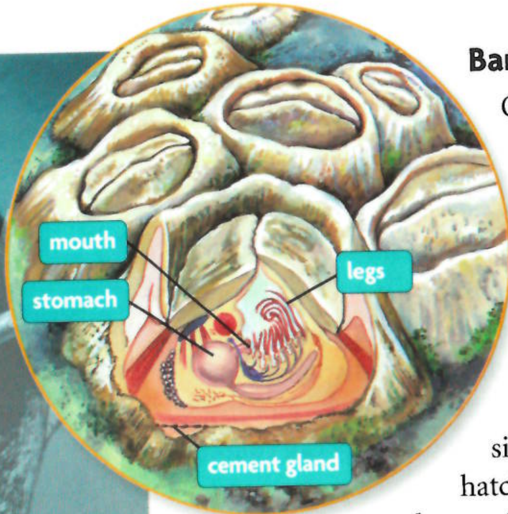


FIGURE 24.11 Attached to the skin of this humpback whale, thousands of barnacles use the whale's constant movement through the water to filter food from the water.

Barnacles, Isopods, and Tongue Worms

Other species of crustaceans look nothing like a "typical" decapod. Although these species are different in structure from other crustaceans, scientists discovered from developmental evidence that most crustaceans pass through similar phases as they grow into adults. Almost all juvenile crustaceans pass through a free-swimming planktonic larval stage. The most common of these larva forms is the nauplius larva. A nauplius larva has a carapace and six long, feathery limbs. When scientists looked at newly hatched barnacles and tongue worms, they found nauplius larvae. Only crustaceans have nauplius larvae, so both groups are recognized as crustaceans. But as they grow into their adult form, these crustaceans look very different from any other crustacean.

- **Barnacles** Barnacles are sessile, or nonmoving, filter feeders wrapped in a heavily calcified shell. They live attached to the surface of rocks, boats, sea turtle shells, and even the skin of humpback whales, such as the one shown in **FIGURE 24.11.** Barnacles have turned their carapace into a saclike "mantle" (similar to that found in a mollusk) that secretes a calcium shell. Inside the shell, the animal sits on its head and sweeps food into its mouth with its legs.
- **Isopods** Isopods have flattened bodies and seven pairs of legs. Most species are marine and freshwater scavengers. Pill bugs and wood lice belong to a group of isopods that have become completely terrestrial. These animals usually live in damp habitats and eat rotting plants.
- **Tongue worms** Tongue worms are parasites that live in the lungs and nasal passages of vertebrates. They have no eyes, mandibles, or antennae, and they have lost most of their limbs. Despite this, molecular evidence shows tongue worms to be most closely related to crustaceans.

Analyze What evidence helped scientists to classify barnacles and tongue worms as crustaceans?

24.2 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What characteristics make **crustaceans** different from other arthropods?
2. What are some of the different functions of arthropod appendages?

CRITICAL THINKING

3. **Summarize** Draw a food web that includes at least three different types of arthropods.
4. **Infer** How did the discovery of nauplius larvae allow scientists to categorize barnacles and tongue worms as crustaceans?

Connecting CONCEPTS

5. **Evolution** Lobster claws can grow extremely large. What selective pressures may have led to the evolution of such large appendages?

Hatching Brine Shrimp

Brine shrimp are small arthropods found in oceans, salt lakes, estuaries, and tidal ponds. Brine shrimp are used primarily for fish food, especially on fish farms where natural food sources are unavailable. Their eggs can be harvested and hatched under controlled conditions by biologists working in an aquaculture facility. In this investigation, you will design an experiment to determine the best conditions for hatching brine shrimp eggs.

MATERIALS

- clear plastic cups
- 100-mL graduated cylinder
- 400 mL sea salt solution
- 0.1 g brine shrimp eggs
- plastic spoon
- balance
- clear plastic wrap
- aluminum foil
- clear plastic bottles with lids
- vinegar
- baking soda
- pH duo-test paper
- 2 eyedroppers
- 10 petri dishes
- hand lens or dissecting microscope
- lamp

PROCESS SKILLS

- **Designing Experiments**
- **Collecting Data**
- **Analyzing**
- **Predicting**

PROBLEM What are the best conditions for hatching brine shrimp eggs?

PROCEDURE

1. Choose one factor to investigate. Some factors to consider are the presence or absence of light, aeration (open container versus air-tight container), and pH (6–8). Make a hypothesis about that factor, and design an experiment to test your hypothesis. Have your teacher approve your design.
2. The conditions of the hatching (temperature, pH, light conditions, and so on) will depend upon your independent variable. If you are testing pH, use vinegar to adjust the pH of the sea salt solution to pH 6.0 or baking soda to adjust the pH to 8.0 as measured with the pH test paper.
3. Determine the number of cups of brine shrimp needed based on your experimental design. Be sure to include a control. Hatch the brine shrimp eggs by filling each cup with 200 mL sea salt solution and 0.1 g brine shrimp eggs. Cover the cups with plastic wrap or aluminum foil depending upon your experiment. If you are testing aeration, use bottles with lids instead of cups.
4. Once you have set up your cups or bottles, remove 5 mL from each with an eyedropper and place each volume in a separate clean petri dish.
5. Examine each dish with a hand lens or microscope. Count the number of eggs and the number of hatched brine shrimp. Note these numbers.
6. Repeat steps 4 and 5 each day for five days and note the numbers of hatched shrimp and eggs each day.

ANALYZE AND CONCLUDE

1. **Analyze** Graph the data with the number of shrimp hatching or number of shrimp hatching rate (shrimp hatching divided by number of eggs) on the *y*-axis and the days on the *x*-axis.
2. **Analyze** On what day did you observe the most shrimp hatching? Was this day consistent with the findings of other members of your group? List possible reasons for inconsistent results.
3. **Experimental Design** Identify possible sources of error in your experiment and give reasons why they might have occurred.
4. **Analyze** How did your factor affect the hatching of brine shrimp?
5. **Infer** Compare your team's result with other teams in your group. Identify conditions that had the most positive effect on the hatching of brine shrimp.
6. **Experimental Design** Explain why it was important to have a control in your experiment.

24.3 Arachnids

KEY CONCEPT Arachnids include spiders and their relatives.

MAIN IDEAS

- Arachnids are the largest group of chelicerates.
- Arachnids have evolved into a diverse group.

VOCABULARY

chelicerate, p. 740
arachnid, p. 740
book lung, p. 740
spiracle, p. 741
trachea, p. 741

REVIEW AT CLASSZONE.COM

Connect At first, the bump on Emily's back looked like an insect bite. But soon the rash grew into a bulls-eye that was six inches wide. Emily began complaining of aches, and her temperature shot up to 102 degrees. A trip to the doctor gave her parents a startling surprise—Emily had Lyme disease. This disease is caused by bacteria that is carried and spread by a tiny arachnid called a deer tick.

MAIN IDEA

Arachnids are the largest group of chelicerates.

Deer ticks are chelicerates—arthropods without mandibles. **Chelicerates** (kih-LIHS-ur-AYTS) are arthropods that lack antennae and have six pairs of appendages, which include four pairs of walking legs. One set of highly modified appendages form fanglike mouthparts called chelicerae, which are used to mash up food and shove it into a holelike mouth. A second set of appendages, called pedipalps, are used to grasp and subdue prey. Chelicerate bodies have two sections: a cephalothorax and an abdomen.

There are three main groups of chelicerates. The horseshoe crabs and sea spiders are two of these groups. Arachnids are the third group, representing more than 80 percent of all chelicerate species. **Arachnids,** such as the spiny spider shown in **FIGURE 24.12,** are a terrestrial group of chelicerates characterized by eight legs, fanglike pincers that inject venom, and the ability to produce silk.

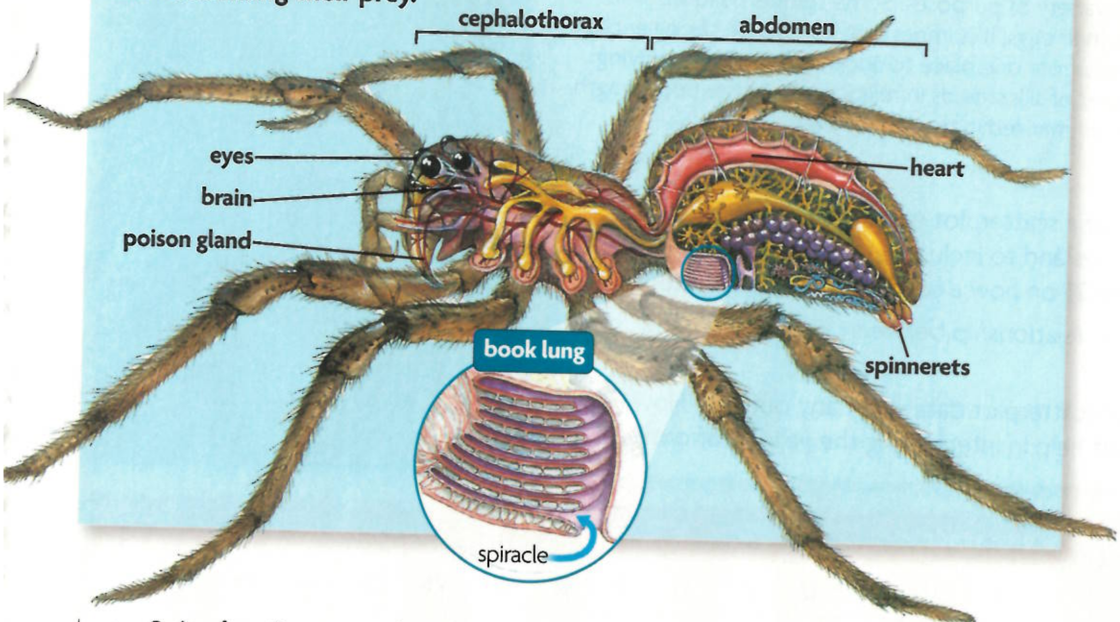
Evidence from fossils nearly 400 million years old suggests that arachnids evolved adaptations that allowed them to conserve water and live on land. Arachnids have four different adaptations that reduce water loss.

- **Waterproof cuticle** An arachnid's cuticle is waterproof, so water cannot evaporate across the skin.
- **Book lungs** Some arachnids have specialized respiratory structures called book lungs that allow them to breathe air. **Book lungs** are structures built of many thin, hollow sheets of tissue that look like the pages of a book. They provide a large surface for gas exchange but also create a very large surface for water loss. To prevent water loss, book lungs are enclosed in a humid chamber covered by a plate of abdominal cuticle.
- **Malpighian tubules** Excretory structures called Malpighian (mal-PIHG-ee-uhn) tubules allow spiders to minimize loss of water while excreting metabolic wastes.

FIGURE 24.12 The bright coloration of the spiny spider actually attracts insects to the spider's web, where they are trapped and made into an easy meal.

FIGURE 24.13 Arachnid Anatomy

Arachnids have many unique adaptations for catching and consuming their prey.



- **Spiracles** Some species of arachnid use spiracles to breathe. **Spiracles** are tiny holes on the abdomen that open and close to allow oxygen to enter. Oxygen flows through a series of tubes called tracheae. **Tracheae** (singular, *trachea*) carry oxygen directly to the arachnid's tissues.

Explain **How do the features of an arachnid allow it to live on land?**

VOCABULARY

The word *spiracle* comes from the Latin word *spirare* meaning "to breathe."

MAIN IDEA

Arachnids have evolved into a diverse group.

Spiders make up half of the more than 60,000 known arachnid species. They are predators that hunt or trap their prey. All spiders have the ability to make silk and produce venom. Silk is made by glands in the spider's abdomen and released by modified appendages called spinnerets. Spiders use silk for building webs, wrapping prey and egg cases, building shelters, and producing drag lines that anchor the animal like a climber's safety line.

All spiders produce venom. Spiders inject venom into their prey through modified chelicerae. Neurotoxic proteins paralyze the victim by attacking the central nervous system, and digestive enzymes in the venom begin to dissolve the prey from the inside. Among North American spiders, only the black widow and brown recluse spiders have venom that can affect a human, but many species around the world have venom that can paralyze or even kill humans.

Mites, ticks, and chiggers are a large group of very small arachnids. Some species are less than 0.25 millimeters long. Many are parasites of plants and animals, sucking up sap or blood through their needlelike mouthparts. Scorpions are arachnids with huge pincers for grabbing their prey after it has been injected with venom from a stinger at the end of their tail. Scorpions hunt at night by feeling the vibrations made as their prey moves.

Connecting CONCEPTS

Neurotransmitters Neurotoxins in the venom of spiders disrupt neurotransmitter function and lead to paralysis of a victim. You will learn more about the nervous system and neurotransmitters in **Chapter 29**.

DATA ANALYSIS

CONSTRUCTING SCATTERPLOTS

Spiders produce silk for a wide variety of purposes. Some spiders build webs to capture prey, or to safely wrap their eggs. It is important that silk be strong enough to support the spider as it moves from one place to another. Scientists studying spider silk measured the diameter of silk strands in relationship to the body length of the spider. Their results are summarized in the table below.

1. **Graph Data** Construct a scatterplot using the data from the table. Be sure to label the axes and to include a title for your graph. Refer to page 721 in Chapter 23 on how a scatterplot is constructed.
2. **Interpret** What is the relationship between silk diameter and spider length?
3. **Interpret** Does your scatterplot data show any outliers? How might a larger data set help in interpreting the validity of outliers?

TABLE 1. SPIDER LENGTH AND SILK DIAMETER

Body length (mm)	7	8	10	11	12	15	16	17	18	20	25	26	26	35	40	45
Silk diameter (mm)	.02	.03	.03	.04	.04	.06	.05	.08	.06	.05	.08	.09	.10	.18	.14	.15

Most scorpions eat insects, spiders, and other scorpions, while some of the largest species eat lizards and small rodents.

Arachnids are important prey species for vertebrates, but they are even more important as predators. Spiders are some of the most widespread predators on the planet and play an important role in most terrestrial food webs. The mass of the insects they eat each year is larger than the combined mass of all human beings. Mites and ticks also have a major impact on ecosystems. Spider mites are serious pests of fruit trees, cotton, and other crops. Ticks can transmit serious human diseases such as Rocky Mountain spotted fever and Lyme disease.

Infer How might the loss of many arachnid species affect an ecosystem?

NSTA SCILINKS scilinks.org
To find out more about arachnids, go to scilinks.org.
Keycode: MLB024

24.3 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What unique features do all **arachnids** share?
2. What four adaptations do arachnids have for conserving water?
3. Why are spiders such an important part of an ecosystem?

CRITICAL THINKING

4. **Summarize** How do **book lungs** help arachnids to reduce water loss?
5. **Infer** Spiders use different kinds of silk for different purposes. What might a spider build with sticky silk?

Connecting CONCEPTS

6. **Ecology** Describe a situation in which spiders would be a secondary consumer. What species might prey on a spider? Draw a simple food web to illustrate your answer.

24.4 Insect Adaptations

KEY CONCEPTS Insects show an amazing range of adaptations.

MAIN IDEAS

- Insects are the dominant terrestrial arthropods.
- Insects undergo metamorphosis.
- Insects have adapted to life on land.

VOCABULARY

incomplete metamorphosis, p. 744
complete metamorphosis, p. 744
pupa, p. 744

REVIEW AT CLASSZONE.COM

Connect Everywhere you turn, there are more of them. They are under your feet, flying over your head, nestled in your clothing fibers, and waiting for you to go to bed. Insects are virtually everywhere, and many times you may not even know it. With more than 900,000 known species, insects are the single largest and most diverse group of animals on the planet.

MAIN IDEA

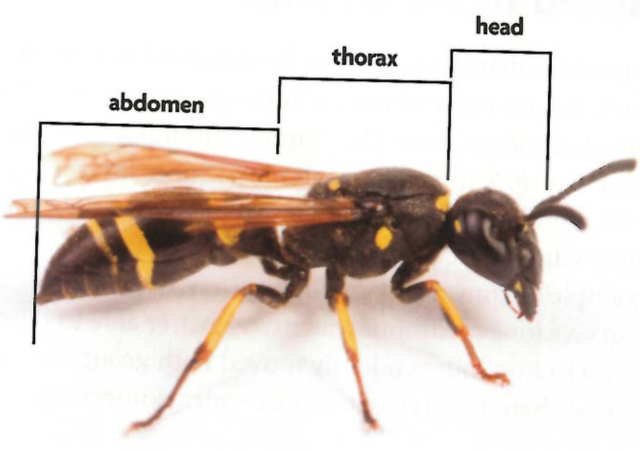
Insects are the dominant terrestrial arthropods.

Insects are an incredible success story. Like the arachnids, they invaded land around 400 million years ago. They have many of the same adaptations for terrestrial life as arachnids do. Insects have moved into virtually every ecological niche, which has helped them diversify into the largest group of animals.

Insects can be found in the most extreme places, including hot sulphur springs and the soil of Antarctica. They are also found in streams and ponds. Though some species live in the marine intertidal zone, they are largely absent in the seas, where crustaceans are the dominant arthropods. Due to such a wide distribution, scientists are discovering new species of insects each day.

All insects have a body with three parts: a head, a central region called the thorax (THAWR-AKS), and an abdomen, as shown in **FIGURE 24.14.** The thorax has three pairs of legs, and most adult insects also have two pairs of wings. Insects usually have one pair of antennae and one pair of compound eyes. Many have mandibles that they use to chew up their food, but others have modified mouthparts for more specialized feeding behaviors.

FIGURE 24.14 This potter wasp illustrates the three-part body structure of all insects: head, thorax, and abdomen.



Some insect species live in colonies of hundreds or thousands of individuals. Within these colonies, complex social structures exist. Individuals perform specific jobs that help the colony be successful. Scientists believe that an insect's genetic code determines what role it will play in a colony.

Compare and Contrast How are insects similar to and different from crustaceans and arachnids?

MAIN IDEA
Insects undergo metamorphosis.

VOCABULARY
The word *metamorphosis* comes from the Greek word *metamorphoun*, which means "to transform."

Insects do not develop the same way you do. When you were first born, you had all of the same body parts as an adult. The same is not true of most insects. Some insects, such as butterflies and mosquitoes, go through dramatic physical changes between their immature and mature forms.

Some insects, such as grasshoppers and cockroaches, look like miniature adults when they hatch. This pattern of development, illustrated in **FIGURE 24.15**, is **incomplete metamorphosis** (MEHT-uh-MAWR-fuh-sihs), or direct development. These immature insects are often called nymphs. They have six legs and a head, thorax, and abdomen, but they do not have wings or sex organs. Nymphs get larger with each molt, but only grow wings and sexual organs during the later molting stages.

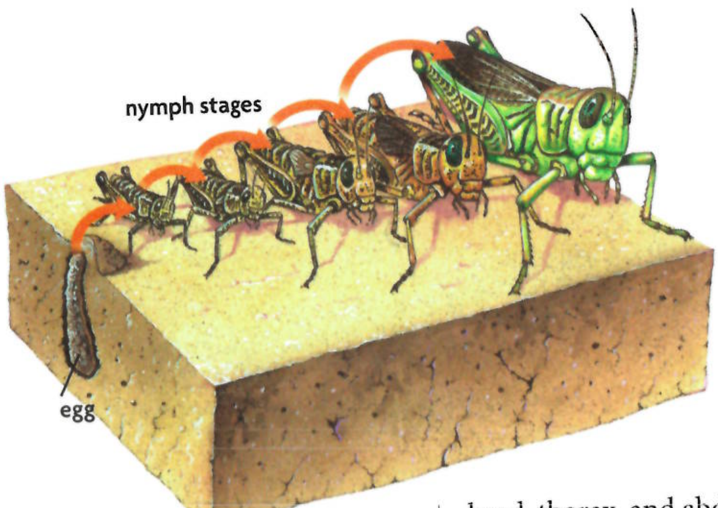


FIGURE 24.15 In the process of incomplete metamorphosis, a nymph appears to be a miniature copy of the adult insect. But on closer inspection, these immature insects lack important features such as wings and sex organs.

In the process of **complete metamorphosis**, illustrated in **FIGURE 24.16**, young insects do not look like adults but molt and change their form as they mature. Young insects hatch out of eggs as wormlike larvae whose bodies are not clearly divided into a head, thorax, and abdomen, and they often lack legs or antennae. As they grow, larvae pass through several molts, getting bigger each time, until they molt into an inactive form called a **pupa.** Inside the pupa, some tissues are broken down for energy and others are reorganized to produce a completely new body form. When the adult insect emerges from the pupa, it looks very different from a larva. It has wings, legs, and compound eyes, and is ready to fly away and begin its search for a mate.

Connect Which type of metamorphosis more closely resembles human development? Explain.

MAIN IDEA
Insects have adapted to life on land.

Insects have several adaptations that allow them to be successful terrestrial species. Just like arachnids, insects retain water for survival using exoskeletons, Malpighian tubules, spiracles, and tracheae. Gases move through the tracheae by diffusion, and spiracles can close to prevent water loss. Some insects can also pump air through their bodies by rapidly squeezing and expanding the tracheae. The water-conserving characteristics that are shared by insects and arachnids are an example of convergent evolution. In both groups, individuals that could survive longer without water were better able to reproduce. In this way, natural selection independently moved both groups toward similar features that allowed them to carry out similar water-conserving functions.

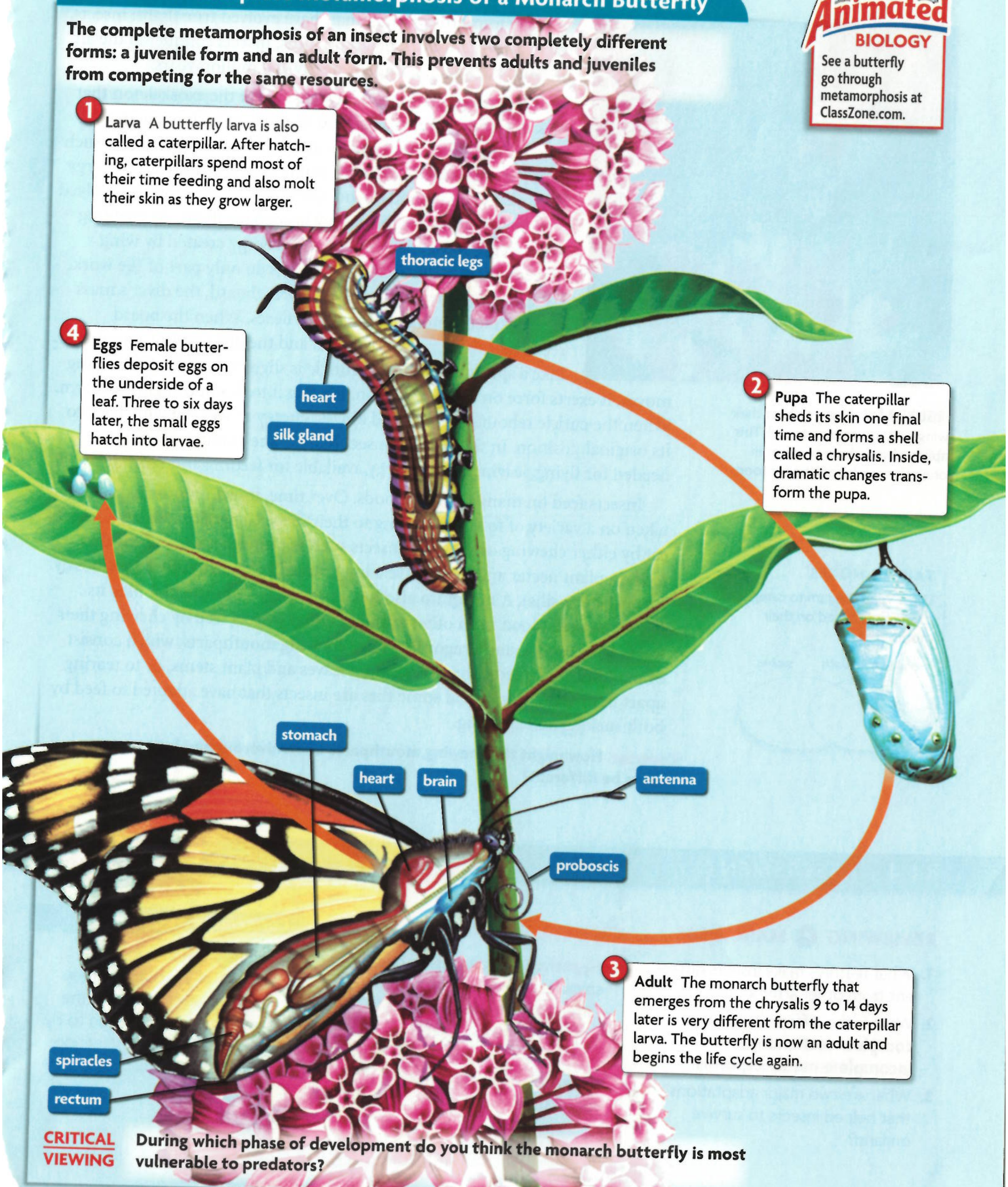
Connecting CONCEPTS

Plants Recall from **Chapter 21** that stomata are holes in the leaves of plants that open and close to control transpiration and gas exchange. Many arthropods use spiracles in the same way, opening and closing them to control water and gas exchange.

FIGURE 24.16 Complete Metamorphosis of a Monarch Butterfly

The complete metamorphosis of an insect involves two completely different forms: a juvenile form and an adult form. This prevents adults and juveniles from competing for the same resources.

Animated BIOLOGY
See a butterfly go through metamorphosis at ClassZone.com.



CRITICAL VIEWING During which phase of development do you think the monarch butterfly is most vulnerable to predators?

Only four groups of animals have evolved true flight: insects, the extinct pterosaurs, bats, and birds. Insects conquered the air first and have been flying for nearly 400 million years.

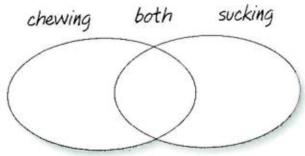
Insect wings are long, flat extensions of the exoskeleton that stick out of the animal's back. At the base of each wing are muscles that move the wing up and down, allowing insects, such as the bee in **FIGURE 24.17**, to fly. But it takes a great deal of energy to move a wing up and down. The insect exoskeleton has evolved in ways that conserve the energy needed for flight. By enabling the insect to reuse the stored kinetic energy created by wing movement, muscles attached to wings do only part of the work. For example, when a diver uses a springboard, the diver's mass creates kinetic energy as the board flexes. When the board rebounds, this energy is released and the diver is shot into the air. Like a springboard, insect cuticle is slightly flexible. As the wing moves, it exerts force on the exoskeleton, causing it to flex and slightly deform. When the cuticle rebounds, the stored kinetic energy moves the wing back to its original position. In this way, an insect reduces the amount of energy needed for flying, leaving more energy available for feeding and reproduction.

FIGURE 24.17 Bees can beat their wings 200 times per second. This ability allows them to hover in one place while looking for food.

Insects feed on many different foods. Over time, insect mouth shapes have taken on a variety of forms according to their diets. Generally speaking, insects eat by either chewing or sucking. Insects such as butterflies and moths that feed on plant nectar and fruits have a long, strawlike mouth called a proboscis (proh-BAHS-sihs). A mosquito also has a proboscis, but instead it uses its mouth to suck blood from other animals. Other insects feed by chewing their food. Ants, beetles, and dragonflies have chewing mouthparts, which consist of mandibles adapted either to crushing leaves and plant stems, or to tearing apart flesh. Bees, wasps, and some flies are insects that have adapted to feed by both sucking and chewing.

TAKING NOTES

Use a Venn diagram to categorize insects based on their mouth parts.



Contrast **How might the chewing mouthparts of carnivorous and herbivorous insects be different?**

24.4 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING MAIN IDEAS

1. What features make insects different from other arthropods?
2. What is the difference between **complete metamorphosis** and **incomplete metamorphosis**?
3. What are two major adaptations that helped insects to survive on land?

CRITICAL THINKING

4. **Hypothesize** How might the spiracles of a desert insect be different from the spiracles of a tropical rain forest insect?
5. **Infer** Give two reasons why flight has enabled insects to be so successful.

Connecting CONCEPTS

6. **Evolution** Hundreds of millions of years ago, spiders began to use silk around the same time insects began to fly. Explain how natural selection affected these changes.

24.5 Arthropods and Humans

KEY CONCEPT Arthropods and humans interact in many ways.

MAIN IDEAS

- Arthropods and humans share many of the same resources.
- Some arthropods can spread human diseases.

VOCABULARY

insecticide, p. 747
vector, p. 748

Review
biomagnification

REVIEW AT CLASSZONE.COM

Connect People have a love-hate relationship with arthropods. Some arthropods are important pollinators that fertilize human crops. Others are pests that destroy crops and infest our homes. Still others are predators that eat pests. Insect species are used for food and fibers in many human cultures, but other insect species spread human diseases. Over time, the unavoidable interactions between arthropods and humans have created many conflicts.

MAIN IDEA

Arthropods and humans share many of the same resources.

FIGURE 24.18 Aphids devour plant tissues, often killing the host plant. Arthropod pest species can cause damage to crops, forests, and even homes.

Many arthropods are herbivores, and many of them eat the same plants people use for food, textiles, and building materials. These arthropods compete with humans for the same resources. Competition is stiff, because there are far more arthropods than people. For example, when you look under the leaves of apple trees or pepper plants, you may see clusters of tiny bumps. These bumps are insects called aphids. Aphids, shown in **FIGURE 24.18**, use their needlelike mouthparts to pierce the cell walls of a plant and suck up the sugary liquid inside. A single aphid is small and cannot do much damage on its own. But aphids live in large colonies. Hundreds of aphids on a plant can remove enough sap to damage or kill the plant.

Each year, arthropods cause millions of dollars in damage to crops such as corn, wheat, and cotton. To prevent costly infestations, farmers use insecticides to control arthropod populations. An **insecticide** is a chemical compound that kills insects and other arthropods. But spraying toxic chemicals on plants can have unwanted side effects. Many insecticides are toxic to other animals, including people. Some, such as chlordane and DDT, do not break down quickly. They can accumulate in predator species through the process of biomagnification. Arthropods can also become resistant to insecticides through natural selection. This resistance causes humans to use even larger doses of the toxin.

To avoid the potential hazards of using insecticides, scientists have discovered ways to use the unique characteristics of arthropods to find safer ways of controlling pest populations.

FIGURE 24.19 Many arthropods are important pollinators. In addition to getting a nectar meal, this Eastern tiger swallowtail butterfly helps to pollinate flowers by carrying pollen from one flower to another.

- Insecticides can be developed to be specific to arthropods. One example is a neurotoxin that blocks a particular receptor that is common in arthropod nerves but not found in other animal nerves.
- Integrated pest management, or IPM, reduces the number of insect pests on a plant crop by managing their ecology. By using a variety of other methods including insect traps, physical barriers, and introduced predators such as ladybugs and parasitic wasps, IPM helps to control pest species.
- Genetically modified plants can be made to resist particular pest species. For example, Bt corn has been engineered to include a gene from a soil bacterium, *Bacillus thuringiensis,* artificially inserted into its DNA. The gene makes a protein that kills caterpillar pests such as the European corn borer but is harmless to most other animals.

Infer What would be a disadvantage to introducing a predator insect for pest management?

MAIN IDEA

Some arthropods can spread human diseases.

Humans are a source of food to arthropods such as mosquitoes, biting flies, fleas, and ticks. **FIGURE 24.20** shows how arthropods can also be vectors that carry diseases. A **vector** is an organism that carries a disease from one host to another.

Diseases spread by arthropods can have serious effects on human populations. Many methods for controlling arthropod vectors have been developed. Vaccinations have been developed to protect individuals from many types of diseases by delivering small doses of the pathogen to the immune system, which can then fight off future pathogen invasions. The use of pesticides targeted to specific arthropods can also help slow the spread of disease.

- **Bubonic plague** is caused by a bacterium carried by a flea. The disease normally affects rodents such as prairie dogs, squirrels, and rats. Human infections occur when a flea that has fed on an infected rat feeds on a human. Outbreaks of bubonic plague devastated European cities between the 1300s and the 1600s. The largest of these epidemics, between 1347 and 1350, killed between one-third and one-half of the people living in Europe. Today, bubonic plague is controlled by antibiotics and improved hygiene.
- **Yellow fever** is caused by a virus and normally affects monkeys, but it can be carried to humans by mosquitoes. The virus causes fever and bleeding. It was common in the United States until the early part of the 1900s and is still common in Africa and South America. Yellow fever epidemics killed nearly 20,000 people during the construction of the Panama canal before mosquito eradication programs brought the disease under control.
- **Malaria** is caused by a protozoan parasite carried by mosquitoes. The parasites enter red blood cells to breed, periodically emerging and destroying them. Like yellow fever, malaria was once common in the United States and Europe. Malaria was largely eliminated in temperate countries during the 1950s by a program of DDT spraying. It is still common in tropical regions of Africa, Asia, and Central and South America.

TAKING NOTES

Use a main idea diagram to list the diseases carried by arthropod vectors.

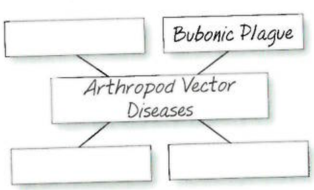
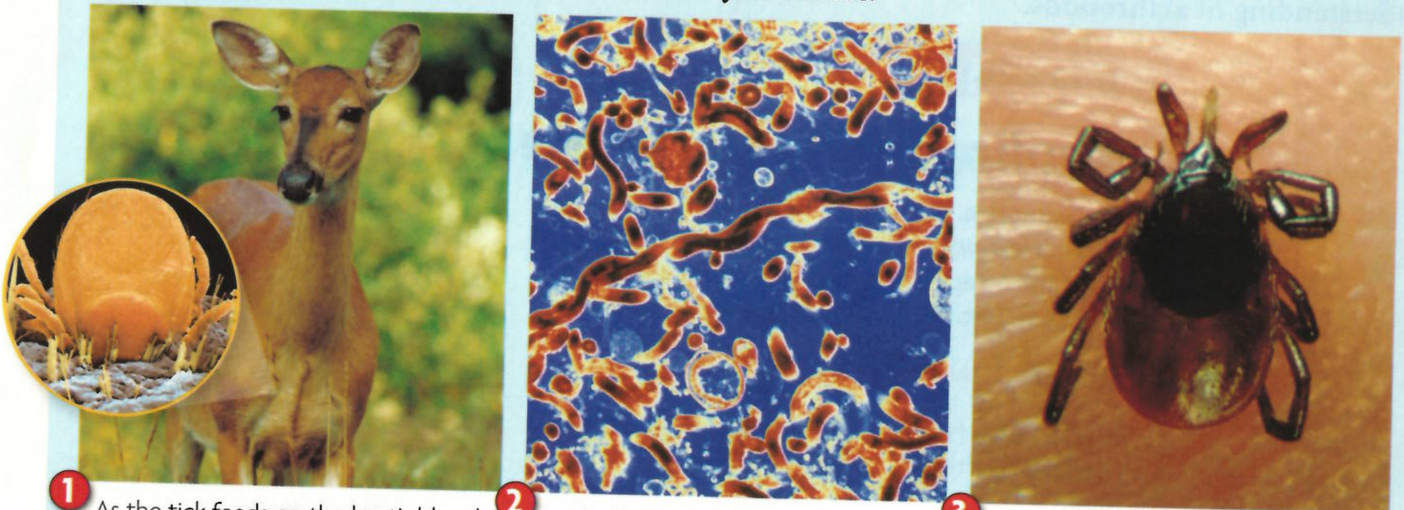


FIGURE 24.20 Arthropod Vectors

Arthropods are vectors for carrying diseases such as Lyme disease.



1. As the tick feeds on the host's blood, microscopic pathogens pass from deer to tick. (colored SEM tick; magnification 15×)
2. Inside the tick, the pathogens are stable and do not affect the tick. (LM; magnification 4000×)
3. When the tick feeds on another host, pathogens are passed from the tick to the new host.

Analyze **Though vectors can bring disease into human populations, explain why diseases carried by arthropods spread more quickly through the populations of other animals.**

- **West Nile virus** is contracted from mosquito carriers that have previously fed on birds infected with the virus. Originally discovered in Africa, West Asia, and the Middle East, the virus has spread throughout the world and has been identified in 46 of the United States. Fever, headache, and skin rashes are some of the minor symptoms, but the virus can lead to meningitis or encephalitis, potentially fatal diseases. Scientists are currently working to control the spread of the virus.

Infer **Explain how an organism other than an arthropod could be a vector.**

> ***Connecting* CONCEPTS**
>
> **Immune System** Vaccines can only work to prevent a disease; they cannot cure a person who is already sick. The human immune system has specifically designed cells which work to fight diseases in your body.

24.5 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING ▶ MAIN IDEAS

1. What are three effective ways of managing insect pest populations?
2. How does a **vector** spread a disease such as malaria?

CRITICAL THINKING

3. **Analyze** What are the potential costs and benefits of using an introduced predator to control a pest population?
4. **Connect** What effect, if any, would the development of a vaccine against a tick-borne disease have on the tick population? Explain.

Connecting CONCEPTS

5. **Natural Selection** Describe a situation in which natural selection could lead to an arthropod population that is resistant to pesticides.

Use these inquiry-based labs and online activities to deepen your understanding of arthropods.

INVESTIGATION

Daphnia and Heart Rate

The water flea, or *Daphnia*, is a tiny crustacean that lives in fresh water. Biologists often use *Daphnia* to study the effects of various chemicals, such as hydrogen peroxide, on freshwater ecosystems.

SKILLS Collecting Data, Graphing, Analyzing

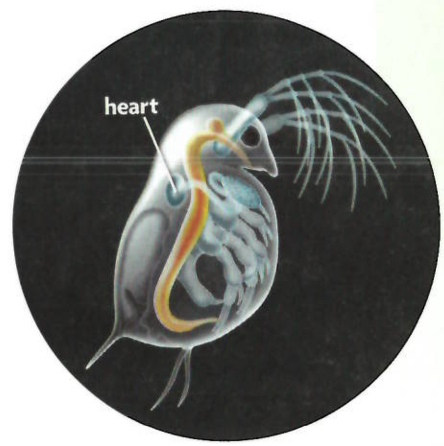
PROBLEM How does hydrogen peroxide affect *Daphnia* heart rate?

MATERIALS

- cotton swab
- tissues
- petroleum jelly
- microscope slide
- culture of *Daphnia magna*
- 2 eyedroppers
- cover slip
- stopwatch
- microscope
- hydrogen peroxide solutions

PROCEDURE

1. Make a ring of petroleum jelly on a slide and make wet mount with a *Daphnia* sample.
2. Observe the *Daphnia* under low and high power.
3. Looking through the microscope, measure the heart rate of the *Daphnia* by tapping a pencil on the desk once for each heartbeat. Your partner should count the number of taps in 15 seconds. Calculate the number of beats per minute by multiplying this number by 4. Take the average of three trials, and record the data in a data table.
4. Predict the effect of adding hydrogen peroxide to the *Daphnia* environment, and record it in your notebook.
5. Place two drops of one of the hydrogen peroxide solutions on one side of the wet mount. Draw the liquid under the cover slip by placing the edge of a tissue on the opposite edge of the cover slip.
6. Repeat step 3 to measure the *Daphnia* heart rate.
7. Calculate the change in heart rate by subtracting the average heart rate observed after adding hydrogen peroxide from the average heart rate observed in water.
8. Collect average heart rate data from other groups who used different hydrogen peroxide concentrations.



Daphnia

ANALYZE AND CONCLUDE

1. **Analyze** Using your own data and the data collected by your classmates using different hydrogen peroxide concentrations, construct a graph with the change in heart rate on the *y*-axis versus hydrogen peroxide concentration on the *x*-axis.
2. **Interpret** How did hydrogen peroxide affect the heart rate of *Daphnia*? At what concentration was the effect greatest?
3. **Experimental Design** What are possible reasons for error in the experimental design?

INVESTIGATION

Inside a Crayfish

A crayfish is a freshwater crustacean similar to shrimp, crabs, and lobsters. In this lab, you will dissect and examine the parts of a crayfish.

SKILL Observing

PROBLEM How do the form and function of crayfish organs help it survive in a marine environment?

MATERIALS

- dissecting tray
- scissors
- forceps
- dissecting needle
- 12 dissecting pins
- preserved crayfish specimen
- hand lens or dissecting microscope
- paper towels
- paper and pencil
- Anatomical Crayfish Drawings

PROCEDURE

1. Examine the external anatomy of the crayfish. Draw and label a picture of the crayfish anatomy, using illustrations in your handout. Label the structures listed on the drawing.
2. Turn the crayfish on its side and remove the legs below the carapace.
3. Using the forceps and scissors, lift and cut the carapace to expose the featherlike gills.
4. Carefully remove the gills and the joints. Cut the remaining plates from the top (dorsal) midline to the base of each leg to expose the internal organs. Examine the inside of the crayfish and identify as many internal organs as you can.

ANALYZE AND CONCLUDE

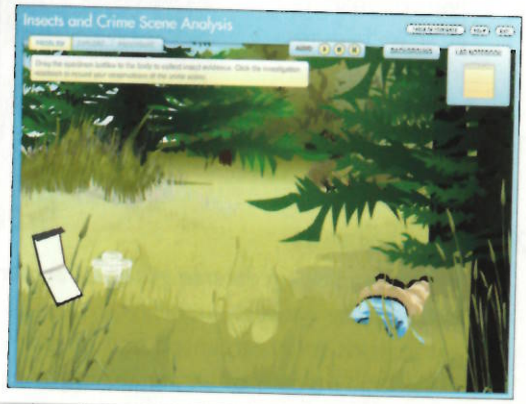
1. **Infer** What do you think the antennae and antennules do?
2. **Analyze** How does the feathery structure of the gills help with their function?
3. **Infer** Why do you think the gills are attached to the legs?

Online BIOLOGY
CLASSZONE.COM

VIRTUAL LAB

Insects and Crime Scene Analysis

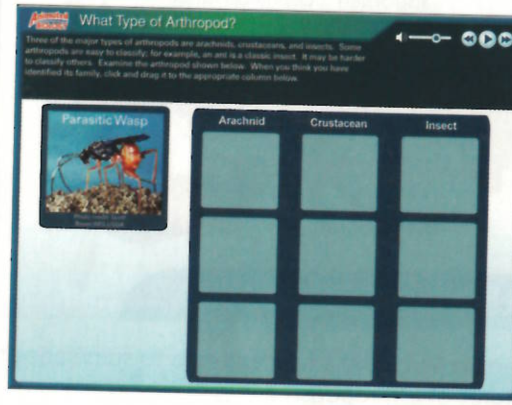
How can bugs help solve a crime? In this interactive lab, you will examine insects found on a corpse to determine how long the body was lying in a field.



ANIMATED BIOLOGY

What Type of Arthropod?

Can you tell what group an arthropod belongs to just by looking at it? Examine a series of arthropod images and try to categorize them. Be careful—looks can be very deceiving!



WEBQUEST

Arthropods live in almost any environment. As a class, develop a field guide of arthropods in your area. Research and report on each arthropod's habitat, feeding habits, life cycle and evolutionary history.

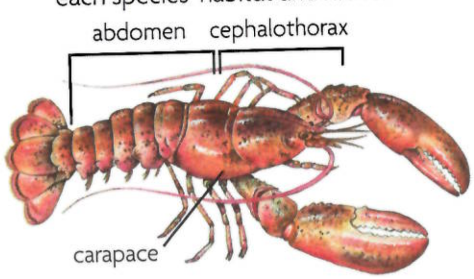
KEY CONCEPTS | Vocabulary Games | Concept Maps | Animated Biology | Online Quiz

24.1 Arthropod Diversity

Arthropods are the most diverse of all animals. The five major groups of arthropods are trilobites, crustaceans, chelicerates, insects, and myriapods. Each group has unique features that have evolved over millions of years, but all share features—including an exoskeleton made of chitin, and jointed appendages.

24.2 Crustaceans

Crustaceans are a diverse group of ancient arthropods. Most crustaceans are aquatic arthropods with segmented bodies, a hard exoskeleton, two pairs of antennae, and one pair of appendages per segment that set crustaceans apart from other arthropods. The recognizable decapods have two major body segments: a cephalothorax and an abdomen. Isopods, barnacles, and tongue worms appear very different but share the same characteristic features. The appendages of crustaceans are highly adapted to each species' habitat and niche.



24.3 Arachnids

Arachnids include spiders and their relatives. Chelicerates are arthropods that are distinguished by four pairs of walking appendages and two pairs of modified appendages used for feeding. The arachnids are terrestrial chelicerates that have evolved book lungs and other adaptations for survival on land. The most common arachnids are spiders, but mites, ticks, chiggers and scorpions are also members of this family. They play an important ecological role as invertebrate predators.

24.4 Insect Adaptations

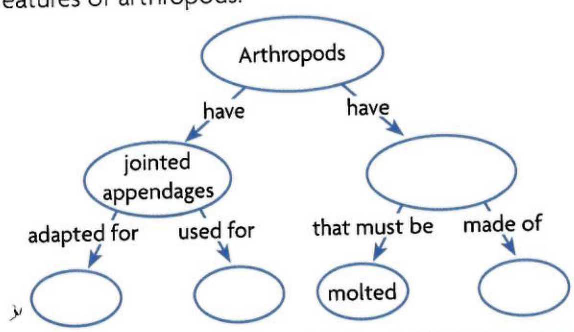
Insects show an amazing range of adaptations. Insects are the dominant terrestrial arthropods and are found in all of Earth's biomes. All insects have three body segments—a head, thorax, and abdomen—as well as wings, compound eyes, and three pairs of legs. Insects grow through either complete or incomplete metamorphosis. Breathing through a system of tracheae and spiracles helps insects to conserve water.

24.5 Arthropods and Humans

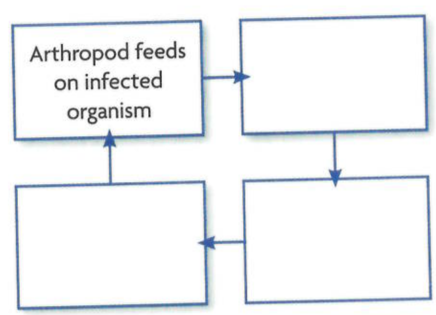
Arthropods and humans interact in many ways. Humans and arthropods often compete for the same resources. Pesticides are a common way in which humans control arthropod populations. Arthropods are also vectors for many different diseases, carrying viruses and bacteria from one species and infecting another.

Synthesize Your Notes

Concept Map Use a concept map to summarize the features of arthropods.



Process Diagram Use a process diagram to explain arthropod vectors.



Chapter Assessment

Chapter Vocabulary

24.1 arthropod, p. 730
exoskeleton, p. 730
chitin, p. 730
appendage, p. 730
segmentation, p. 730

24.2 crustacean, p. 735
cephalothorax, p. 735
abdomen, p. 735
carapace, p. 735
mandible, p. 737

24.3 chelicerate, p. 740
arachnid, p. 740
book lung, p. 740
spiracle, p. 741
trachea, p. 741

24.4 incomplete metamorphosis, p. 744
complete metamorphosis, p. 744
pupa, p. 744

24.5 insecticide, p. 747
vector, p. 748

Reviewing Vocabulary

Vocabulary Connections

For each pair of words below, write a sentence or two that clearly shows how the terms are connected. For example, for *appendage* and *chelipeds,* you could write, "A cheliped is a type of appendage that looks like a large claw."

1. pupa, metamorphosis
2. cephalothorax, carapace
3. chitin, exoskeleton
4. mandible, chelicerae

Keep It Short

Write a short, precise phrase that defines each vocabulary term below. For example, a short phrase to describe *exoskeleton* could be "hard, outer covering."

5. segmentation
6. chelicerae
7. book lung
8. metamorphosis
9. spiracle

Word Origins

10. The term *appendage* comes from the Latin word *appendere,* which means "to cause to hang (from something)." Explain how this meaning relates to what an appendage is.

11. The term *carapace* is a French word that means "tortoise shell." Explain how this meaning relates to what a carapace is.

Reviewing MAIN IDEAS

12. Each of the thousands of known arthropod species can be placed into one of five groups. What features do arthropods in all five groups have in common?

13. Your skeleton is inside your body, and it grows along with you. How does an arthropod's exoskeleton differ in both its location and its response to growth?

14. Explain how scientists can determine relationships between ancient arthropods that lived 500 million years ago and arthropods of today.

15. Crustaceans, such as crabs and shrimp, are found in nearly all aquatic food chains. Describe the significance of crustaceans to these ecosystems.

16. Arachnids were some of the first land animals. How did the development of methods for conserving water allow them to colonize land?

17. What important function do arachnids serve in an ecosystem?

18. What features set insects apart from other arthropods?

19. What stages does a butterfly go through during metamorphosis?

20. Insects evolved from ancestors that lived in water. What adaptations did insects develop that allowed them to live on land?

21. Insects and humans interact in many ways. Give two ways in which insects are beneficial to humans, and two ways in which they are harmful to human societies.

Critical Thinking

22. Classify You turn over a rock and several long, thin animals with many sets of legs scurry away into the leaves. To what group of arthropods do they likely belong? What do they likely eat?

23. Apply If you walk along a rocky shoreline, you will likely see many barnacles attached to rocks. But barnacles can also be found attached to large whales that never swim up on the shore. How do these barnacles get onto whales?

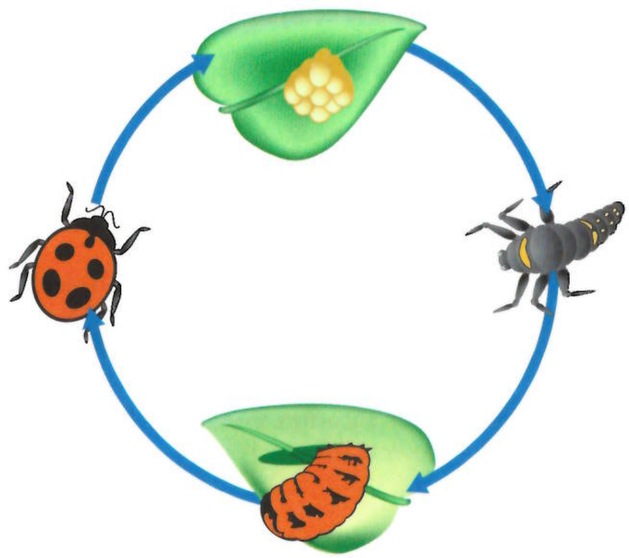
24. Compare and Contrast The tracheae of insects branch out throughout the body. Humans can only breathe through their mouth or nose. What are the advantages and disadvantages of having tracheae instead of a mouth or nose?

25. Apply Termites are a pest species that feed on the cellulose found in wood. They live in large colonies and can destroy houses over the course of a few years if left untreated. What are some ways in which a homeowner might eliminate a termite colony?

26. Infer The world's largest spider is the goliath bird-eating spider of South America, which can be as large as a dinner plate. What anatomical features may prevent spiders from growing any larger than this?

Interpreting Visuals

Use the diagram to answer the next two questions.



27. Apply What type of metamorphosis is illustrated in the diagram?

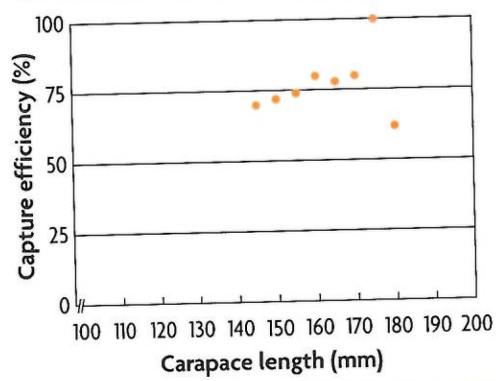
28. Identify Name and describe each phase of metamorphosis shown above. What adaptive advantage does this type of metamorphosis give this species?

Analyzing Data

Use the data below to answer the next three questions.

Crab nets have to be designed to capture crabs of varying lengths. The data below show the efficiency of crab nets at capturing crabs of varying carapace length.

CAPTURE EFFICIENCY AND CARAPACE LENGTH



29. Interpret What is the relationship between capturing efficiency and carapace length?

30. Interpret Does the scatterplot have any outliers? If so, what explanation might explain the outlier?

Connecting CONCEPTS

31. Write Science Fiction Create your own species of arthropod. Imagine that you are sampling arthropod species 1 million years into the future. Arthropods are very different than they are today. Draw and label the appendages and other features of this new species. Write a brief description of the species, and include your hypothesis on its ancestors, what environmental pressures selected for its features, and describe its habitat, food, and lifestyle.

32. Compare and Contrast Insect predators such as the potter wasp hunt numerous species of arthropods. In what ways are the hunting styles of arachnids and wasps similar and different?