Section 28–3

1 FOCUS

Objectives

28.3.1 ***Identify*** the distinguishing features of insects.
28.3.2 ***Describe*** two types of development in insects.
28.3.3 ***Explain*** what types of insects form societies.

Guide for Reading

Vocabulary Preview

Help students organize the section's Vocabulary words by pointing out that they fall into two general categories. The first four apply to the life cycle of insects; the last three apply to the behavior of insects and the formation by some kinds of insects of complex arrangements called societies.

Reading Strategy

Point out that in looking for the important concepts in each paragraph, students should pay attention to the headings of the section. The important concepts usually relate to the headings.

2 INSTRUCT

Use Visuals

Figure 28–14 Have students study the information contained on the pie chart. Then, ask: **What percentage of animals are insects?** *(73%)* **What percentage are vertebrates?** *(4%)* **What are some nonarthropod invertebrates you've studied?** *(These include sponges, cnidarians, worms, and mollusks.)* **What are some noninsect arthropods?** *(These include crustaceans, chelicerates, centipedes, and millipedes.)* L1 L2

28–3 Insects

Guide for Reading

Key Concepts
- What are the distinguishing features of insects?
- What two types of development can insects undergo?
- What types of insects form societies?

Vocabulary
incomplete metamorphosis
nymph
complete metamorphosis
pupa
pheromone
society
caste

Reading Strategy: Summarizing As you read, find the most important concepts in each paragraph. Then, use the important concepts to write a summary of what you have read.

What animals other than humans have the greatest impact on the activities of this planet? If you said "insects," you would be correct. From bees that flit from flower to flower to weevils that feed on crops, insects seem to be everywhere. As **Figure 28–14** shows, class Insecta contains more species than any other group of animals. Ants and termites alone account for nearly one third of all the animal biomass in the Amazon basin.

Many characteristics of insects have contributed to their evolutionary success. These include different ways of responding to stimuli; the evolution of flight, which allowed insects to disperse long distances and colonize new habitats; and a life cycle in which the young differ from adults in appearance and feeding methods. These features have allowed insects to thrive in almost every terrestrial habitat on Earth, as well as in many freshwater and some marine environments.

The insects cover an incredible variety of life forms—from stunning, iridescent beetles and butterflies to the less attractive fleas, weevils, cockroaches, and termites. Biologists sometimes disagree on how to classify insects, and the number of living orders ranges from 26 to more than 30.

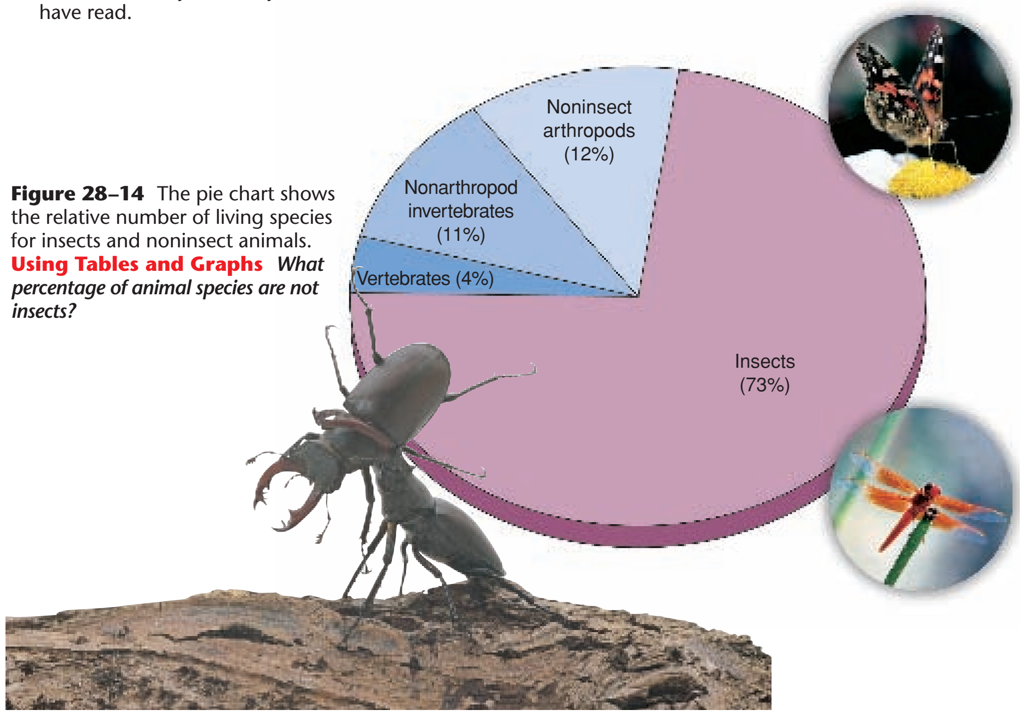
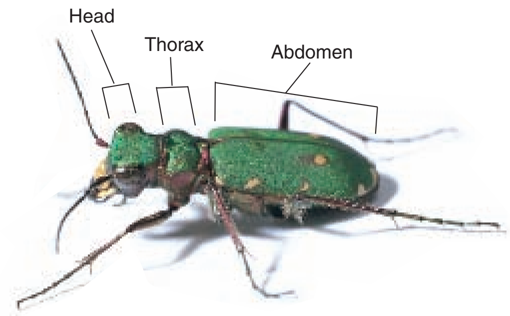


Figure 28–14 The pie chart shows the relative number of living species for insects and noninsect animals. **Using Tables and Graphs** ***What percentage of animal species are not insects?***

SECTION RESOURCES

Print:
- ***Laboratory Manuals A, B,*** Chapter 28 Lab
- ***Teaching Resources,*** Lesson Plan 28–3, Adapted Section Summary 28–3, Adapted Worksheets 28–3, Section Summary 28–3, Worksheets 28–3, Section Review 28–3, Enrichment
- ***Reading and Study Workbook A,*** Section 28–3
- ***Adapted Reading and Study Workbook B,*** Section 28–3
- ***Lab Worksheets,*** Chapter 28 Design an Experiment
- ***Investigations in Forensics,*** Investigation 8

Technology:
- ***BioDetectives DVD,*** "Insect Clues: The Smallest Witnesses"
- ***iText,*** Section 28–3
- ***Transparencies Plus,*** Section 28–3



◀ **Figure 28–15 Insects have a body divided into three parts—head, thorax, and abdomen. Three pairs of legs are attached to the thorax.** In addition to these features, this green tiger beetle has other characteristics of a typical insect—wings, antennae, compound eyes, and tracheal tubes for respiration.

What Is an Insect?

Like all arthropods, insects have a segmented body, an exoskeleton, and jointed appendages. They also have several features that are specific to insects. **Insects have a body divided into three parts—head, thorax, and abdomen. Three pairs of legs are attached to the thorax.** The beetle in **Figure 28–15** exhibits these characteristics. In many insects, such as ants, the body parts are clearly separated from each other by narrow connections. In other insects, such as grasshoppers, the divisions between the three body parts are not as sharply defined. A typical insect also has a pair of antennae and a pair of compound eyes on the head, two pairs of wings on the thorax, and tracheal tubes that are used for respiration.

Insects carry out life functions in basically the same ways as other arthropods. However, insects have a variety of adaptations that deserve a closer look.

CHECKPOINT *What are the three main parts of an insect's body?*

Responses to Stimuli Insects use many sense organs to detect external stimuli. Compound eyes are made of many lenses that detect minute changes in color and movement. The brain assembles this information into a single image and directs the insect's response. Compound eyes produce an image that is less detailed than what we see. However, eyes with multiple lenses are far better at detecting movement—one reason it is so hard to swat a fly!

Insects have chemical receptors for taste and smell on their mouthparts, as might be expected, and also on their antennae and legs. When a fly steps in a drop of water, it knows immediately whether the water contains salt or sugar. Insects also have sensory hairs that detect slight movements in the surrounding air or water. As objects move toward insects, the insects can feel the movement of the displaced air or water and respond appropriately. Many insects also have well-developed ears that hear sounds far above the human range. These organs are located in what we would consider odd places—behind the legs in grasshoppers, for example.

What Is an Insect?

Use Visuals

Figure 28–15 To emphasize the differences between spiders and insects, have students study the figure and read the caption. Then, ask them to turn back to Figure 28–9 on page 722 and do the same. Ask: **What is the difference in body parts between spiders and insects?** *(Spiders have two body parts, the cephalothorax and abdomen. Insects have three body parts, the head, thorax, and abdomen.)* **What is the difference in pairs of legs?** *(Spiders have four pairs of legs, whereas insects have three pairs of legs.)* L1 L2

Build Science Skills

Designing Experiments Divide the class into small groups, and give each group these materials: a vial containing 10 fruit flies, a light source, and a meter stick. One culture tube of fruit flies should provide enough flies for an entire class. Transfer 10 adult flies to a separate vial for each group. Caution students not to open the vials. Challenge each group to formulate a hypothesis and design an experiment to investigate how fruit flies respond to light. (*In a typical experiment, students might vary the distance of the light from the flies and observe any differences in behavior.*) Have groups review their experiments with you before proceeding with the activity. L2 L3

UNIVERSAL ACCESS

Less Proficient Readers
To help students understand metamorphosis as described on page 729, make a Venn diagram on the board and then slowly read aloud the descriptions of the two processes. As you read, write important terms about incomplete and complete metamorphosis in the diagram. L1 L2

English Language Learners
Reinforce the idea of metamorphosis by explaining the meaning of the word parts in the term, which is derived from a Greek word meaning "to transform." Explain that *meta-* means "change" and that *morph* means "form." Thus, *metamorphosis* means "to change in form." L1 L2

Advanced Learners
Encourage interested students to read the short story *The Metamorphosis* by Franz Kafka, a classic of world literature. Ask readers to analyze the symbolism in the story according to both how it parallels metamorphosis in insects and how it uses the process to shed light on human development. L3

Answers to . . .

CHECKPOINT *Head, thorax, and abdomen*

Figure 28–14 *27 percent*

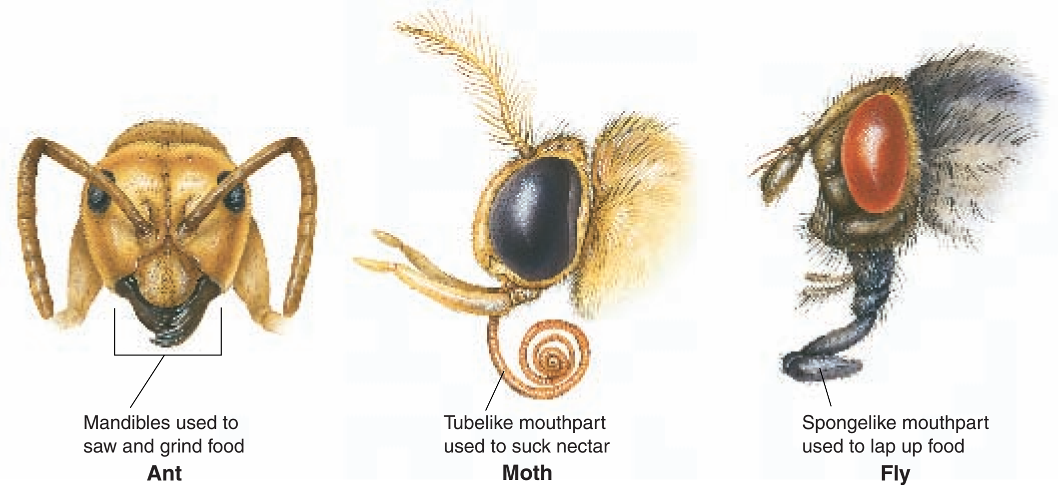
28–3 (continued)

Build Science Skills

Observing Have specimens of large grasshoppers serve as a representative insect for students to examine both with the unaided eye and with a hand lens. You may also want to provide students with diagrams on which they can label the various structures and their functions. If possible, have preserved specimens of other insects so that students can examine the variety of mouthparts that enable insects to obtain food from many different sources. Have students wear disposable plastic gloves and safety goggles when they examine the preserved insect. Students should wash their hands after the activity. L2 L3

Use Community Resources

Invite a local lepidopterist to address the class about collecting and preserving butterflies. You might be able to find such a collector through the biology department of a local college or by contacting an entomologist. Ask the lepidopterist to present his or her collection, explain how the insects are caught, and demonstrate how butterflies are preserved and mounted. Have students prepare for the presentation by brainstorming for a list of questions to ask. Make sure that students look for specific insect structures as they examine the mounted butterflies. L2



▲ **Figure 28–16** Insect mouthparts are specialized for a variety of functions. An ant's mouthparts can saw through and then grind food into a fine pulp. The mouthpart of a moth consists of a long tube that can be uncoiled to sip nectar from a flower. Flies have a spongy mouthpart that is used to stir saliva into food and then lap up the food. **Applying Concepts** *What is the function of saliva?*

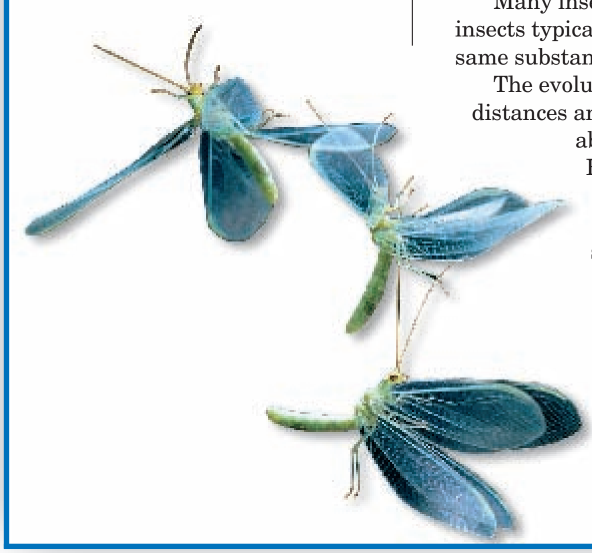
Adaptations for Feeding Insects have three pairs of appendages that are used as mouthparts, including a pair of mandibles. These mouthparts can take on a variety of shapes, as shown in **Figure 28–16.**

Insect adaptations for feeding are not restricted to their mouthparts. Many insects produce saliva containing digestive enzymes that help break down food. The chemicals in bee saliva, for example, help change nectar into a more digestible form—honey. Glands on the abdomen of bees secrete wax, which is used to build storage chambers for food and other structures within a beehive.

Movement and Flight Insects have three pairs of legs, which in different species are used for walking, jumping, or capturing and holding prey. In many insects, the legs have spines and hooks that are used for grasping and defense.

Many insects can fly, as shown in **Figure 28–17.** Flying insects typically have two pairs of wings made of chitin—the same substance that makes up an insect's exoskeleton.

The evolution of flight has allowed insects to disperse long distances and to colonize a wide variety of habitats. Flying abilities and styles vary greatly among the insects. Butterflies usually fly slowly. Flies, bees, and moths, however, can hover, change direction rapidly, and dart off at great speed. Dragonflies can reach speeds of 50 kilometers per hour.



◀ **Figure 28–17** Flying insects, such as this lacewing, move their wings using two sets of muscles. The muscles contract to change the shape of the thorax, alternately pushing the wings down and lifting them up and back. In some small insects, these muscles can produce wing speeds of up to 1000 beats per second! **Drawing Conclusions** *How might the evolution of flight change an animal's habitat?*

BIO INSIGHTS — FACTS AND FIGURES

Survivability through the senses
A large measure of insects' survival ability is due to the development of their senses. The hairs that cover most insects are sensitive to touch and can detect chemicals as well. These hairs are concentrated on the head and lower legs, where they are most likely to come in contact with objects and materials in the environment. The compound eyes of insects consist of many lenses—up to 30,000 in some dragonflies. These large, multilensed eyes give insects the ability to scan a wide area at one time, allowing them to detect the motion of predators or prey. Some insects rely heavily on hearing. Mosquitoes, for example, can detect sounds with their antennae. Crickets, grasshoppers, and other insects have a membrane called a tympanum on the abdomen or legs. These structures function much like the human eardrum in sensing sound vibrations.

Metamorphosis

The growth and development of insects usually involve metamorphosis, which is a process of changing shape and form. Insects undergo either incomplete metamorphosis or complete metamorphosis. Both complete and incomplete metamorphosis are shown in **Figure 28–18.** The immature forms of insects that undergo gradual or **incomplete metamorphosis,** such as the chinch bug, look very much like the adults. These immature forms are called **nymphs** (NIMFS). Nymphs lack functional sexual organs and other adult structures, such as wings. As they molt several times and grow, the nymphs gradually acquire adult structures. This type of development is characterized by a similar appearance throughout all stages of the life cycle.

Many insects, such as bees, moths, and beetles, undergo a more dramatic change in body form during a process called **complete metamorphosis.** These animals hatch into larvae that look and act nothing like their parents. They also feed in completely different ways from adult insects. The larvae typically feed voraciously and grow rapidly. They molt a few times and grow larger but change little in appearance. Then they undergo a final molt and change into a **pupa** (PYOO-puh; plural: pupae)—the stage in which an insect changes from larva to adult. During the pupal stage, the body is completely remodeled inside and out. The adult that emerges seems like a completely different animal. Unlike the larva, the adult typically can fly and is specialized for reproduction. **Figure 28–18** shows the complete metamorphosis of a ladybug beetle.

CHECKPOINT *What is a pupa?*

Quick View Video

Discovery School Video To find out how insect metamorphosis plays a part in forensic science, view track 8 "Insect Clues: The Smallest Witnesses" on the *BioDetectives* DVD.

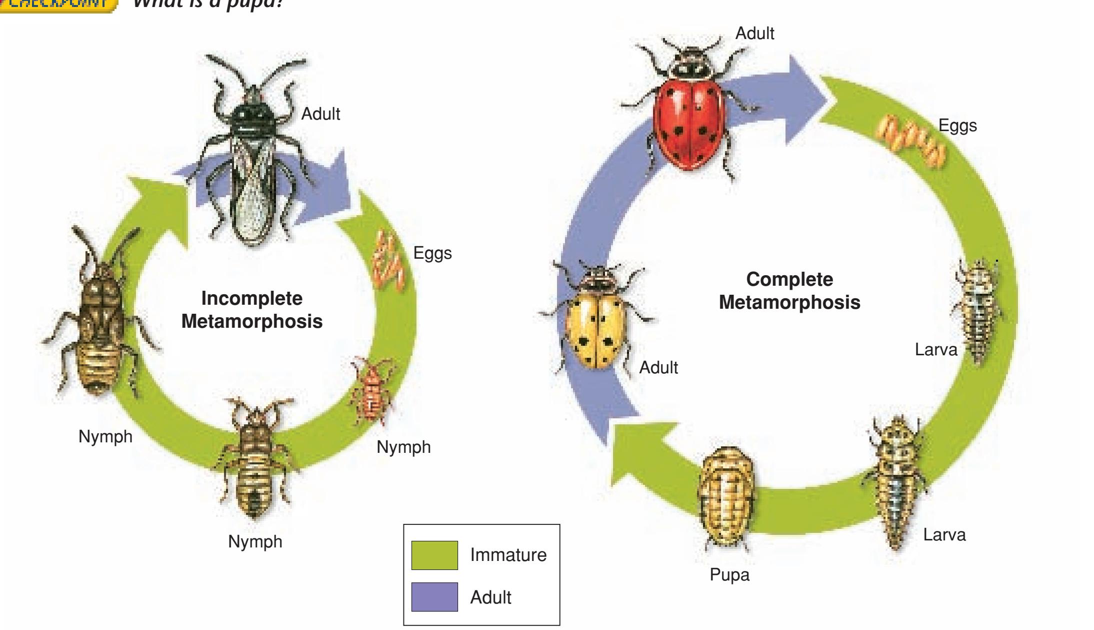


Figure 28–18 The growth and development of insects usually involve metamorphosis, which is a process of changing shape and form. The chinch bug (left) undergoes incomplete metamorphosis, in which the developing nymphs look similar to the adult. The ladybug (right) undergoes complete metamorphosis. During the early stages, the developing larva and pupa look completely different from the adult.

Use Visuals

Figure 28–18 Point out that the insects in the two life cycles shown are in different orders. The chinch bug is a plant bug, Order Homoptera, and it feeds on grasses. The ladybug is a type of beetle, Order Coleoptera. Then, ask: **Which type of metamorphosis includes larva and pupa stages?** *(Complete metamorphosis)* **In incomplete metamorphosis, what are the differences between the nymph and the adult?** *(Nymphs lack functional sexual organs, wings, and other adult structures.)* **In which type of metamorphosis is there a dramatic change in shape?** *(Complete metamorphosis)* L1 L2

Build Science Skills

Designing Experiments Challenge groups of students to design an experiment in which the life cycle of an insect could be observed. A typical design might involve placing food, such as an overripe banana, in an open jar for a few days until flies can be seen on the food. Then, the flies can be waved away and the jar covered with a nylon stocking. Within a few days, maggots—fly pupae—will be seen on the food. Some students may recall that in Chapter 1 they studied a similar experiment carried out by the Italian physician Francesco Redi in the 1600s. L2 L3

Quick View Video

Discovery School DVD Encourage students to view track 8 "Insect Clues: The Smallest Witnesses" on the *BioDetectives* DVD.

BIO INSIGHTS — FACTS AND FIGURES

Studying insects from murder scenes
Insects and their larvae provide clues to forensic scientists about the circumstances of crimes—especially murders. Forensic entomologists examine the species of insects in a piece of evidence—a package of marijuana or a corpse, for example—to determine where the crime was committed. Since the larvae of many insects, such as blowflies, develop at an extremely regular rate, larvae removed from a corpse can be raised in carefully controlled conditions. The length of time it takes the larvae to develop into adults gives investigators a fairly accurate indication of when the parent fly laid her eggs on the corpse. And because the time it takes for a corpse to attract insects is also a known constant, the investigators can pinpoint the time of death.

Answers to . . .

CHECKPOINT *A pupa is the stage in which an insect changes from larva to adult.*

Figure 28–16 *Saliva contains digestive enzymes that help break down food.*

Figure 28–17 *The habitat would change from mostly on the ground to include the air and the high places previously difficult to reach.*

28–3 (continued)

Insects and Humans

Use Community Resources

Invite a local farmer to speak to the class about insect pest problems common to farms in your area. Have the farmer talk about kinds of damage insects can do to crops, specific insects that are a threat in your area, and methods commonly used to prevent insect damage. If possible, have the farmer bring to class examples of insect damage caused to crops. L2

Biology and History

After students have examined the timeline, discuss the ethics of using insecticides to eliminate disease-causing organisms. DDT, for example, proved invaluable in controlling outbreaks of malaria. But the chemical did so much damage to the environment that its use was banned in the United States. Yet, DDT is still used in other countries for disease control. Elicit students' opinions about whether the benefits of DDT use outweigh the harmful effects. L2

Writing in Science

Students might use encyclopedias, microbiology textbooks, or medical reference books on diseases to complete their research. Bubonic plague is a serious disease caused by the bacterium *Yersinia pestis.* Plague is normally a disease of rats, and the intermediate host is the rat flea, *Xenopsylla cheopis.* In the late 1800s, physicians in various parts of the world began to observe that plague outbreaks in humans were associated with large populations of rats and that diseased rats were infested with fleas that left the rats' bodies after the rats died of plague. The rat flea transmits the pathogen when it jumps from rat to rat or from rat to human. This disease is known as *bubonic* plague after the swollen lymph nodes, called buboes, that it causes. The spread of the disease can be controlled by reducing rat and flea populations.

Insects and Humans

Many insects are known for their negative effects. Termites destroy wood structures, moths eat their way through wool clothing and carpets, and bees and wasps produce painful stings. Insects such as desert locusts cause billions of dollars in damage each year to livestock and crops. Boll weevils are notorious for the trouble they cause cotton farmers in the South. Mosquitoes are annoying and have been known to spoil many a leisurely outdoor activity. Only female mosquitoes bite humans and other animals to get a blood meal for their developing eggs. Male mosquitoes, on the other hand, do not bite; they feed on nectar. Many insects, including mosquitoes, cause far more serious damage than itchy bites. Their bites can infect humans with microorganisms that cause devastating diseases such as malaria, yellow fever, and bubonic plague.

Despite their association with destruction and disease, insects also contribute enormously to the richness of human life. Agriculture would be very different without the bees, butterflies, wasps, moths, and flies that pollinate many crops. One third of the food you eat depends on plants pollinated by animals, including insects. Insects also produce commercially valuable products such as silk, wax, and honey. They are even considered a food delicacy in certain countries of Africa and Asia.

CHECKPOINT *How do insects affect humans negatively? Positively?*

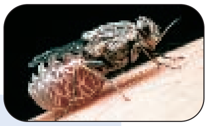
Biology and History

Insect-Borne Diseases

For as long as humans and insects have shared planet Earth, humans have been victims of diseases carried by insects. Researchers have discovered which insects transmit specific diseases. Such discoveries have often shed light on how the diseases can be controlled.

1906
Robert Koch
discovers that fleas transmit the bubonic-plague bacterium. The plague killed 25% of Europe's population between 1347 and 1351.

1909
Charles Nicolle
discovers that one form of typhus, caused by a bacterium, is transmitted by the body louse.



1924
African sleeping sickness is discovered in inhabitants of central Africa. The disease is caused by a protist transmitted by tsetse flies that live in forests and areas near water.

1943
DDT, a powerful insecticide, is used for the first time during World War II to control the spread of typhus. It is also used to control outbreaks of malaria.

1900 — 1925 — 1950

BIO INSIGHTS

FACTS AND FIGURES

Yikes—that bite itches!

Although almost everyone has been bitten by a mosquito, most people may not be aware that it is only the female that bites. Male mosquitoes cause no trouble at all, flying around and collecting pollen from flowers. The biting females use the nutrients in blood to help them produce large numbers of eggs. To prevent blood from clotting as they drink it, mosquitoes inject their saliva when they first pierce the skin. It is this saliva that can carry disease-causing organisms such as the malaria-causing protozoan, *Plasmodium falciparum.* And it is the human body's allergic reaction to this saliva that causes the itching and swelling that come with mosquito bites.

Insect Communication

Insects communicate using sound, visual, chemical, and other types of signals. Much of their communication involves finding a mate. To attract females, male crickets chirp by rubbing their forewings together, and male cicadas buzz by vibrating special membranes on the abdomen.

Visual Cues Male fireflies use visual cues to communicate with potential mates. As shown in **Figure 28–19**, a light-producing organ in the abdomen is used to produce a distinct series of flashes. When female fireflies see the signal, they flash back a signal of their own, inducing the males to fly to them. This interaction is sometimes more complicated, however, because the carnivorous females of one genus of fireflies can mimic the signal of another genus—and then lure unsuspecting males to their death!

Chemical Signals Many insects communicate using chemical signals. These chemicals are called **pheromones** (FEHR-uh-mohnz), which are specific chemical messengers that affect the behavior or development of other individuals of the same species. Some pheromones function to signal alarm or alert other insects. Other pheromones enable males and females to communicate during courtship and mating.

▲ **Figure 28–19** Fireflies use light to communicate with other individuals of their species. They are programmed to respond to specific patterns of light. **Applying Concepts** *What are some other ways in which insects communicate?*

Writing in Science

Some insect-borne diseases have an intermediate host in which the parasite reproduces asexually. Conduct research on the bubonic plague to identify its intermediate host. Write a report on how this host was discovered and how the discovery affected control of the disease.

1972
Use of DDT is severely restricted in the United States because it is found to be toxic to fishes, birds, and possibly humans.

1974
The World Health Organization begins to get rid of the black fly population of West Africa. Black flies transmit river blindness, which is caused by a roundworm.

1999
An outbreak of West Nile virus occurs in New York City and its suburbs. The disease is carried by mosquitoes and can affect humans as well as birds and livestock. Officials order spraying of insecticides near bodies of water in which mosquitoes might breed.

1950 1975 2000

TEACHER TO TEACHER

When I teach students about arthropods, I try to present issues and ideas that they can relate to in their own everyday lives. A teacher should always remember that with very few exceptions the students taking high school biology will become neither biologists nor doctors. We as teachers, then, should strive to give students a handle upon which to grab life—the biology of life. For instance, I try to spend class time on spiders and their webs, as well as on the process of silk production. I also try to help students understand how and why common insects function as they do. I make a daily effort to capitalize on students' interests in order to make the study of living things relevant to their lives.

—*Dr. Chuck Campbell,*
Biology Teacher
Burbank High School
Burbank, CA

Insect Communication

Build Science Skills

Observing If the season is right, ask volunteers to use a jar to collect fireflies one evening. Instruct students to cover the mouth of the jar with cheesecloth to allow airflow so that the insects can breathe. Have the students bring the jar of fireflies to class the next day, and encourage students to examine the organisms with a hand lens. Explain that fireflies are a type of beetle. People in primitive societies around the world have long trapped fireflies to use for light at night. Instruct students to release the insects in a field or meadow after the activity. L1 L2

Demonstration

Help students understand how insects communicate by demonstrating several ways that insects make sounds. To mimic insects such as cockroaches that produce a hissing sound, clamp your teeth together and blow air between them. To mimic insects such as grasshoppers and crickets that produce sounds by rubbing body parts together, pull a fingernail file across the edge of an index card. To mimic insects such as some moths that produce a whistling sound by blowing air through a pharynx, blow up a balloon and let the air out slowly while holding the neck of the balloon with your fingers. Challenge students to think of other insect sounds and ways to mimic those sounds. L1

Answers to . . .

CHECKPOINT *Insects affect humans negatively by destroying structures, wool clothing, and carpets; by producing painful stings; by causing billions of dollars of damage each year to crops; and by transmitting devastating diseases. Insects affect humans positively by pollinating crops; by producing commercially valuable products such as silk, wax, and honey; and by serving as food.*

Figure 28–19 *Other ways in which insects communicate include sounds, chemicals, and other types of signals.*

28–3 (continued)

Insect Societies

Use Visuals

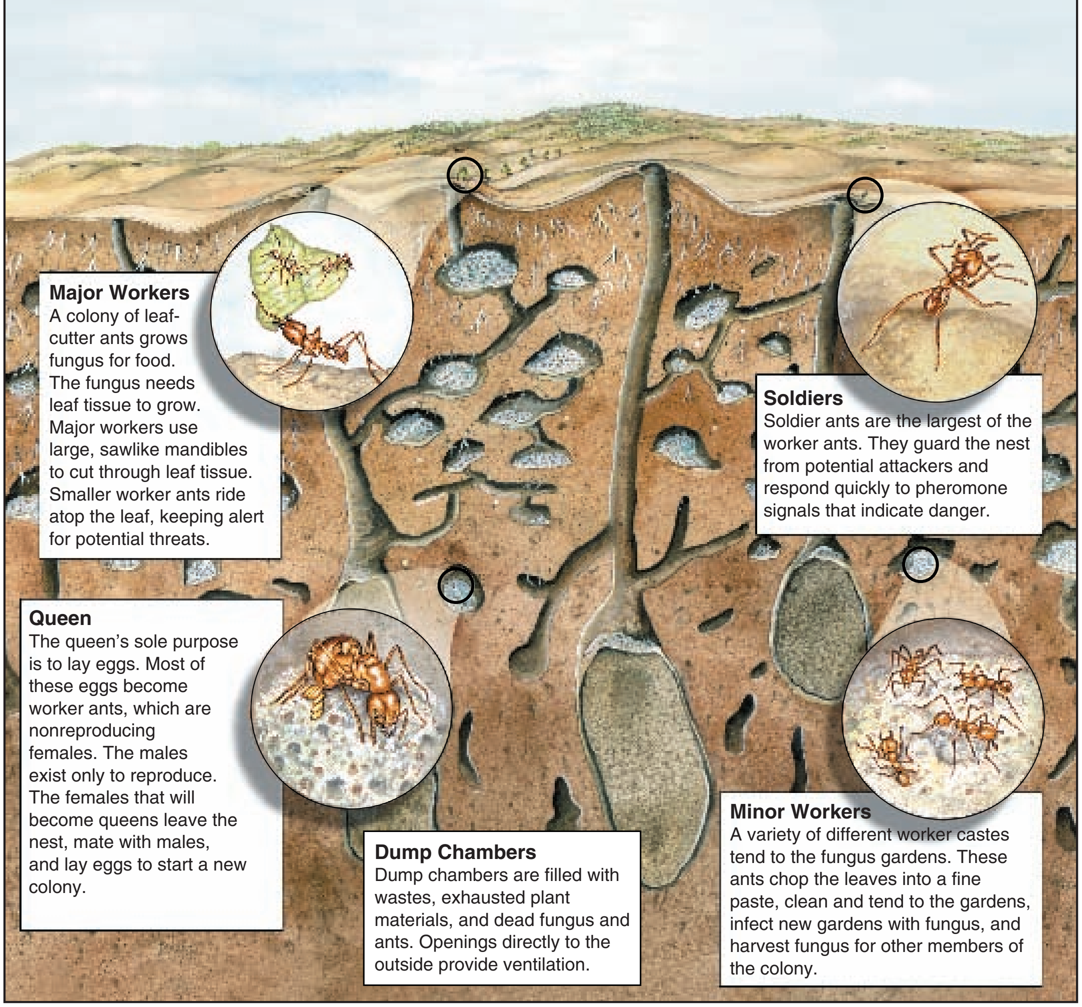
Figure 28–20 Ask students: **What is the role of the queen in a tropical leaf-cutter society?** *(The queen's sole purpose is to lay eggs.)* **Which kind of ants would you likely observe outside the nest?** *(Major workers would likely be seen outside the nest, because they forage for food.)* **What kinds of insects form societies?** *(Ants, bees, termites, and some of their relatives)* L1 L2

Use Community Resources

Invite a local beekeeper to speak to the class. You might find a beekeeper by contacting an entomologist at a local university or by asking at a local store that sells beekeeping supplies. Ask the beekeeper to talk about how to start a hive, what supplies and implements are needed, how the bees behave, and what purpose the bees serve in the community. Before the speaker arrives, encourage students to make a list of questions to ask about beekeeping. L2

Demonstration

Ask students to help locate an active anthill outdoors. (Avoid stinging ants; caution students not to touch the ants.) Then, put a spoonful of honey on the ground about 1 meter away from it. Put a sheet of paper between the honey and the anthill, and have students observe the ants. The ant scouts will find the honey and establish a pheromone trail directly back to the anthill. While the ants are traveling back and forth on the trail regularly, quickly turn the paper one-quarter turn. The ants will seem confused as they search for the old trail, but eventually, they will establish a new trail to the honey. L2 L3



▲ **Figure 28–20** **Some insects, such as these tropical leaf-cutter ants, form societies.** In a tropical leaf-cutter society, only a single queen reproduces. The queen can produce thousands of eggs in a single day. Several different castes of leaf-cutter ants perform all other tasks within the colony. They care for the queen and her eggs and young; they grow fungus for food; and they build, maintain, and defend the colony's home. One group of workers even cultivates bacteria that produce antibiotics! These antibiotics prevent the growth of parasitic molds on the fungus that the ants use for food.

Insect Societies

Just as people form teams that work together toward a common goal, some insects live and work together in groups. Unlike people, however, insects act instinctively rather than voluntarily. **Ants, bees, termites, and some of their relatives form complex associations called societies.** A **society** is a group of closely related animals of the same species that work together for the benefit of the whole group. Insect societies may consist of more than 7 million individuals. A tropical leaf-cutter ant colony is shown in **Figure 28–20.**

Castes Within an insect society, individuals may be specialized to perform particular tasks, or roles. These are performed by groups of individuals called **castes.** Each caste has a body form specialized for its role. The basic castes are reproductive females called queens (which lay eggs), reproductive males, and workers. Most insect societies have only one queen, which is typically the largest individual in the colony.

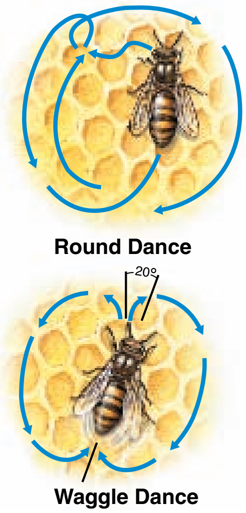
BIO INSIGHTS — FACTS AND FIGURES

Life in a honeybee colony
In a honeybee colony, the queen bee most of the time does little more than eat honey and lay eggs that will develop into workers. In the spring, workers build two kinds of enlarged brood cells in the honeycomb. Into one set of the cells, the queen deposits unfertilized eggs that develop into males (drones). Into the other set of enlarged cells, workers place special salivary-gland secretions that turn their honey into "royal jelly." The fertilized eggs that the queen deposits in these cells develop rapidly into large pupae that emerge as new queens. In the meantime, the workers lose interest in the old queen. Eventually, she leaves the hive with a few thousand of her daughters and a number of drones in a swarming flight to found a new colony.

Communication in Societies A sophisticated system of communication is necessary for the functioning of a society. Each species of social insect has its own "language" of visual, touch, sound, and chemical signals that convey information among members of the colony. When a worker ant finds food, for example, she leaves behind a trail of a special pheromone as she heads back to the nest. Her nest mates can then detect her trail to the food by using sensory hairs on their antennae.

Honeybees communicate with complex movements as well as with pheromones. Worker bees are able to convey information about the type, quality, direction, and distance of a food source by "dancing." As shown in **Figure 28–21,** bees have two basic dances: a round dance and a waggle dance. In the round dance, the bee that has found food circles first one way and then the other, over and over again. This dance tells the other bees that there is food within a relatively short distance from the hive. The frequency with which the dancing bee changes direction indicates the quality of the food source: The more frequent the changes in direction, the greater the energy value of the food.

In the waggle dance, the bee that has found food runs forward in a straight line while waggling her abdomen. She circles around one way, runs in a straight line again, and circles around the other way. The waggle dance tells the other bees that the food is a longer distance away. The longer the bee takes to perform the straight run and the greater the number of waggles, the farther away the food. The straight run also indicates in which direction the food is to be found. The angle of the straight run in relation to the vertical surface of the honeycomb indicates the angle of the food in relation to the sun. For example, if the dancer runs straight up the vertical part of the honeycomb, the food is in the same direction as the sun. In contrast, if the straight run is 10° to the right of the vertical, the food is 10° to the right of the sun.



▲ **Figure 28–21** Bees use dances to communicate information about food sources. The round dance indicates that food is fairly close to the hive. The waggle dance indicates that food is farther away. It also indicates the direction of the food. **Interpreting Graphics** *In what direction does the food lie, according to this bee's waggle dance?*

28–3 Section Assessment

1. **Key Concept** Describe the basic body plan of an insect.
2. **Key Concept** Compare the processes of incomplete and complete metamorphosis. Which involves a dramatic change in form?
3. **Key Concept** Describe the organization of a leaf-cutter ant society. What are the roles of the different castes?
4. What are pheromones? Identify two functions of pheromones.
5. What information is passed on by the dances of honeybees? Compare the messages of both types of dances.
6. **Critical Thinking Drawing Conclusions** The compound eyes of insects are better at detecting movement than the fine details of an image. Why might the ability to detect movement be important to insects?

Writing in Science

Explanatory Paragraph
Write a paragraph in which you briefly explain how insects communicate. *Hints:* In the first sentence in your paragraph, identify the different ways in which insects communicate. Then, in the sentences that follow, explain these ways. Use specific examples to clarify the points you make.

28–3 Section Assessment

1. Insects have a body divided into three parts—head, thorax, and abdomen. Three pairs of legs are attached to the thorax.
2. Students' comparisons should reflect understanding of Figure 28–18 and the explanation in the text on the same page.
3. The society consists of the queen, who reproduces; males, who mate with the queen; and various castes of female workers, who perform tasks such as growing fungus.
4. Pheromones are chemical messengers that affect the behavior or development of other individuals of the same species. Two functions of pheromones are signaling alarm and communicating during courtship and mating.
5. The dances communicate the quality, distance, and direction of food. A round dance indicates that food is closer than a waggle dance.
6. Sample answer: An ability to detect motion helps insects escape from predators.

3 ASSESS

Evaluate Understanding

Have students turn back to the labeled drawing of a grasshopper in Figure 28–4. Ask them to explain what characteristics the grasshopper has that make it an insect and not a crustacean or a chelicerate.

Reteach

Ask students to look at one of the ants shown in Figure 28–20. Then, help them identify the structures that make up that insect and explain how those structures help the organism carry out the essential functions.

Writing in Science

Paragraphs will vary in content, though each should reflect knowledge of what the student has learned by reading the section. In the first sentence of the paragraph, students should explain that insects communicate using sound, visual, chemical, and other types of signals. Within the paragraph, students should emphasize that much of insect communication involves finding mates. Students should also explain how certain insects communicate in societies.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 28–3.

Answer to . . .

Figure 28–21 *The food lies in the direction that is 20° from the position of the sun.*