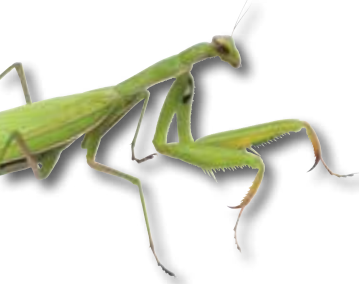
MERIT BADGE SERIES







INSECT STUDY







Scouting America

How to Use This Pamphlet

The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

Merit badge pamphlets are reprinted annually and requirements updated regularly. Your suggestions for improvement are welcome.

Who Pays for This Pamphlet?

This merit badge pamphlet is one in a series of more than 100 covering all kinds of hobby and career subjects. It is made available for you to buy as a service of the national and local councils of Scouting America. The costs of the development, writing, and editing of the merit badge pamphlets are paid for by Scouting America in order to bring you the best book at a reasonable price.

Send comments along with a brief statement about yourself to
Program Development Department
Scouting America • 1325 West Walnut Hill Lane • Irving, TX 75038 If you prefer, you may send your comments to merit.badge@scouting.org







SCOUTING AMERICA
MERIT BADGE SERIES

INSECT STUDY



"Enhancing our youths' competitive edge through merit badges"

Scouting America

Note to the Counselor

The *Insect Study* merit badge pamphlet emphasizes a heightened awareness on safety as a result of hazards that may be associated with exposure to ants and bees and the addition of a new optional requirement for working close to a bee hive or colony. Also new to this merit badge is the addition of the standard risk- and health-related requirement for safety and first aid.

Scouts choosing to pursue optional requirement 5(b)(2) should first find out whether they are allergic to bee stings. This can be determined by a visit to an allergist or a family physician. If it turns out a Scout is allergic to bee stings, the Scout should choose option 5(b)(1). If the Scout visits a beekeeper with another Scout, parent or guardian, then all participants also should be checked by a physician before the visitation.

Prior to counseling Scouts, Insect Study merit badge counselors are strongly encouraged to become familiar with the *Guide to Safe Scouting,* a helpful planning tool for all Scouting volunteers. This resource provides an overview of Scouting policies and procedures rather than comprehensive, stand-alone documentation. For some items, the policy statements are complete. However, unit leaders are expected to review the additional reference materials cited (such as the *First Aid* merit badge pamphlet) prior to conducting certain activities. Counselors can access the *Guide to Safe Scouting* online by visiting scouting.org/health-and-safety/gss/.

35911
ISBN 978-0-8395-3353-5
©2026 Scouting America
2026 Printing

SUSTAINABLE FORESTRY INITIATIVE
Certified Chain of Custody
Promoting Sustainable Forestry
www.sfiprogram.org
SFI-01042

To help keep participants safe during Scouting activities, the National Council has an established set of procedures called the "Scouting America SAFE Checklist." In an effort to assist merit badge counselors, the following considerations provide additional guidance of special interest to them.

Supervision.

- The Insect Study merit badge counselor should have knowledge of the applicable local and state USDA regulations for handling bees and beekeeping equipment.

Assessment.

- Counselors should take reasonable measures to provide participants with a well-constructed hive that passes USDA inspection.

Fitness and Skill.

- Counselors should be aware of youth participants who might be allergic to bee stings.

Equipment and Environment.

- Counselors should ensure hives follow USDA guidelines.
- Counselors should ensure all participants are wearing proper protective beekeeping clothing such as hat, veil, coveralls, gloves, long sleeves, pants, and other protective devices.
- Counselors teaching this merit badge must have experience with beekeeping and be recruited to do the work involved. As a rule, Scouting activities may not include activities for youth that, by law, they would not be allowed to do in the workplace.
- Counselors should take reasonable measures to ensure all participants are using beekeeping tools and equipment properly.

The SAFE checklist is available at scouting.org/health-and-safety/safe/.

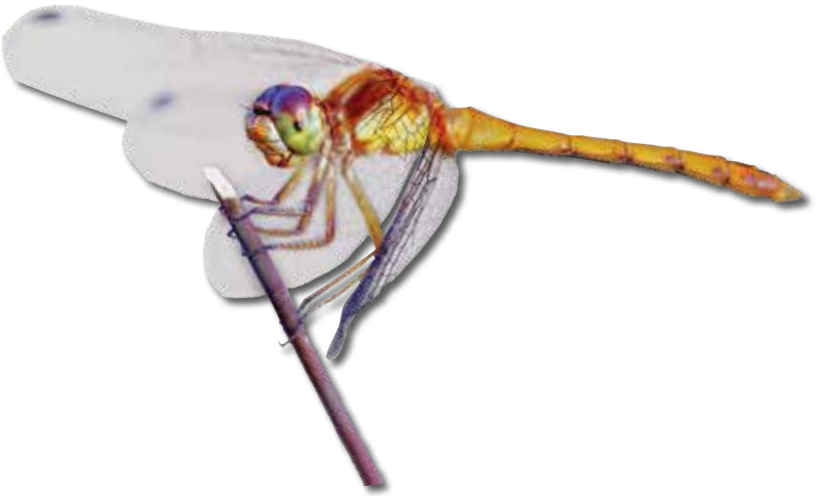
Requirements

Scouts should go to scouting.org/merit-badges/insect-study or check Scoutbook for the latest requirements.



Scan this QR code for the latest Insect Study requirements.

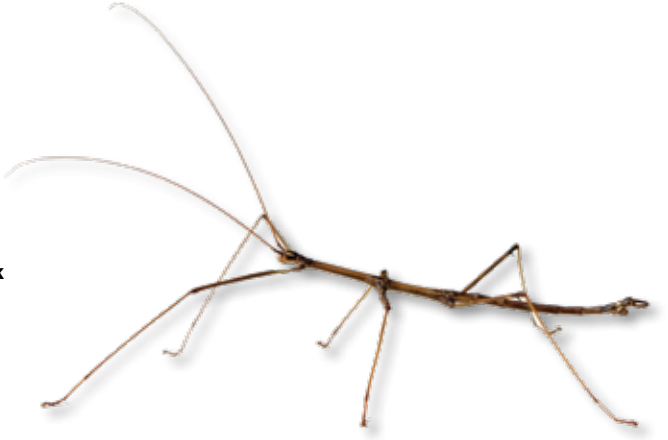
Yellow-legged meadowlark





Mole cricket

Walking stick



Contents

The World of Insects 9
What Is an Insect? 14
Parts of an Insect. 17
Insect Safari 33
Identifying Insects 47
The Life of an Insect 55
The Social Insects 63
Insects and Humans 75
Careers in Entomology. 87
Insect Study Resources 92





The World of Insects

Hiking in the woods or fields on a summer day, you are sure to see dozens, perhaps hundreds, of insects. Many are so tiny and seem so insignificant (except when they bite you) that you might dismiss them simply as nuisances. If you do, you are missing a chance to explore a world of unbelievable variety, filled with marvels hard to imagine.

Get ready to meet tiny creatures with tremendous strength and speed. You will see insects that undergo startling changes in habits and form as they grow. You will learn how insects see, hear, taste, smell, and feel the world around them; how they find food; and how some of them live together in amazingly complex societies. You will learn about insects that are helpful to humans and others that are harmful or even deadly.

The field of insect study is as broad as all outdoors and just as open. *Entomologists,* scientists who study insects, have described about 1.5 million different insects, each a distinct type known as a *species.* Scientists discover from 7,000 to 10,000 new species of insects every year. They estimate that there are between 1 million and 10 million species still undiscovered. However, research in the Amazon region of South America has led some scientists to think there could be as many as 30 million insect species worldwide.

Clearly, much remains to be learned about insects. While working on the requirements for this merit badge, you might discover something about insects that no one ever knew. Remember that you are welcome to watch and study insects wherever you find them, but it is illegal to collect insects in many natural areas, especially state parks, national parks, and wildlife refuges.

Extreme Insects



Red fire ant

Extremely strong: An ant can lift 50 times its own body weight. If a 180-pound person could do that, that person could lift 9,000 pounds—4½ tons!



Dragonfly

Extremely fast: Dragonflies can fly 60 miles per hour. A housefly's wings beat about 200 times a second (the buzzing of a fly is the sound of its wings beating). Some midges move their wings 1,000 times a second.



Cat flea

Extremely nimble: A flea can broad jump about 13 inches. By comparison, a human athlete would have to jump 700 feet to equal the flea's performance.

Extremely big: Goliath beetles grow to about 5 inches long. Australia's giant Hercules moth and South America's giant owl moth have wingspreads of about 12 inches. The Queen Alexandra's birdwing butterfly has a wingspread of about 11 inches. Some extinct dragonflies were 18 inches long with wingspans of 2½ feet.

Extremely small: Fairyflies and feather-winged beetles could easily pass through the eye of the smallest needle. The pygmy mole cricket is a tiny insect as well, with a maximum length of ¼ inch.

Extremely colorful: Butterflies are every color imaginable, from bright yellows, reds, and oranges to shimmering coppers; pale, silvery blues; and pearly whites. Some beetles are a rainbow of brilliant metallic or jewel-tone shades.

Extremely bright: Fireflies are even bioluminescent—they literally shine like a light. Bioluminescence is the result of a reaction between a molecule (luciferin) and an enzyme (luciferase). It serves many purposes from attracting mates and prey, to warding off predators, or providing a form of camouflage.



Goliath beetle



Fairyfly



Eastern tiger swallowtail



Firefly



Brown stinkbug

Extremely smelly: Stinkbugs, some beetles, and lacewings emit foul odors to repel enemies. The bombardier beetle fends off attackers by squirting two chemicals from the end of its body. The chemicals mix to produce a hot puff of gas.



Silverfish



Extremely ancient: Insects first appeared on Earth in prehistoric times. Dragonflies flitted through the skies and silverfish and cockroaches scurried on the ground while dinosaurs walked the land.

Extremely versatile: Among insects there are builders and carpenters, hunters and trappers, farmers and livestock raisers, nurses, guards, soldiers, papermakers, sanitation workers, slaves, and even thieves.



American cockroach



Texas leafcutting ant





Extremely adaptable: Insects are everywhere—in trees and forests, in grasslands, in deserts, on mountains, in lakes, in the air, on buses, in homes and offices. The young of some insects can live in pools of crude oil. Some live in hot springs at temperatures of 120 degrees. Others live in ice-cold streams, even above the Arctic Circle. After being frozen and thawed, some insects will revive unharmed. Some insects live in caves deep within Earth, or between the thin walls of a leaf. The only place you are not likely to find many insects is in the oceans.

Extreme travelers: Every fall sees some North American monarch butterflies take a mind-boggling long trip across the United States. Monarchs from east of the Rocky Mountains fly up to 3,000 miles to their winter homes in central Mexico. Western monarchs have a bit shorter trip, traveling to the California coast.



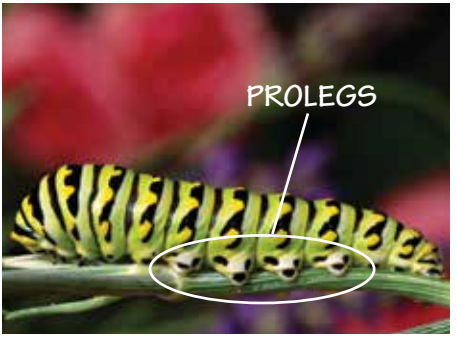

Bush katydid

What Is an Insect?

There are more insects in the world than all other animals combined; 75 percent of all animal species are insects. They come in every imaginable size, shape, description, and color. Most insects pass through life stages during which they look quite different from their adult forms. Given the enormous number and variety of these creatures, it might seem difficult to say exactly what an insect is. Nevertheless, all insects have certain things in common that make them recognizable.

All insects belong to a larger animal group known as *arthropods,* which also includes spiders, mites, ticks, scorpions, harvestmen (daddy longlegs), crabs, shrimp, crayfish, sow bugs, barnacles, centipedes, and millipedes. All of these related animals share two unique characteristics that distinguish them from all other animal groups. Arthropods have jointed legs. An external skeleton—the *exoskeleton*—encloses the entire body in a shell.

Differences in body structure separate the insects from their arthropod relatives. Insects have six jointed legs (three pairs); all other arthropods have four or more pairs of legs. Insect bodies are divided into three distinct regions—head, thorax, and abdomen; most other arthropods have only two body regions—head and trunk. Insects have one pair of antennae or "feelers"; spiders and their relatives have no antennae, while crustaceans (crabs, shrimp, crayfish, etc.) have two pairs. Most adult insects have wings; no other arthropod has wings at any stage of life.



Black swallowtail caterpillar



Black swallowtail adult butterfly

Identifying insects from other arthropods and small animals gets easier with experience. For example, a caterpillar you see feeding on a leaf might not look like an insect because it appears to have more than six legs. However, it actually has six jointed legs and 10 fleshy, unjointed accessory legs called *prolegs.* When the caterpillar (larvae stage) transforms into an adult butterfly, you will have no doubt about the number of legs it has.



Ant

Remember these identifying characteristics:

- Insects have an external covering called an exoskeleton (a shell).
- Insects have three body regions, six jointed legs, and one pair of antennae.
- Adult insects usually have wings.

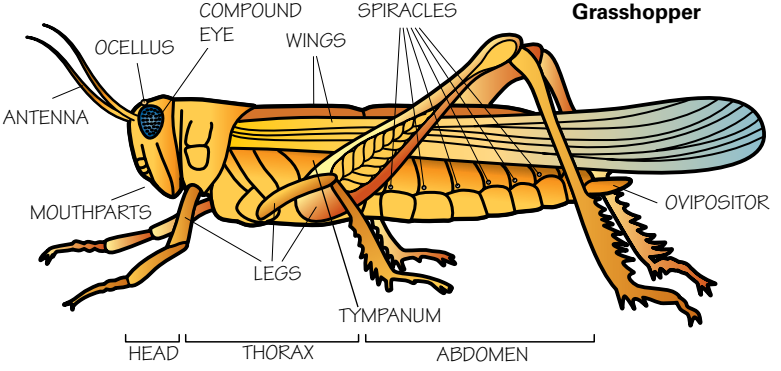


Parts of an Insect

Compare a bumblebee, a grasshopper, and a butterfly. They differ in many ways, but they share the same general body structure. While their body parts might differ in size and shape, they and all other insects are put together in the same way.

Insect Body Regions

The insect body has three distinct regions—head, thorax, and abdomen. The prominent features of the head are the eyes, antennae, and mouthparts. Attached to the thorax are the legs and, when they are present, the wings. The abdomen contains many of the important internal organs, such as the reproductive and digestive systems.



In a few insects, the thorax and abdomen might appear to run together. The jointed legs, however, are always attached to the thorax. The area where the last leg is attached is the point where the thorax ends and the abdomen begins.

The Insect's Armor

An insect's exoskeleton, or shell, is formed of plates fitted together like the armor of a medieval knight. Insects have no bones—no internal skeleton such as humans have. Muscles and other body tissues are attached to the inside of the exoskeleton. The exoskeleton is made of *chitin* (KY-tuhn), a light, strong material. Every insect lives encased in chitin, although shell thicknesses vary. Exoskeletons of caterpillars form thin skins; beetles have thick, armorlike plates.



Cicada nymphs hatch from eggs laid in trees. The young insects burrow into the ground and suck sap from roots, staying buried for up to 17 years. When they do come back out, they crawl up trees, shed their old exoskeletons, and emerge as full-grown adults ready to lay eggs and keep the cycle going.

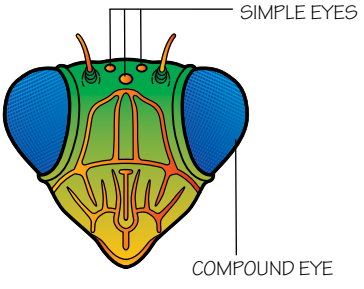
As an insect grows, its skin becomes too tight and splits—it molts, or sheds its skin. The chitinous exoskeleton splits down the back, and the insect emerges from its old skin and expands into a new, larger one. The number of molts needed to reach adult form and size varies from four to 40, depending on the species.

An insect's body structure is related to its senses of sight, smell, hearing, taste, and touch, and to how it moves about, eats, and breathes.

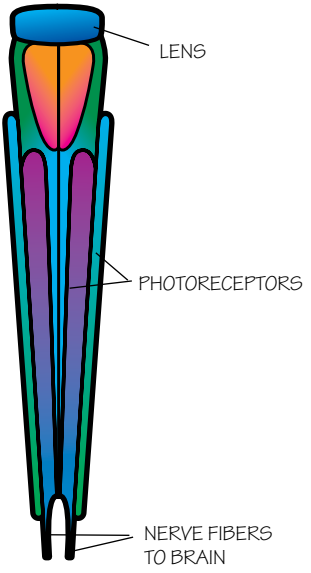
How an Insect Sees

Most insects have two kinds of eyes: *compound eyes* for seeing detail and *simple eyes* for perceiving brightness.

Praying mantis

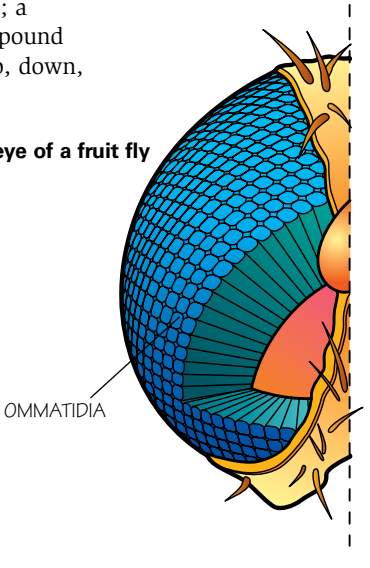


OMMATIDIUM

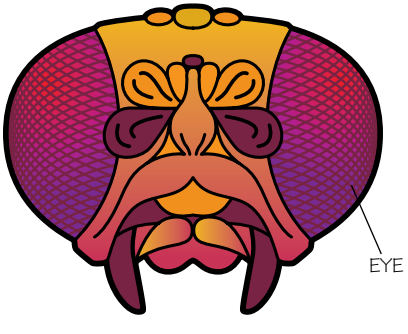


In the **compound eye,** six-sided lenses called *ommatidia* contribute to the complete image the insect sees. A large dragonfly can have as many as 28,000 ommatidia in each compound eye. Some queen ants have about 50 lenses; some robber flies, 4,000; a swallowtail butterfly, 17,000. These large compound eyes bulge outward, allowing insects to see up, down, forward, backward, and to each side.

Compound eye of a fruit fly



Head of fruit fly



Insects cannot focus their eyes first on distant objects and then on near ones, as we can. Their eyes are like fixed-focus cameras. Insects can, however, see "black light," the ultraviolet rays invisible to humans.

The **simple eyes,** called *ocelli,* are set in a triangular arrangement between the compound eyes. Simple eyes seem to help the insect detect changes in brightness rather than for actual vision. In some cases, the ocelli are 16 times more sensitive to light changes than are the compound eyes.

Insects probably never see the world around them in perfect focus. They see objects, but probably not in sharp detail. A dragonfly will dart at bits of floating ash above a campfire, evidently mistaking them for insects on the wing. A wasp might dart repeatedly at the shadow of a fly resting on the other side of a canvas tent. Butterflies will rush at a decoy cut from colored paper as readily as at another butterfly.

Insects can see and remember different colors. The English scientist Lord Avebury proved this in a classic experiment. He placed a little honey on a blue square among squares of other colors. After bees began to come daily to this square for food, he shuffled the squares and put food on none of them. Instead of flying to the square that lay where the blue square used to be, the bees immediately landed on the blue square even though it was in an entirely different position. They associated the color with food, proving they could see and remember blue as a color.

When a bee flies in a "beeline" home to the hive, it navigates largely by using its eyes, recognizing landmarks along the way. If the same bee is carried into country it has never seen before, it is lost. Similarly, wasps find their way back to their nests or burrows by eyesight. If you place a leaf over the entrance of a digger wasp's burrow, the wasp will be confused when it returns because the spot looks different. One scientist found that when he cut off a small bush near the entrance of a wasp's burrow and stuck it in the ground several yards away, the wasp flew to the bush instead of to the burrow. It was using the bush as a landmark.



Digger wasp

How an Insect Smells

An insect's antennae function as its nose. Compare a damselfly with a male cecropia moth. The damselfly has immense eyes but small, spikelike antennae. The moth has small eyes but large, fernlike feelers. The damselfly depends on sight to guide it; the cecropia, flying in darkness, follows its feelers along faint odor trails through the night.



Eastern forktail damselfly



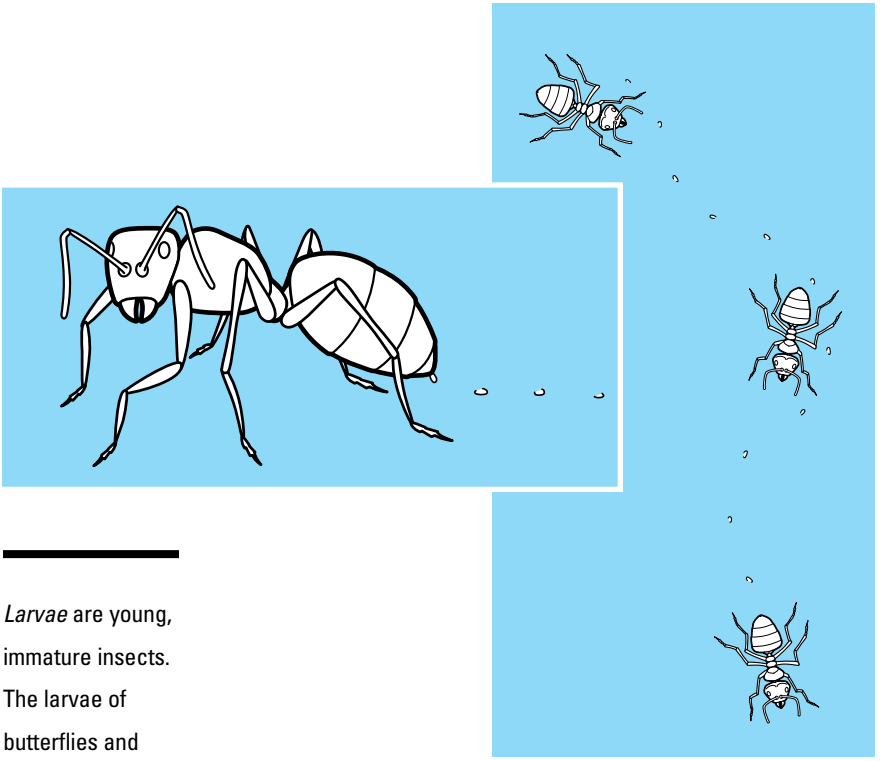
Male cecropia moth

Some *ichneumons* (ik-NOO-muhn), insect parasites that lay their eggs on tree-boring grubs, have such an amazingly keen sense of smell that they can detect the odor of their prey through 2 inches of solid wood.



In the antennae of one june beetle, scientists found 40,000 tiny olfactory pits for detecting odors.

Laboratory tests have proven that honeybees can distinguish more than 40 different odors.

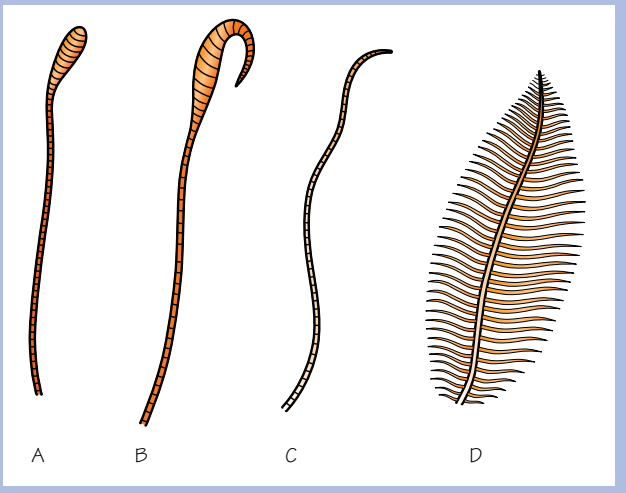


Larvae are young, immature insects. The larvae of butterflies and moths are called *caterpillars*.

Unlike bees and wasps, the earthbound ant seems to depend on smell rather than sight to find its way. Ants leave odor trails on the main routes around their nests. As long as its antennae are intact, an ant can follow these scent trails. Without its antennae, the insect is completely lost, even if placed close to the entrance of its home.

Like a radio tuned to one station, the sense of smell in many insects seems limited to a narrow range of odors. A male moth, traveling through miles of darkness to reach the female, seems insensitive to the thousands of other smells around it. Carrion beetles, which appear as if by magic when a fallen sparrow or dead mole begins to decompose, are led to the spot from far away by their sensitive feelers. All other smells seem not to affect them. Butterflies and moths follow their sense of smell to plants that will provide the right kind of food for their larvae. The females are "tuned in" to that particular smell.

Insect Antennae



Antennae of (A) butterfly; (B) skipper; (C) moth; and (D) saturniid moth



Delaware skipper

The antennae of different insects vary greatly in shape and size. They range from the slender, threadlike feelers of katydids and long-horned grasshoppers to the stubby spikes of robber flies. Ants and bees have jointed, elbowed feelers; butterflies have antennae that resemble long-handled clubs; gnats and mosquitoes have bristly feelers that look like miniature bottle brushes. With such feelers, mosquitoes find their food in the dark.

Only female mosquitoes bite people; males dine on the nectar of flowers.



Asian tiger mosquito

How an Insect Hears

Among all the insect "instrumentalists" (katydids, grasshoppers, crickets, cicadas), only the males—never the females—make music.

Besides detecting odors, the bushy antennae of some mosquitoes and gnats help catch certain sounds. To demonstrate this, a scientist fastened a live male mosquito to a microscope slide, then held a tuning fork with exactly the same pitch as the hum of a female mosquito to the right of the male. Instantly, the hairs on the male's right antenna began to quiver. The scientist held the tuning fork to the left of the male mosquito. The hairs on the left antenna vibrated. When the tuning fork was held in front of the insect, the hairs on both antennae quivered. Like an airplane pilot flying on a radio beam, the male insect can find the female in the dark. To stay on course, he has only to keep the hairs on both his feelers vibrating equally. That will lead him to the humming female.

Other insects hear in different ways. A cricket's ears are on its forelegs, just below the knees, as are a katydid's. You can easily see these oval openings, called *tympana,* when the insects are at rest. The ears of short-horned grasshoppers, or locusts, are on the sides of their bodies near the base of the wings. Many species, including honeybees, ants, and dragonflies, give no sign that they hear sounds the way humans do. However, they certainly feel vibrations within the range that we call sound.



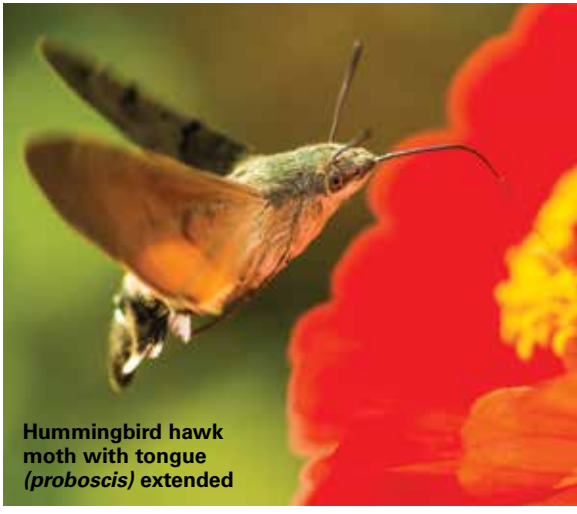
Cicada with wings spread

Many insect sounds are associated with the mating season. The song of the snowy tree cricket, the fiddling of the katydid, the chirping of the field cricket, the loud burr of the cicada, even the ticking of the death-watch beetle as it bumps its head against the walls of a tunnel it has hollowed out in a house timber—all of these are serenades to attract females. In a laboratory experiment, a female field cricket was drawn to a telephone receiver 30 feet away when she heard the chirps of a male cricket at the other end of the line.

How an Insect Tastes and Eats

Many insects react to the same four kinds of taste—salty, sour, sweet, and bitter—that people can identify. Some insects are especially sensitive to certain tastes. A honeybee, for example, will react to faint traces of salt that a human tongue cannot detect. A monarch butterfly can taste sugar dissolved in water at a level thousands of times weaker than a person can taste.

The taste organs of most insects are on their mouthparts, as expected. However, the antennae of ants, bees, and wasps help them taste, while some flies and butterflies can taste with their feet. When the legs of a monarch butterfly touch nectar or sweetened water, the insect immediately uncoils its hollow tongue—its *proboscis*—to feed.



Hummingbird hawk moth with tongue *(proboscis)* extended



The praying mantis has powerful jaws for devouring its prey.

Butterflies and moths, with their coiled sucking tubes, take only liquid nourishment, mainly nectar. The paper wasp, with jaws and a tongue, can lap up nectar or chew captured insects to feed to the larvae in its nest. Plant lice and squash bugs have sharp, sucking beaks for drawing sap from plant tissues, as does the tiny froghopper. Beetles, crickets, and grasshoppers have jaws for chewing leaves and other solid food. The jaws, or mandibles, work sideways instead of up and down like the jaws of higher animals.



A grasshopper's strong jaws help it chew.

How an Insect Feels

Tiny hairs and spines connected with its nervous system give an insect a delicate sense of touch. These touch organs cover all parts of an insect's body, even its eyes. Ants and other earth-hugging insects such as crickets, earwigs, and cockroaches have spines that are particularly sensitive to vibrations. Some butterflies have a fringe of sensory hairs along the margins of their wings. Water striders can use the fine hairs on their feet to sense the approach of their prey through vibrations of the water's surface film. Tiny hairs on the leg joints of some insects—hairs that are bent when the legs move—enable the insects to tell the position of their limbs. In contrast, we humans tell the position of our legs by the "feel" of the muscles.

The central nervous system in insects consists of a brain, located in the head, and two nerve cords that lie side by side along the lower side of the body cavity. This position of the nerve cords is opposite to the placement of the spinal cord in higher animals.

How an Insect Moves About

Insects travel on the ground, underground, underwater, and in the air. Many have odd and often surprising means of travel that fit them for the place where they live. Dragonfly *naiads,* for instance, sometimes move like miniature rockets along a pond bottom by expelling jets of water from their rears. This drives them ahead in sudden spurts.

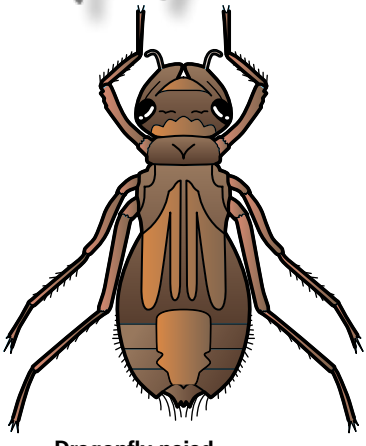


A "cloud" of snow fleas

Primitive insects known as springtails have a forked, taillike appendage that can be bent and then suddenly released like a spring to catapult the insect into the air. Springtails are so light that some of them shoot into the air from the surface film of ponds or streams. The most spectacular are the so-called snow fleas. In mild midwinter weather, these curious black insects sometimes appear on snowdrifts in such numbers that they look like clouds of windblown soot.



Snow flea



Dragonfly naiad



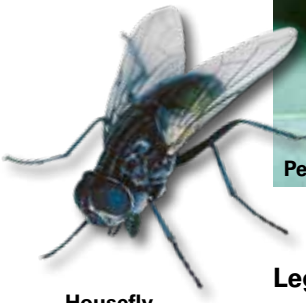
Mature calico pennant dragonfly

A **naiad** is the immature, water-living form of insects such as mayflies and dragonflies.


Praying mantis


Periodical cicada nymph


Camel cricket


Housefly

Legs

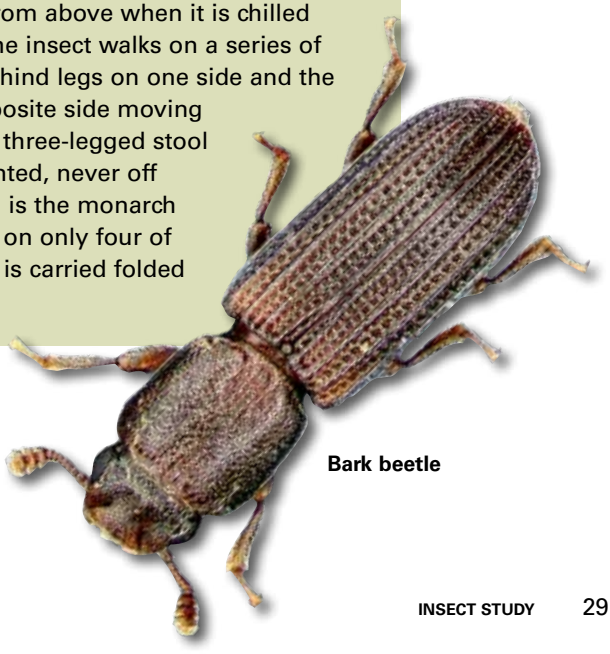
The legs of insects suggest the kind of life they lead. Mole crickets and the *nymphs* (larvae) of periodical cicadas have forelegs enlarged into powerful digging tools. The long, spiked forelegs of the praying mantis are spined traps for capturing prey. Houseflies have feet with sticky pads that help them walk on smooth panes of glass or upside down on ceilings. Robber flies—insect predators that swoop down on victims and grab them in midair with their feet—have unusually long legs ending in hooked claws. Dragonflies are almost completely aerial creatures; they form their spined legs into a basket to catch prey in flight. Their legs are bunched so far forward that they are almost useless for walking, and are used mostly for clinging and climbing. Some water beetles have legs that work like oars.



Water striders walk on the surface film on water-repellent tufts of hair that spread fanwise near the tips of their legs, like snowshoes. When not in use, the hairs fold up into a slot on the insect's leg.

A Solid Footing

To find out how insects use their six legs to walk, watch a large insect from above when it is chilled and moving slowly. The insect walks on a series of tripods, the front and hind legs on one side and the middle leg on the opposite side moving in unison. Thus, like a three-legged stool it is always firmly planted, never off balance. An exception is the monarch butterfly, which walks on only four of its legs. The front pair is carried folded against its body.



Bark beetle

Wings

Most insects have two pairs of wings, a few have one pair, and some have no wings at all. Only adult insects have wings; a winged insect is fully mature, with the exception of the subadults (or subimagoes) of mayflies.

In the air, some insects reach high speeds and high altitudes and travel great distances. Their wings operate differently from the wings of birds. **Instead of the flapping or rowing motion of a bird, the wings of an insect usually move in a series of figure eights**. The English scientist Lord Avebury was the first to demonstrate this motion. He tipped the wings of a wasp with gold leaf and let the insect fly in sunlight. The tiny spots of shining gold traced figure eights in the air. On wings moving in this fashion—often so fast they are blurs to our eyes—many insects can outmaneuver birds. They can stop in midair, turn, go straight up, drop to the ground, and, in some cases, even fly backward.

Some butterflies can reach heights of almost 20,000 feet.



The wing muscles of flying insects are the largest in their bodies. In one kind of fly, the wing muscles account for 48 percent of the insect's body weight. These great muscles change the whole shape of the thorax, causing the wings to move up and down. Other special muscles are used to manipulate the wing to change direction, or to fold the wing when the insect is at rest.

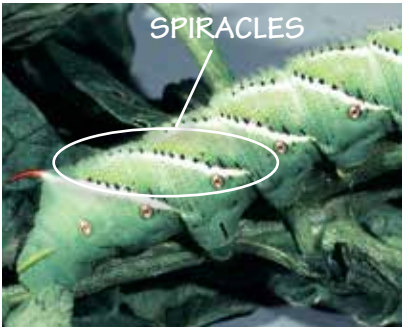
When wasps, butterflies, and bees take to the air, the hind pair of wings attaches to the front pair so that the insect flies as though it had only a single pair of wings. This is done in various ways. In wasps and bees, small rows of twisted hooks on the front edges of the hind wings engage little ridges on the trailing edges of the forewings.

Dragonflies, which have four wings, use a different flying technique than most insects. The two pairs of wings are kept separate and move independently.



How an Insect Breathes

An insect has no lungs, but it still must breathe. Air enters through openings in the body called *spiracles,* and a system of finely branching tubes, or *tracheae,* carries oxygen directly to body tissues. The droning of some flies is the humming sound made by air entering these breathing tubes.



The spiracles are easy to see on the sides of a tobacco hornworm.

Most insects need little oxygen. The most active fliers, however, such as dragonflies, bees, and moths, have small, bladderlike reservoirs connected to air tubes. These reserve "gas tanks" hold extra supplies of air. A dragonfly breathes about 118 times a minute; many humans average about 18 times a minute. Less active species of insects breathe more slowly.

Many diving, air-breathing aquatic insects have a thick coating of fine hair, or pile, on the underside of their bodies. It is called the *plastron.* Air catches in this pile and is carried along when the creature dives. By carrying its own oxygen supply, the insect is able to stay underwater for long periods.

When descending underwater to lay their eggs in the stems of aquatic plants, some female dragonflies are enclosed in a film of air. In the sunshine, it looks as if each diving dragonfly has a shiny silver case or "diving bell."

An Insect's Circulatory System

The insect circulatory system consists of its heart, an open-ended *aorta* (blood vessel), and *hemolymph* (blood). The heart and aorta, located on the body cavity's upper side, pump blood throughout the open body cavity. There is no system of blood vessels as in higher animals. Blood fills the entire cavity, bathing all the organs and muscles.

The blood of most insects is usually straw-colored, pale green, or colorless because it lacks the oxygen-carrying pigment called *hemoglobin*. The blood of most insects is not designed to carry oxygen. Instead, it transports and stores water, waste products, disease-fighting antibodies, and hormones.

A few insects, like bloodworms, do have red blood with *hemoglobin.* They live in low-oxygen environments and use hemoglobin to transport oxygen.


Troop 175

Insect Safari

The most accurate observation of an insect in nature comes from watching it undisturbed. When observing insects in their habitat, be careful to leave them unharmed in the place that you found them.

The Seven Principles of Leave No Trace and the Outdoor Code apply to all outdoor activities, including insect study. Requirements for the Insect Study merit badge call for you to not only observe insects, but in some cases, to collect them.



As with any trek in the outdoors, there are some basic guidelines to follow when searching for insects.

1. When you embark on your insect safari, prepare a trip plan, or at the very least, tell an adult where you are going. It is also a good idea to take a friend with you.
2. It is a good idea to wear long pants, a long-sleeved shirt, a hat, and closed shoes to keep ticks, chiggers, and insects from biting you or hitching a ride.
3. Check with natural resources authorities in advance to be sure that you will not be collecting any protected or endangered species, or wandering in a habitat where collecting is prohibited.
4. Ask permission before entering private property.
5. If you must handle an insect, be careful and gentle to avoid injuring it. Insects are fragile.
6. Avoid touching an insect's nest.
7. In most cases, specimens should be returned to the location of capture after the requirement has been met. Check with your merit badge counselor for those instances where the return of these specimens would not be appropriate.

Playing It Safe

Prevention goes hand in hand with mitigation, which means "to lessen in force or intensity" and "to make less severe." By taking precautions to manage risk and the possibility of injury, you can be prepared to anticipate, help prevent, mitigate, and respond to just about any incident that might happen while you observe insects.

Whenever you are in the outdoors, make it a habit to use sunscreen with an SPF of at least 15. Reapply sun protection as needed.

Like all outdoor activities, insect watching has its risks. You can start by dressing appropriately—for instance, jeans, boots, gloves, and a long-sleeved shirt for protection. The bites of mosquitoes, chiggers, and no-see-ums are irritating but not usually dangerous. However, if your area has had cases of West Nile Virus, protect yourself from mosquitoes by using the right insect repellent when you are outdoors. For protection from ticks, wear long pants tucked into your boots and a long-sleeved shirt buttoned up to the collar.

Be careful when walking through areas where spiders and biting insects might be lurking. Watch out for fire ants, which live in loose mounds of dirt. These bites can usually be treated by washing the area with soap and water, applying an antiseptic, and covering with a sterile bandage. For more relief, take a mild nonaspirin pain reliever and apply a cold pack to the area. Seek medical attention immediately if there is trouble breathing or the pain does not ease.



Anyone who is highly allergic to fire ant bites or bee or wasp stings can have a life-threatening reaction called *anaphylactic shock,* or *anaphylaxis.* Symptoms can include swelling of the throat tissues or tongue that makes breathing difficult or even impossible. **Let others in your group know that you are allergic, and they know where your epinephrine medication is kept and how to use it. In an emergency, all 911 for immediate medical assistance.** Keep the victim comfortable—usually a sitting position—until medical help arrives.

People who know they are susceptible to anaphylaxis should carry an emergency kit that contains an injection of epinephrine, a rapidly acting hormone that reverses the effects of anaphylactic shock.

For more detailed information about first aid, consult the *First Aid* merit badge pamphlet.



Equipment for the Insect Safari

To observe insects, you must go where they live. Bring along the right equipment so you can properly study and document the creatures you encounter. The basic equipment described here should easily fit into a day pack.

The Basics

Some everyday items will be valuable in your search for the most interesting insects:

- Some **magnifying lenses** can be worn around your neck. Others fold up neatly and fit in a pocket.
- A good **insect guide** will help you identify the critters you see.
- Use a **notebook and pencil** for jotting notes and making sketches.
- A **flashlight** will help you investigate bushes and other nooks and crannies where insects are hiding.
- Bring a **camera** that can take close-up photos. Your own photos will make a great addition to your scrapbook.

The Outdoor Code:

As an American, I will do my best to

- Be clean in my outdoor manners.
- Be careful with fire.
- Be considerate in the outdoors.
- Be conservation minded

The Leave No Trace Seven Principles:

- Plan ahead and prepare
- Travel and camp on durable surfaces
- Dispose of waste properly
- Leave what you find
- Minimize campfire impact
- Respect wildlife
- Be considerate of others.

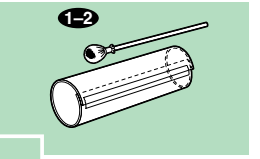
Aspirator

An aspirator is a handy tool that helps you capture most insects without harming them. You can make one easily.

What You'll Need:

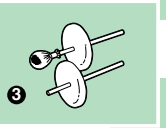
- 4-inch square of clear plastic sheet that can be curled to create a tube
- Tape
- Gauze
- Modeling clay
- 2 straws

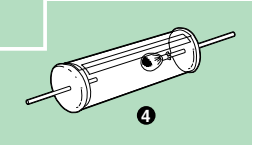
Step 1—Curl a 4-inch-square piece of clear plastic into a tube and secure it with tape or glue.



Step 2—Tape a bit of gauze over one end of a wide drinking straw.

Step 3—Form two ping-pong-sized balls of modeling clay. Press them flat into disks big enough to cover the ends of the tube. Push a straw through the center of each disk.





Step 4—Position the disks at the ends of the plastic tube. Make sure the gauze is inside the tube.

Insects you should not capture with an aspirator are stinging and biting insects, and large insects, such as butterflies, that cannot fit into the straw.



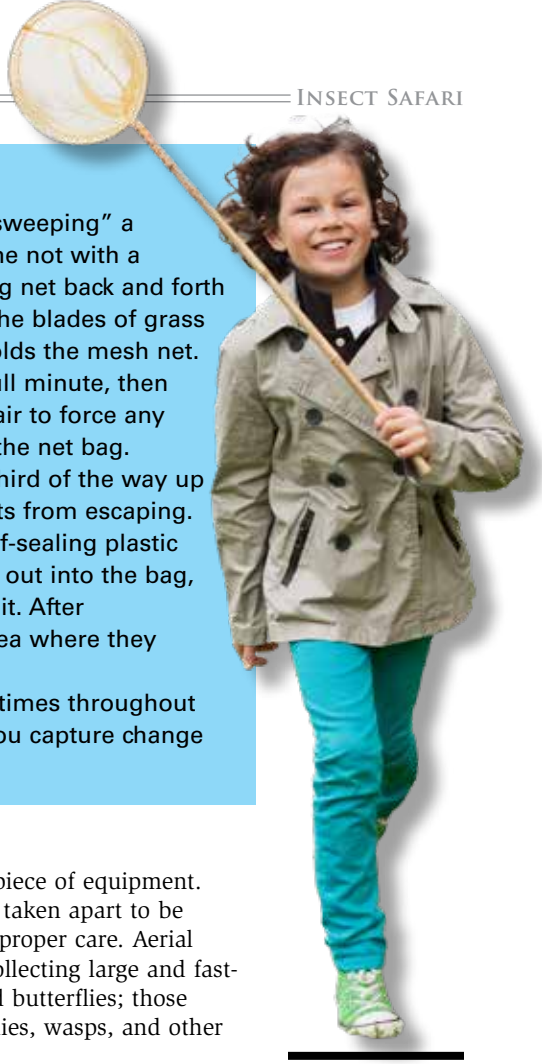
To use the aspirator, place the straw covered with gauze in your mouth. Position the bottom straw near the insect you would like to capture. Suck on the top straw to vacuum an insect into the bottom-end straw *(the gauze will keep the insect from being sucked into your mouth!)*. You may then observe the insect in the aspirator. To free the insect, simply pull the clay disk off the bottom of the aspirator.

A Clean Sweep

You can collect many insects by "sweeping" a lawn or yard. This technique is done not with a broom but by swinging a collecting net back and forth over the grass. Brush the tops of the blades of grass with a flat side of the hoop that holds the mesh net. Sweep for 30 seconds or even a full minute, then swing the net swiftly through the air to force any captured insects to the bottom of the net bag. Quickly grab the net bag about a third of the way up from the bottom to keep the insects from escaping.

Have a friend open a clear, self-sealing plastic bag. Carefully turn your net inside out into the bag, shake the insects into it, then seal it. After observation, return them to the area where they were collected.

Sweep the same area several times throughout the year. Do the kinds of insects you capture change with the seasons?



You can use your collecting net to capture insects from the land, air, and water.

Collecting Net

A good collecting net is an important piece of equipment. Collecting nets are lightweight, can be taken apart to be carried, and will last a long time with proper care. Aerial nets with larger hoops are better for collecting large and fast-moving insects such as dragonflies and butterflies; those with small hoops are better for bees, flies, wasps, and other smaller insects.

You can make a net from a wooden dowel or length of bamboo; a piece of wire or a wire clothes hanger bent into a hoop; a fine-mesh fabric pillowcase or mosquito netting for the bag; monofilament fishing line for sewing the mesh fabric or mosquito netting into a bag shape; and duct tape for attaching the hoop to the wooden dowel. The bag should be rounded or blunt-tipped at the closed end and at least one and a half times as deep as it is wide. The handle length depends on the material from which the handle is made and the kind of collecting for which the net is intended. Do not make the handle too long or heavy.

Building a butterfly garden is a great backyard, schoolyard, or Scout camp conservation project that can serve as a living classroom.

Observation Jar

You might like to take along an observation jar so you can momentarily watch the insects you collect with a net. Remember to keep the insect in the jar for only a few hours, at the very most. As soon as possible, return the insect to the place where you collected it. Be sure to return bark, stones, logs, or anything else you move back to the same position they were found.

To make an observation jar, simply wash and dry a wide-mouthed glass jar, such as a pickle jar. Add a crumpled tissue or blades of grass in the jar to give the insect something to climb on. You can place a piece of mesh in a mason jar lid to help the insect breathe better.

Finding Insects

You will find insects almost everywhere: fields, gardens, beaches, swamps, woods, and roadsides. Look under stones, rotting logs, and leaves, and around flowers and grasses. The best times of year are summer and early fall, but insects can be found any time of year. In winter, look in protected spots such as under tree bark or stones, and indoors. Here are some suggestions for finding common insects.



Butterfly bush (Buddleja)

Butterflies

Bright, sunny days with little wind are best for butterfly observation. Clover fields and overgrown lots with thistles, asters, milkweed, and similar plants are excellent locations for collecting.

Orange milkweed attracts so many of these insects that it is commonly called butterfly weed. Butterfly bushes (Buddleja) also are worth visiting often. On windy days, open fields on the wind-sheltered side of wooded areas usually are good hunting grounds, as are flower-filled fields on protected hillsides.

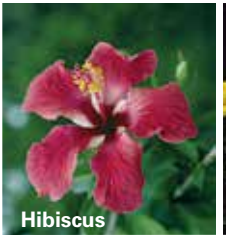
Blooms for Butterflies

Attract butterflies by planting some of their favorite flowers in a garden or a window box. Choose a sunny spot that is protected from wind—the south or southeast side of a building, wall, hedge, or slope might provide sufficient protection. Or, arrange your plants to grow into a bowl shape, with the taller plants on the outside as a windbreak.

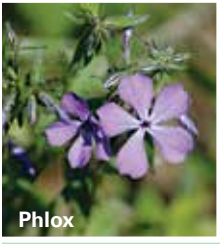
Do not use pesticides in your butterfly garden. The poison that kills insect pests will also kill butterflies.

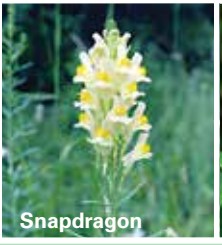

Milkweed


Goldenrod


Hibiscus


Marigold


Phlox


Snapdragon


Red clover


Sunflower

Plant a variety of fragrant flowers with large petals or blossoms. Good choices include goldenrods, dahlias, geraniums, hibiscus, marigolds, milkweed, phlox, snapdragons, lilacs, lavender, thyme, red clover, zinnias, sunflowers, and common daylilies. Check with a local nursery, the county extension agent, or your state's department of natural resources to find out which plants are best for a butterfly garden in your area. It's always best to use native species.

When trying to catch a butterfly on a sunny day, keep the sun ahead or to one side of you. Approaching with the sun behind you will cast a shadow that could alarm the butterfly before it is within reach. Typically, it works best to drop the net over the butterfly you are pursuing. Once your target is in the net, pull up the bottom of the bag with your free hand, and the butterfly will dart upward into the bag. Raise the net, rotating it quickly to lock the butterfly inside.

In some cases, sweeping the net from the side is more effective, but you will have to flip the bag over the hoop to trap the butterfly in the tip of the bag. Do this carefully so that you do not damage the specimen.

Different butterflies have different flight habits; some will dart quickly upward, some will drop to the ground. Note the flight habits of different butterflies, learn from your mistakes, and you will become expert at capturing these lively and colorful insects.


Sulfur butterfly

Moths

Moths usually fly at night, so different methods are used to capture them than are helpful in catching their butterfly relatives. Working the lights, sugaring, and mate attraction are some favorite techniques of moth collectors.



Cabbage moth

Working the lights takes advantage of the attraction that some artificial lights hold for night-flying moths. Moths will circle endlessly around black-light or mercury-vapor bulbs. You can catch many moths after dark from around an isolated streetlight, or at a local gas station or shopping center—with adult supervision. Or, attract moths by setting up a white sheet at the edge of a wooded area, then shining a lantern or vehicle headlights on it. You can observe moths by catching those that come to your porch light at night or that flutter along the lighted windows of your home.

Sugaring is an exciting method—and one of the most successful ways—of catching moths. Flies, bees, beetles, wasps, and butterflies also are frequent visitors to sugared trees. Mash or blend some peaches, apricots, or bananas, add a bit of brown sugar, molasses, or honey, some apple cider, and a teaspoon of yeast (optional) in a plastic container. Loosely cover the container and let the mixture ferment in the sun for a couple of days. Use a stick or an old paintbrush to smear the mixture on tree trunks in long streaks. The best trees for sugaring are those out in the open or at the exposed outer edge of a wooded area. The best time is dusk. Sugar several trees in a rough circle, creating a moth trapline that you can visit easily.

Hot nights when storms threaten will bring the most moths.

Make the rounds with a flashlight to observe insects attracted to the trees. Add more of the concoction each night. Spring and fall are best for sugaring, but sugaring can be successful whenever moths are active. Visit the trees occasionally during the day. Be aware that sugaring might also attract various animals.

To try the technique of **mate attraction,** you need any newly emerged female saturniid moth. (The *saturniid* family includes the promethea, io, luna, polyphemus, and cecropia moths.) Place the female in a screened box or in a jar with a mosquito-net top. Put this container in an open area and wait for results. Males attracted by the scent of the female can be netted easily. If your female is a promethea, the males of the species typically will begin to arrive in the late afternoon. Males of the io, luna, and polyphemus species usually arrive after dark; the males of the cecropia arrive just before dawn.



Luna moth

Dragonflies

The best place to observe dragonflies is near vegetation where they frequent, but you will need to be patient. These swift aerial insects are skillful at dodging the sweep of a net. During the evening after dragonflies have landed in vegetation, they can sometimes be found clinging quietly to weed stems or leaves. In early autumn they remain quiet for some time after sunrise while the morning chill keeps them inactive.

To catch a dragonfly on the wing, sweep the net from behind the insect, if possible. Sweeping a net back and forth through the tops of swampside or pondside vegetation is another way of capturing small dragonflies and damselflies. Use great care, as their delicate wings and body can easily be damaged.

Rake out trash from the bottom of a pond to capture underwater naiads of dragonflies. Raised to maturity in an aquarium, the naiads will provide perfect adult specimens.

A few species of dragonflies land as soon as the sun goes behind a cloud. The smaller damselflies flutter slowly about and can be netted easily.

Beetles

Beetles are everywhere, and most of them are easy to catch. Look around dead trees, logs that are rotting in shade, clumps of goldenrod, late-summer mushrooms, trees in bloom, and piles of trash left by receding streams or spring runoff. Search along woodland paths and moss banks or under old stones.

Many beetles can be picked up by hand, some are best netted, and some can be caught by "beating" or "sifting." To beat, hold an open umbrella upside down under a bush and hit the base of the bush sharply with a stick. Or, spread a sheet under the bush. Startled beetles let go of the bush and drop into the umbrella or onto the sheet. Return insects back to where you collected them on the same day you found them. Most insects will not survive captivity for very long.

Be careful; wasps may have built a nest in the bush you have in mind, so use a flashlight to investigate the bush before attempting to oust any insects.

Sift plant trash from a forest floor over a newspaper, a white bedsheet, or a sheet of white poster board, and catch the beetles as they appear. A beetle trapline also can excellent results. Bury empty jars or tin cans in the ground with their open tops just level with the earth. Bait them with old meat or decaying fish to attract beetles, which tumble into the traps. Remember to refill the holes with the earth when you are finished.

Never pull an insect off a branch—its legs could rip off its body.

You also can work the lights for beetles just as for moths. Frequently, a blundering beetle will strike against the glass of a streetlight or a bright window and fall, kicking, on its back. Simply pick it up.



Handling Insects

Insects are fragile creatures and must be handled with extreme care. The best way to catch one is to gently coax it to crawl onto your hand, into the observation jar, or onto a piece of cardboard or clear plastic, where you may observe it without harming it. Always wash your hands after handling insects, even if you were wearing gloves.



An Insect Zoo

Besides collecting larvae, pupae, and cocoons during the summer, you can collect adult insects for observation and maintain a temporary but fascinating insect zoo. Katydids, praying mantises, and similar insects make unusual short-term pets. Ants can be kept in ant houses for observation. (See "Preparing an Ant Farm" later in this pamphlet.)

You can keep crickets in transparent cages formed of old-fashioned glass lamp chimneys pushed down into the dirt in a flowerpot. Or, check out the wide variety of small cages available at retailers. After you put the crickets inside, cover the tops of the chimneys with mosquito netting. Lettuce and other greens and an occasional bit of meat protein, as found in bone meal and dry dog food, will keep crickets in good condition. The meat protein is essential; without it, the crickets will begin to eat one another.

Some butterflies that emerge indoors become so tame they will alight on your hand and drink sugar water from a spoon or nectar from flowers held in your fingers. Another way to feed butterflies indoors is to dip a small sponge into a mixture of sugar or honey and water. The insects will uncoil their tongues and insert them into the sponge's pores to suck out the sweet fluid. If your butterfly needs coaxing, use the end of a pin to carefully uncoil the tongue and lead it to the sugar water. Once you do this, the butterfly probably will continue to feed.

Food Plants of Butterfly and Moth Larvae

Butterfly	Preferred Food Plant of Larva
Pipevine swallowtail	Pipevine, Dutchman's-pipe
Tiger swallowtail	Wild cherry, birch, poplar, ash
Cabbage butterfly	Cabbage, Swiss chard, mustard, radish
Great spangled fritillary	Violets
Black swallowtail	Carrots, dill, celery, caraway, parsley
Clouded sulfur	Clover, vetch, lupine
Regal fritillary	Violets
Pearl crescent	Asters
Red admiral	Nettles and hops
Painted lady	Thistles
Mourning cloak	Willow, elm, poplar
Buckeye	Plantain, snapdragons
Monarch	Milkweed
Viceroy	Willow, poplar
American copper	Sorrel
Red-spotted purple	Willow, wild cherry, plum, hawthorn

Moth	Preferred Food Plant of Larva
Cecropia	Willow, maple, apple, elm, lilac, bridal wreath
Promethea	Wild cherry, lilac, tulip tree
Polyphemus	Oak, birch, hawthorn, dogwood, willow
Luna	Walnut, hickory, butternut, sweetgum, persimmon
Cynthia moth	Wild cherry, tree of heaven
Darling underwing	Willow, poplar
Five-spotted hawk	Tomato

Preparing a Scrapbook

Creating a scrapbook of the insects you observe will give you a valuable resource. If you use a three-ring binder and devote one scrapbook page to each insect you observe, you can add to the book as you observe more insects. You may want to keep your scrapbook electronically, and scan photos or use digital photos.

Labels. Label each insect in your scrapbook with the place and date of observation, and write the insect's scientific and common names (check a reference book for the correct spellings). Some enthusiasts like to record fun facts such as the plant the insect was found feeding upon, or weather conditions.

Sketches. Sketching an insect is a way to learn about and become more familiar with its parts. Perhaps you will have time to sketch from real life as you watch an insect in its habitat, before it hopped or flew away, or from an observation jar. You might enjoy working from a photograph or illustration. Check out the resources in the back of this book from which you can create your own art.

Articles. Another way to learn more about an insect you observe is to research it. Copy or print out articles you find. If the article is short, you may want to write it out by hand. In all cases, be sure to document the author of the article, the place it was published, and the publication date.

Photographs and Illustrations. You may be lucky enough to snap some great shots of insects. If not, you can use a copier to reproduce images found in books and magazines, or redraw yourself.

Take Some Basics. Carry a few tools of a naturalist: magnifying glass, binoculars, notebook and pen, drawing paper and pencils, a camera, a compass, and a map.

Use Technology. The same electronic devices that draw us away from nature can also enrich our understanding of it. That is especially true when they are coupled with actual outdoor experiences. There are smartphone applications for identifying insects. Electronic field guides lead users through steps to identify insects. Cameras on many cellphones produce photographs and videos ideal for recording signs and sounds of environmental exploration.

You can organize your scrapbook using a phylogenetic system, arranging insect pages from the most primitive to the most advanced. Most books about insects use this system.



Identifying Insects

Watching and documenting insects can be fun all by itself, but it is twice as much fun if you know precisely what you have seen. Scientists must be able to determine exactly what they are observing. One scientist can't tell others about an insect unless they all know and agree on the exact name of the insect being described.

About 250 years ago, scientists began naming the hundreds of thousands of known insect species. They started by dividing all the insects into *orders,* broad groupings of insects. Some scientists recognize 22 orders of insects; others, more than 30. Most of the orders are based on the kind of wings and mouthparts of an insect. For example, the order Coleoptera includes all sheath-winged insects—that is, all beetles.

Carl Linnaeus (1707–1778)

Swedish botanist and naturalist Carl Linnaeus was the first to formulate principles for defining genera and species of plants and animals, to simplify the *binomial* (two-name) system for naming species, and to use the system consistently. His binomial system quickly became the standard method among zoologists and botanists for naming species and is still in wide use (though with modifications) today.

There are about 300,000 different known kinds of beetles; simply knowing the order is not enough. Scientists further divide the orders into *families.* These are smaller groupings within an order based on finer distinctions such as size, hardness of armor, and shape of antennae and other body parts.

There are about 150 families of beetles. While dividing the order Coleoptera into families simplifies the problem of naming a single beetle, this still is not going far enough. Scientists next subdivide the families into *genera.* (The singular form of genera is *genus.*) Each genus is then divided into *species.* To pinpoint the name of an insect, therefore, the scientist must know four things: the insect's order, its family, its genus, and its species.

When scientists write an insect's name, they use only the genus and the species, often followed by the name of the person who first described the insect. The genus name is capitalized; the species name is not. The name of the person who described the insect also is capitalized and may be abbreviated. The person's name is placed in parentheses if the species was first described in a different genus. Scientific names are always italicized in print or underlined in writing.



A familiar beetle is the ladybird or ladybug. It is one of the most common and most welcome insects, but there are more than 450 species of ladybug beetles in North America. If scientists want to talk about one of them, they must use its scientific name. One of the species is called the convergent ladybird. It looks like all the other species except that it has 12 spots. A scientist talking about the convergent ladybird calls it by its scientific name, *Hippodamia convergens* Guérin-Méneville.

With more than 700 different families of insects, it is impossible to cover in this pamphlet the characteristics of them all. Therefore, to fulfill requirement 4 you will have to do your own scientific research. Make it a point to observe the habits of the insects you observe or collect. This type of research is valuable because you will remember the facts you see in action longer than those you merely read about. Make notes as you observe.

Sources of Help

Plenty of sources can help you determine an insect's scientific name:

- Field guides, such as those listed in the resources section at the back of this pamphlet.
- Local amateur or professional entomologists. If you live near a college, natural history museum, agricultural school, or national park, you can probably find someone there who knows about the insects in your area. A biology teacher at a local high school or a county agricultural agent might also be helpful.
- There are several apps that can help you identify insects using your phone. Be sure to ask your parent or guardian's permission before using the internet or searching the app stores.

Major Insect Orders

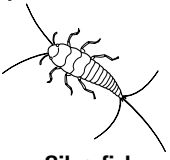
Most of the insects you see will belong to the orders listed in the following table. Some of the less familiar orders, including the proturans, springtails, stoneflies, earwigs, lice, thrips, scorpion flies, and caddis flies, are not listed. You can find more information about them in field guides.

The descriptions in the table refer to adult insects only. Remember, the young of these insects often do not look much like the adults. (The difference between immature and adult insects is discussed later in this pamphlet.)



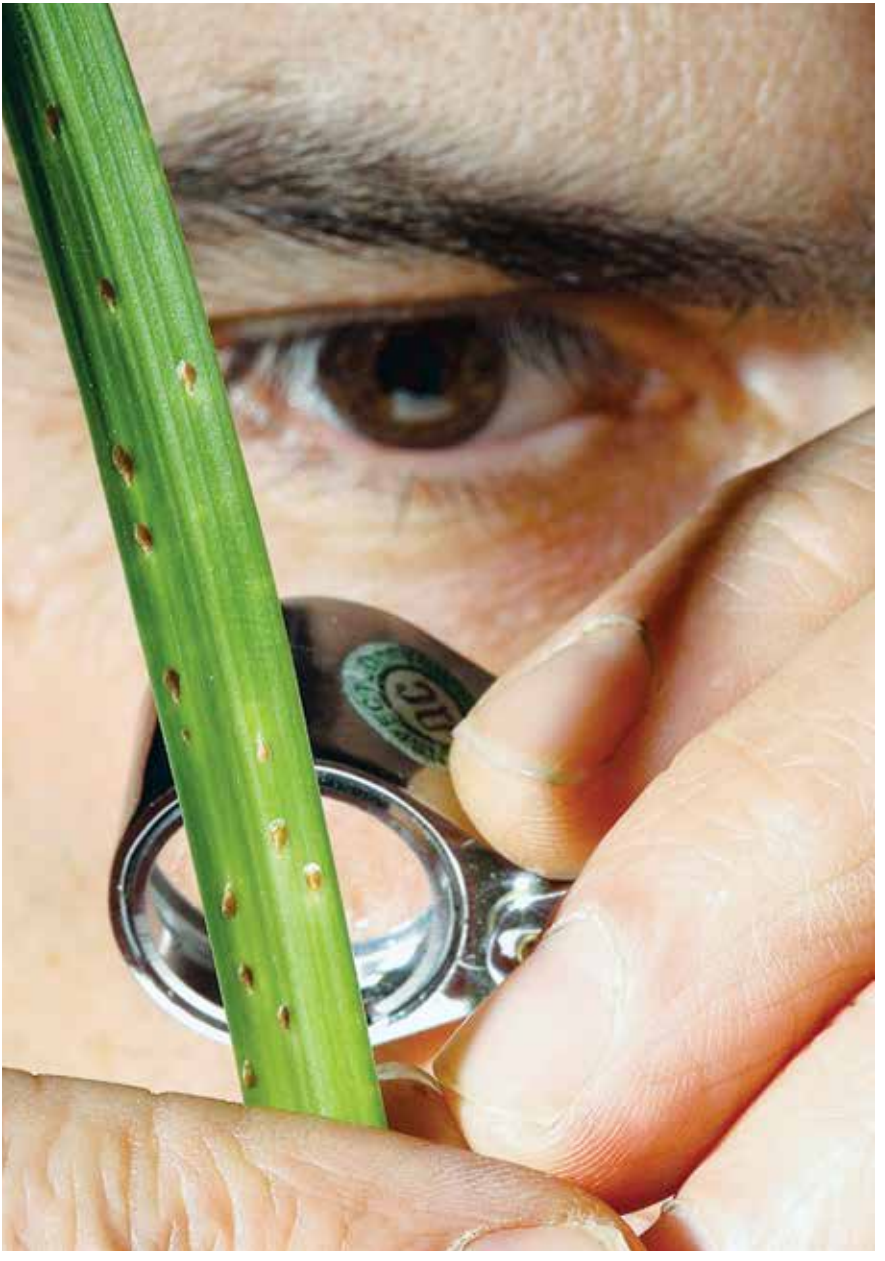
European earwig

DESCRIPTIONS OF MAJOR INSECT ORDERS

Order	Characteristics	Typical Members
Thysanura  **Silverfish**	**Bristletails and silverfish:** wingless, usually scaly body; long, slender antennae; two or three bristlelike tails; no metamorphosis	Bristletail Silverfish
Ephemeroptera  **Mayfly**	**Mayflies:** net-veined wings folding over the back like a butterfly's; two or three long tails; found near water; most live only a few hours as adults; incomplete metamorphosis	Mayfly
Odonata  **Dragonfly**	**Dragonflies and damselflies:** two pairs of net-veined wings; very large compound eyes; chewing mouthparts; adults are strong fliers but cannot walk; incomplete metamorphosis	Dragonfly Damselfly
Orthoptera  **Katydid**	**Katydids, crickets, and grasshoppers:** chewing mouthparts; two pairs of wings; forewings leathery, hind wings broad and membranous, folded under front wings when at rest; incomplete metamorphosis	Field cricket Katydid Grasshopper
Isoptera  **Winged termite**	**Termites:** small, mostly white and soft-bodied; chewing mouthparts; live in large, hidden communities; incomplete metamorphosis	Termite

Order	Characteristics	Typical Members
Hemiptera  **Giant water bug**	**True bugs:** usually two pairs of wings; forewings leathery at base, membranous at tip; sucking mouthparts at the front of the head; feed on plant or animal juices; many are harmful to crops; incomplete metamorphosis	Box elder bug Squash bug Water strider Giant water bug
 **Periodical cicada**	**Aphids, scales, leafhoppers, etc.:** winged or wingless; those with wings (usually four) hold them arched above abdomen; mouthparts connect at the back of the head or between the legs; beak usually short; cicada males make loud buzzing sounds; incomplete metamorphosis	Cicada Aphid Spittlebug Mealybug Leafhopper
Neuroptera  **Ant lion nymph**  **Adult lacewing**	**Lacewings, etc.:** chewing mouthparts; two pairs of net-veined wings, roofed over body when at rest; long, slender antennae; complete metamorphosis	Lacewing Ant lion
Coleoptera  **Boll weevil**	**Beetles:** hard-shelled front wing covers *(elytra)* under which rear wings fold; chewing mouthparts; largest of the insect orders; complete metamorphosis	Ladybird beetle Boll weevil Rove beetle Colorado potato beetle Tiger beetle Firefly

Order	Characteristics	Typical Members
Lepidoptera  Thistle butterfly	**Butterflies and moths:** two pairs of wings covered with scales (the "dust" that rubs off when one is handled); sucking mouthparts (long, coiled proboscis); antennae club-shaped on butterflies and fernlike or threadlike on moths; complete metamorphosis	Monarch butterfly Buckeye butterfly Mourning cloak butterfly Painted lady butterfly Swallowtail butterfly Sphinx moth Cecropia moth Fall webworm
Diptera  Housefly  Biting midge  Mosquito	**Flies:** two wings; usually small, often swift and agile fliers; many are nuisances to humans and livestock; some carry disease; complete metamorphosis	Housefly Horsefly Gnat Mosquito Midge
Siphonaptera  Dog flea	**Fleas:** tiny, wingless, jumping insects; adults are bloodsucking parasites of birds and mammals; body flattened side to side like a sunfish; complete metamorphosis; caterpillarlike larvae	Cat flea Dog flea Rat flea
Hymenoptera  Winged ant	**Bees, wasps, and ants:** all have four membranous wings (ant workers are wingless); one of the highest orders of insects, as many are social; complete metamorphosis	Ant Honeybee Sawfly Hornet Ichneumon Wasp





Metamorphosis of the locust boring beetle

The Life of an Insect

With the exception of aphids (the eggs hatch inside the female, which gives birth to live young), all insects hatch from eggs. Insects reach adulthood in a variety of ways. Some look like miniature wingless adults when they hatch; others pass through several stages during which they look entirely different from the adult. This process of change is called *metamorphosis.*

Types of Metamorphosis

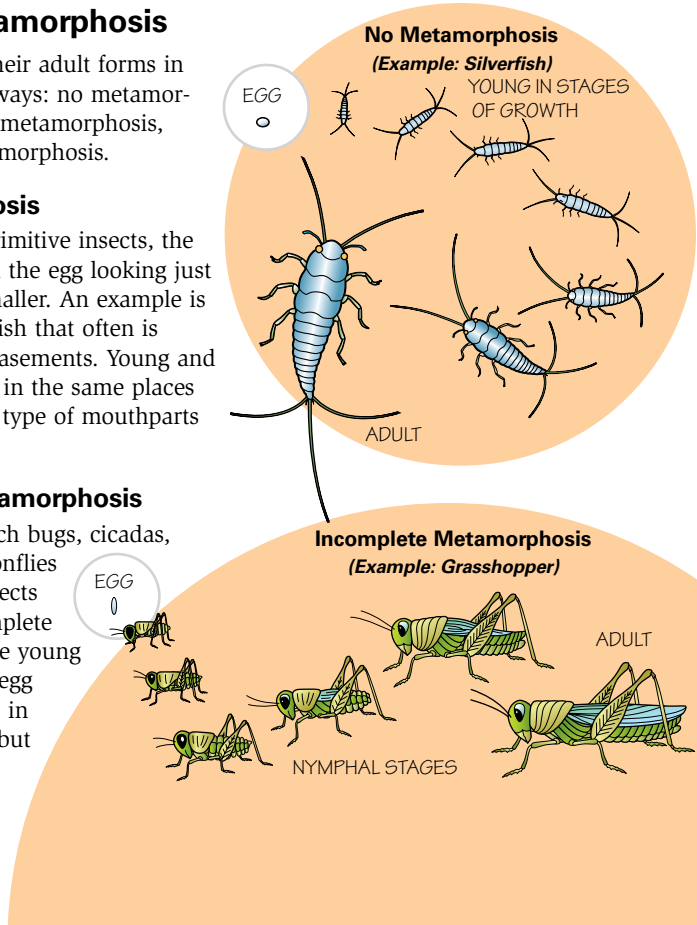
Insects grow into their adult forms in one of three basic ways: no metamorphosis, incomplete metamorphosis, and complete metamorphosis.

No Metamorphosis

Among the most primitive insects, the young emerge from the egg looking just like adults, only smaller. An example is the wingless silverfish that often is found in attics or basements. Young and adult silverfish live in the same places and have the same type of mouthparts and feeding habits.

Incomplete Metamorphosis

Grasshoppers, chinch bugs, cicadas, mayflies, and dragonflies are examples of insects that undergo incomplete metamorphosis. The young emerging from the egg resemble the adults in general body form but do not have wings.

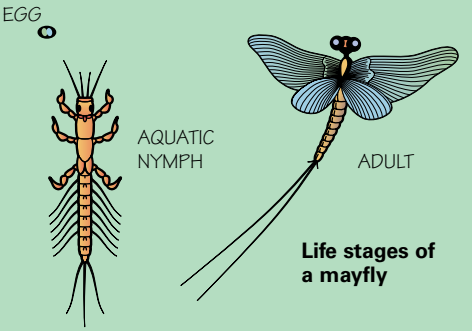


Water Babies

Among mayflies, stoneflies, and dragonflies, the nymphs live in water, while the adults are airborne. The nymphs only slightly resemble the adults into which they develop. They hatch from eggs laid in the water or on aquatic plants. They breathe through gills and will die if removed from the water.



Blue-winged olive mayfly



Life stages of a mayfly

The dragonfly nymph is often mud-colored and well-camouflaged as it stalks smaller insects on the bottom of a stream or pond. Nearing its prey, it darts out an armlike underlip nearly half as long as its body and grabs the prey with a pair of sharp pincers.

After going through several growing stages and molts in the process of incomplete metamorphosis, the nymph reaches its full size and climbs out of the water. The back of its skin splits as the nymph undergoes its last molt, and a mature dragonfly emerges. The adult insect is fitted for an aerial life with fully developed wings and has a tracheal system for breathing oxygen from the air.



Whitetail dragonfly





Red-legged grasshopper

The young of such insects as grasshoppers and chinch bugs—the nymphs—go through a series of feeding stages, each followed by a molt. With each successive molt, the nymph looks more like the adult than it did in the preceding stage. The wing buds appear in the later stages. Both nymphs and adults have the same type of mouthparts, eat the same foods, and live in the same kinds of places.

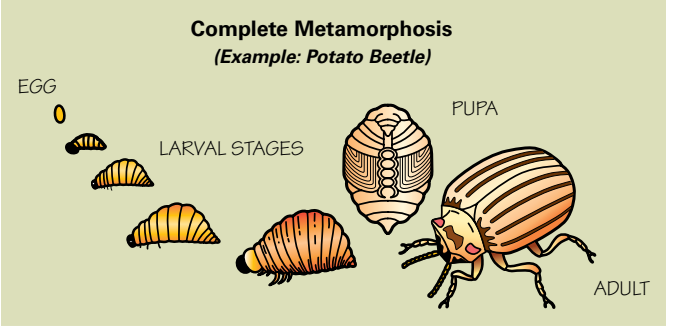
Consider the life of the red-legged grasshopper, *Melanoplus femur-rubrum* (De Geer). In the late summer, the female digs an inch-deep hole in the ground with her long *ovipositor,* the egg-laying apparatus on the rear of her body, and lays tiny eggs. She then carefully covers the hole by scratching and sweeping dirt around it.

Unless a bird or a predatory insect finds the egg mass, it remains buried in the ground all winter. Hatching begins in the spring, and within one or two days the young grasshoppers have dug their way out of the hole. They emerge looking like short, stubby, wingless versions of the parent.

During a two-month growing period, the red-legged grasshopper molts about five times, each time shedding its old skin for a new, larger one. After the final molt, the adult has fully developed wings and has reached full length—about 1½ inches. If it escapes its enemies, the grasshopper will live until autumn, only to be killed by winter weather.

Complete Metamorphosis

The most advanced insects go through four life stages: the egg, the young or larva, the *pupa* or resting stage, and the adult. Their needs and ways of life during each of these stages are different. Butterflies, moths, ants, bees, wasps, beetles, flies, fleas, and mosquitoes all undergo complete metamorphosis.





Colorado potato beetle larva



Adult Colorado potato beetle

The larvae differs greatly in form from the adult into which it develops. It passes through a series of growing stages and molts, but, unlike insects with incomplete metamorphosis, the larva does not resemble the adult any more closely after a molt than it did before a molt; it remains wormlike or grublike in form. The larva is primarily a growing stage. While most larvae have chewing mouthparts, some are equipped instead with mouth hooks.

The larvae of different insect orders are known by various names. Beetle larvae are grubs, butterfly and moth larvae are caterpillars, fly larvae are maggots, and mosquito larvae are wigglers or wrigglers.

When the larva is mature, it stops feeding and transforms into the pupa. In this stage, the insect usually is inactive and does not feed, but it undergoes a remarkable change into the adult form. After several days or months, the adult emerges from the pupal stage. The adult's most important job is to reproduce. In many insect groups, the adults die soon after laying eggs.

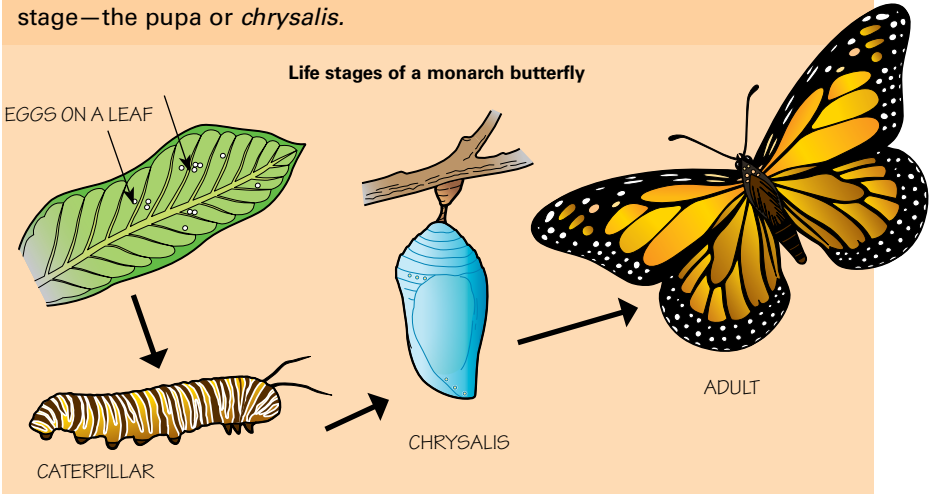
A Monarch's Life

Let's take a close look at an insect that undergoes complete metamorphosis—the monarch butterfly, *Danaus plexippus.* This common yet beautiful orange-and-black butterfly begins life as a pale-green egg on a milkweed leaf. A tiny caterpillar emerges four or five days after the egg is deposited. This is the larval stage of the butterfly. The caterpillar immediately eats the eggshell and then the leaves of the milkweed, the only food it will eat thereafter.

For about 12 days, the caterpillar does almost nothing but eat milkweed leaves, cutting off pieces with its strong jaws. By the end of that period, it will have molted three or four times. The caterpillar is then about 2 inches long and striped with bands of yellow, black, and green.

As the end of the larval stage draws near, the caterpillar begins spinning a silken thread from glands in its mouth and attaches one end to a leaf. The other end is tied to its rear. The skin splits and slowly slides off the body while the caterpillar hangs downward, revealing the third stage—the pupa or *chrysalis.*

Life stages of a monarch butterfly





Monarch butterfly chrysalis

The chrysalis is a shiny, transparent green with several spots of gold. It hangs from the leaf for several days to about three weeks, depending on the weather. Near the end of this period, the chrysalis turns very dark (almost black), and the wing pattern of the adult butterfly can be seen beneath the thin skin.

Finally, the bottom of the chrysalis splits and out crawls the adult monarch butterfly. Its wings gradually expand and harden, and the butterfly starts to use its long, hollow, coiled "tongue" to suck nectar from flowers.

Usually, the adult will live four to six weeks, feeding occasionally but mostly just wandering from field to field. The last brood of summer, however, will migrate south, often in large numbers and journeying an incredible 2,500 miles. This brood lives longer—some of the monarchs live through the winter in Mexico or along the southern coast of California. Many fly northward the next spring and begin the cycle of life over again.

Moths, which go through the same stages as butterflies, often spin a protective cocoon of silk around the pupa. Only a few butterfly species spin cocoons.

Studying the Life Cycle

One of the most dramatic events you are likely to witness during your insect watching will be when a large moth or a brilliant butterfly comes out of its cocoon or chrysalis. During the summer, look for caterpillars of moths and butterflies to collect and raise. Watch them spin their cocoons or turn into chrysalides and, later, see them come forth as adults. You can get an early start by collecting the cocoons of larger moths during the winter.

Caterpillars must have the right food. Most of them will eat the leaves of only one sort of plant and will quickly starve to death if given other leaves. You can assume that you are feeding a caterpillar the right food if you give it the leaves of the plant upon which you found it.

Offer only fresh leaves. Keep your caterpillars in covered shoeboxes so the leaves will not wilt rapidly. Or, place caterpillars on a small tree branch enclosed in a sleeve of mosquito netting to keep out birds and insect parasites.

Not all butterflies or moths spend the entire winter in chrysalides or cocoons. Many caterpillars collected in late spring or early summer will emerge as adults before winter.

Some moths, notably the sphinx, change from larvae to adults in the ground. You often can collect pupal cases of the five-spotted hawk moth by digging carefully around the roots of tomato plants in late summer or early fall. Look for a large (about ¾ of an inch thick and 1½ inches long), shiny, mahogany-colored, jug-handled pupa. A live pupa is heavy and plump. A dead pupa is light and usually shriveled.

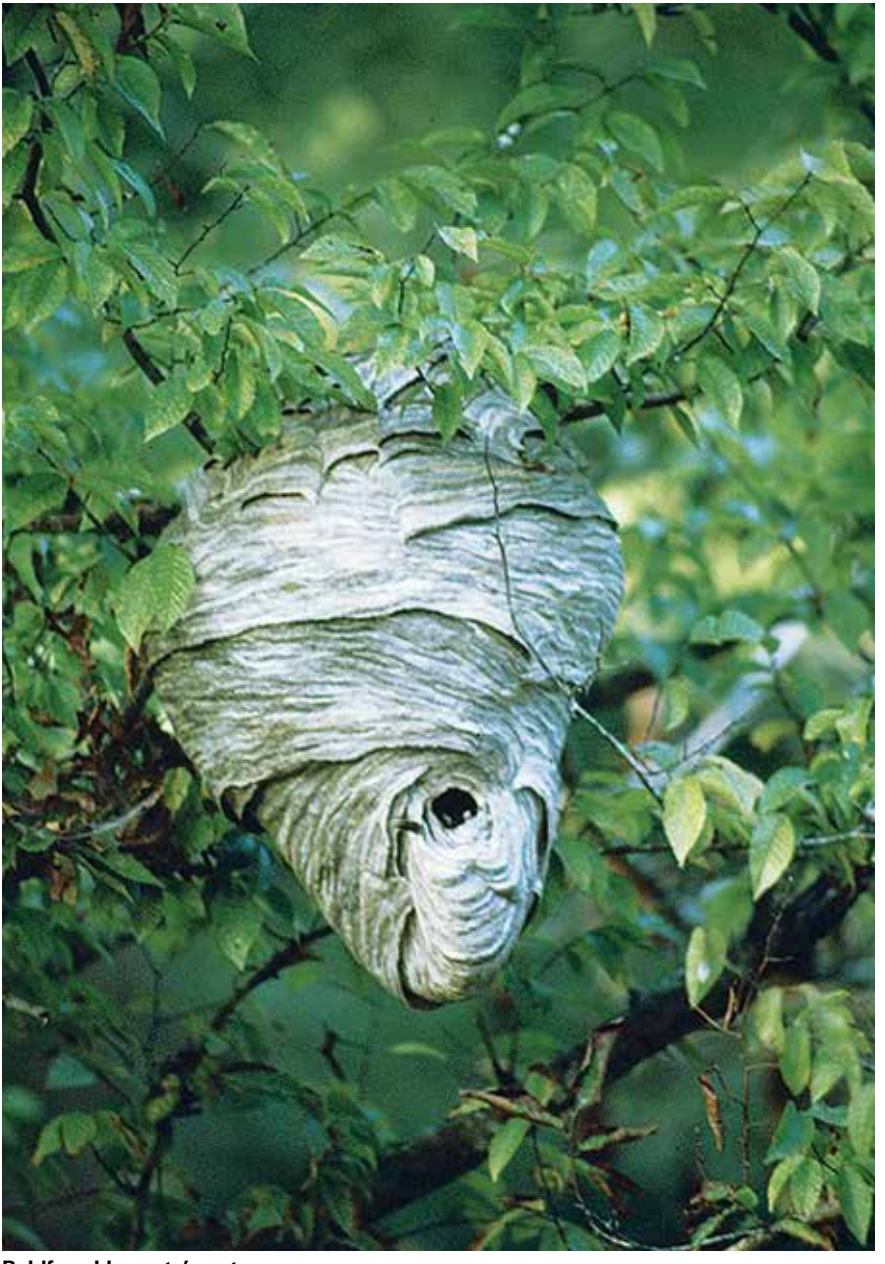
It is best to leave cocoons, pupae, or chrysalides outdoors over winter. If you keep them indoors, dampen them occasionally. Cocoons kept indoors at room temperature all winter seldom develop. They must be exposed to cold temperatures to trigger development. Place cocoons in the refrigerator for one to two months, then return them to room temperature to stimulate emergence. This will cause the adults to emerge sooner than they would if the cocoons were kept outside.







Black swallowtail larva, pupa, and butterfly



Baldfaced hornets' nest

The Social Insects

Most insects are not dependent upon one another, but for a few species, the story is different. *Social insects* will swarm and sleep, hibernate, and migrate together. Social insects include termites, ants, and certain species of bees, wasps, and hornets.

These insects live together in groups all their lives. By instinct, each individual performs a certain task that is of value to the whole community. Social insects care for their young (something most insects do not do), build nests, and sometimes feed each other. Let's look at some species of social insects.

The Paper Wasp



Golden paper wasp

You may have come upon the paper wasp *(Polistes)* while hiking with your patrol, on a family picnic, or in your backyard. You might not have enjoyed the encounter, as the female of this species can give quite a painful sting when annoyed. Even so, this wasp must be considered a friend to people because it preys upon such pests as caterpillars. The larvae of various destructive insects are food for the paper wasp's young.

A paper wasp colony begins in the spring when a queen, the only survivor of a nest from the previous summer, awakens from her winterlong hibernation. She immediately starts building a new nest out of coarse paper. She makes this paper by gouging out bits of old wood from stumps or logs and chewing them into a pulp with her strong jaws.

She first makes a single, six-sided cell, suspending it upside down in a protected place—beneath the eave of a garage or barn, or from the underside of a tree branch. As soon as the first cell is completed, the queen lays a single egg in it, attaching it with a gluelike substance inside the upside-down cell. She also places a drop of nectar in the cell for the larva's first meal.

Notify an adult if a paper wasp nest needs to be removed because it poses a risk to people, such as in a bathroom or tent.



Paper wasp colony

The queen makes more cells surrounding the first and lays eggs in them. As the tiny, white, helpless larvae mature, they are given solid food—the bodies of insects the queen has captured. When a larva reaches full size, it spins a cover over the end of its cell and transforms into an adult paper wasp. The emerging wasp breaks out of its cell and immediately begins to help the queen make new cells and feed the larvae.

All of these workers are sterile females. Only the queen can lay eggs. When she has plenty of papermakers at work, the queen retires and concentrates on egg laying. Occasionally, a wasp colony has more than one queen; then the nest grows faster.

A few of the larvae get extra rations of food. These will become queens of future generations of paper wasps. As summer ends, the old queen lays unfertilized eggs that develop into male wasps. These white-faced wasps mate with the young queens.

As the chill of winter nears, the wasps become sluggish and less active. Finally, all but the young queens die. These fertile females find a snug harbor under a log, in a trash pile, or in an attic or shed, and hibernate for the winter. With the spring sun, the queens come out of their hiding places and begin the cycle of wasp life over again.

Optional Requirement 5(b)(2)



If you want to choose optional requirement 5(b)(2), you should first find out whether you are allergic to bee stings. This can be determined by a visit to an allergist or your family physician. If it turns out you are allergic to bee stings, you should choose another option.

In completing requirement 5(b)(2), your counselor can help you find an established beekeeper. Ask if the beekeeper can meet with and another Scout and a parent or guardian and, as part of this requirement, whether the beekeeper will allow you to remove the combs. Before your visit, be sure all participants also have been checked by a physician and are not allergic to bee stings.

For help with locating a beekeeper in your state, visit beeculture.com and click on "find a beekeeper near you."

Ants and Bees

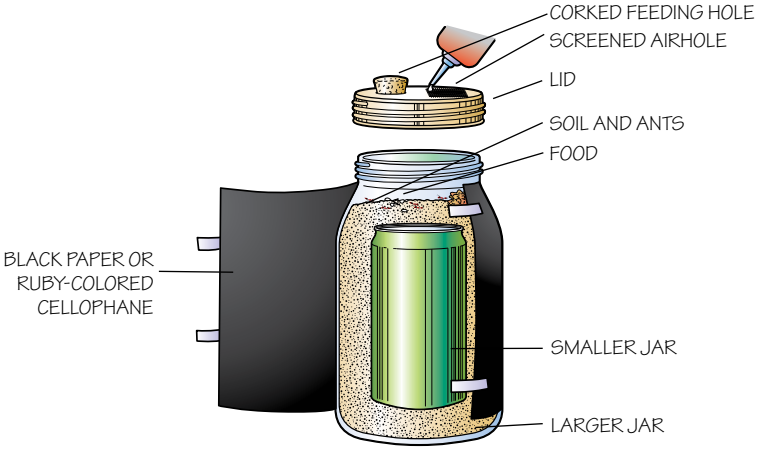
Ants and bees are the most social of the social insects; both are interesting to watch. If you choose to observe an ant colony, you will have to make a special observation unit called a formicarium and put the colony in it, because you cannot see much ant activity above ground.

Just as they do in nature, ants will dig elaborate tunnels within a formicarium, or ant farm. The tunnels allow a route from one area of their living space to another, as well as access to the surface. The tunnels lead to sections and chambers that have specific purposes. Some are designated for food storage, while others are where the ants store their garbage or where the queen will live and lay eggs.

The queen's tunnel and chamber is specially constructed to prevent her from drowning; the tunnel that leads to it branches off from another tunnel and then turns up. As the ants dig their tunnels, they carry the extra material to the surface, which creates a mound. These mounds are called ant hills.

Preparing an Ant Farm

The simplest method of preparing an ant farm, or formicarium, is to use two widemouthed glass jars with lids. One of the jars must be smaller and slightly shorter than the other; when it is placed inside the larger jar, there should be about a half inch of space between the outside of the smaller jar and the inside of the larger one.



The soil in your ant farm must remain damp. Be sure to add a little water from time to time.

Follow these steps to prepare your ant farm:

Step 1—Securely tighten the lid of the smaller jar, then put that jar into the larger one.

Step 2—Drill two holes approximately ¼ inch in diameter in the lid of the wider jar.

Step 3—Put a tight-fitting cork into one of the holes; this will serve as an opening for feeding the colony.

Step 4—Use quick-drying rubber cement or a glue gun to fasten a screen of fine cloth or wire mesh over the other hole. A small piece cut from a discarded pair of women's hose will work well as a screen and will let plenty of air into the observation unit. The opening will be small enough to prevent the soil in the unit from drying out rapidly and endangering the ants' lives.

Your next step is to collect a living, functioning ant colony. The simplest way during summer is to turn over some large flat rocks until you find a full-fledged colony. The center of the nest is often at the surface directly beneath a rock. You may see the workers, soldiers, larvae, cocoons, eggs, and winged males and females (young queens and their mates) in one scrambling mass when you suddenly overturn a rock.

Quickly scoop up that living mass, along with the surface soil, and pour it into the space between the two jars in your observation unit. Do not pack the dirt tightly. Fill the space to within an inch of the top and secure the lid of the larger jar. You now have the makings of a functioning ant colony and can watch members of the colony, especially the workers, make order out of the complete chaos. They set to work, tunneling in all directions until finally all galleries are interconnected. They gather all of the eggs, larvae, and cocoons and place them in neat piles to be tended by other workers.

Be extra careful and observant, and do not collect fire ants or other biting or stinging ants. Get your parent's or guardian's permission before setting up an ant farm.

As with any insects you collect and maintain at home, keep the ant colony away from direct sunlight and direct heat. Whenever you are not watching the colony, wrap a piece of black paper or ruby-colored cellophane around the outside of the jar and secure it with a rubber band or tape.

Feed the colony by pulling the cork and using a medicine dropper to add honey water or sugar water as an energy food. Bits of hard-boiled egg and dry pet food will provide the ants with needed protein. Be sure not to overfeed the colony, because any surplus will decompose and contaminate the nest.

Keep the soil damp but not wet. Ants must have at least some water to survive. From time to time, add a few drops of water from your finger, a dropper, or a spoon.

Ant Society

Although not the oldest living insect type (that honor probably belongs to the silverfish, the dragonfly, and the cockroach), the ant developed the first cooperative communities. While their tasks vary among the species, citizens of ant colonies hold roles as agriculturalists, livestock raisers, soldiers, and even slave-makers.

There are about 9,000 species of ants worldwide.

ANT CASTES

Ants have at least three *castes,* or groups of members that perform specialized functions: queens, males, and workers. The new queens and the males have wings, and when the time comes for mating they all swarm out of the colonies by the thousands and mate in the air. After mating, the males die. The fertilized queens alight and rub or tear off their own wings. Then they either return to the colony or make new nests away from the original colony. Each nest can have several queens, unlike a honeybee colony, which has only one queen.

After establishing a new colony, the ant queen stays in the nest and tends the helpless young. When new workers emerge, they take over the work of the colony and the queen restricts herself to laying eggs. She might live for 15 years or longer. A single colony can grow to more than a half-million ants and survive longer than 20 years.

Although we commonly think of ants as pests that crawl into the picnic basket or invade the kitchen, they are, on the whole, beneficial creatures. They feed on countless dead or dying insects, thus helping dispose of natural wastes.

Ants also are important in water conservation. Those that live in the soil move great amounts of earth in making their tunnels and chambers. They make the soil loose and porous so that it can absorb much water that might otherwise run off.

Most ants nest in the ground. The nests have tunnels, chambers, and galleries sometimes extending over many acres (as with the fungus-growing ants). A few ants nest in wood.

The workers enlarge and maintain the nest, gather food, feed and care for the young, and defend the colony from its enemies. Ants have a four-stage (complete) metamorphosis—from egg to larva to pupa to adult. The care and feeding of the young varies from species to species. Most ants eat both plant and animal matter.

FARMING ANTS

Several types of ants farm in one way or another, but the most interesting are the leafcutters. These ants spend much of their time cutting pieces of leaves and bringing them back to the nest to be used as mulch on the ants' fungus gardens—practically their only source of food. While some of the workers are

bringing in new supplies of leaves, others carefully tend the gardens so that only the desired fungus grows. All other growths are destroyed. The size of the tunnel is controlled to maintain just the amount of heat and moisture this fungus needs. Some leafcutters fertilize their gardens with their own excrement to increase yields.



A Texas leafcutter worker ant



Harvester ants

Another interesting type of farming ant is the harvester ant, which lives in southwestern portions of the United States and on all of the other continents except Antarctica. Harvester ants eat seeds that they gather and store. After a heavy rain, the ants bring their stored seeds above ground and spread them out to dry so that they will not become moldy. In some species, the large-headed soldier–caste ants serve as millers and grind the flinty seeds to a flourlike powder with their powerful jaws.

Fungus-growing leafcutter ants live in North and South America, but the greatest numbers of them are seen in tropical areas.

LIVESTOCK RAISERS

Some kinds of ants raise their own "livestock." Plant lice, or aphids, secrete a sweet, honeylike substance called *honeydew* of which ants are very fond. The ants care for the aphids like a human farmer cares for cattle.

The aphids live with the ants and are protected from harm. When an ant wants some food, it strokes an aphid with its antennae to obtain a drop of honeydew. In the fall, ants carry young aphids or aphid eggs down into the nest so that they will survive the winter.

Soldier Ants

Many species of ants have a special class of workers with large heads and strong jaws called *soldiers.* Their duties include defending the colony and, in the case of the harvesters, crushing seeds and other hard food.

A few ant species in Africa, North America, and South America seem to be almost all soldiers. These *army ants—legionary ants* in North and South America and *driver ants* in Africa—are foragers. Periodically, the whole colony goes on a long march, preying upon creatures that cross their path. Small workers carry the larvae while the larger ones, working together, do the killing. Some of them march by night and make temporary camps in the morning. They spend much of each day in raiding parties that go out from headquarters and kill whatever they find, including insects, mammals, and birds that can't get away quickly enough.

HONEYPOT ANTS

Honeypot ants, another type of ant with a fondness for honeydew, have overcome the problem of storage in an unusual way. Some of their workers, called *repletes,* become living honeypots, consuming great amounts of the sweet fluid until their abdomens expand to enormous proportions (the size of grapes). They spend all their time—months or even years—clinging to the ceilings of their underground chambers. When a hungry worker passes by, she strokes a honeypot with her antennae and gets a drop of nectar. Honeypot ants live in warm, dry areas throughout the world, including western portions of the United States.

Communication among ants is almost entirely by touch and smell.

SLAVE-MAKING ANTS

In the cool climates of Europe, Asia, and North America, slave-making ant species make war on other ants to capture their pupae. The pupae are brought to the nest and, when they mature, must do the work of their adopted colony. A few slave-makers have become so dependent upon these workers that they have lost the ability to do work themselves. They must continually kidnap workers from other colonies to survive.

Bee Society

Humans have been keeping the honeybee, *Apis mellifera* L., for more than 4,000 years. This relationship between humans and honeybees is *symbiotic,* or cooperative: Honeybees are managed as domestic livestock, thus depending on humans; at the same time, humans depend on bees to pollinate crops. Many fruit trees cannot be pollinated profitably any other way. Trees would not produce much fruit if not for honeybees going from blossom to blossom. These insects also provide honey and ingredients for the production of candy, beeswax, and candles.

Honeybee society is much more advanced than that of the wasp, and it rivals the ant's. In a beehive there are three castes (the queen, the male or drone, and the worker), just as there are in a wasp colony, but honeybees have many more divisions of labor and more specialized tasks.

Unlike a wasp colony, a swarm of bees survives the winter, although individual bees (especially workers) might live only a few weeks during the active season. To live through the winter, the colony must have high-energy food, which is why bees make and store honey. A honeybee society has two goals: to be sure the young will be cared for and survive, and to collect enough food to see the whole colony (which might number 50,000 bees) through the dormant season.

Each bee has a task to do to ensure the proper working of the colony. Let's examine their roles.

It is estimated that about one-third of the U.S. diet depends on honeybee pollination. Honeybees provide 80 percent of the pollination for vegetable, fruit, seed, and flower crops.

THE QUEEN BEE

A honeybee colony has only one queen, who is the mother of all the bees. All she does is lay eggs, sometimes at the rate of 1,500 to 2,000 a day. She might live several years and lay more than a million eggs.

A bee becomes a queen because she is fed a creamy, highly nutritious substance called *royal jelly* during all five or six days of her larval stage. Workers and drones get royal jelly during only the first three days of the larval stage. Then they get *beebread*—pollen mixed with honey.



The queen honeybee sits among workers on the honeycomb.

Sixteen to 18 days after her own egg was laid, the young queen emerges from her comb cell, and often will sting and kill the other queens that are still developing. If two queens hatch at the same time, they fight until one has been stung to death. Then, the old queen must either leave or fight for her life. Usually she leaves, taking with her a large number of workers to start a new colony. Their flight is referred to as *swarming.*

After the young queen has gotten stronger, she leaves the colony for her mating flight, then returns to the hive and begins her lifework of laying eggs.

THE DRONES

While the new queen is maturing in the hive, a few hundred male bees also are growing. They develop from unfertilized eggs. Their sole purpose in the honeybee society is to mate with the young queen.

When the new queen takes off on her mating flight, all the drones trail her. Usually, the strongest and swiftest flier among them mates with her in the air. After a drone mates with the queen, he dies. The other drones, having been pampered and cared for carefully until this time, find they are no longer welcome in the hive. The workers might starve them to death (drones cannot get food for themselves), drive them from the hive, or sting them to death (drones cannot fight back because they have no stingers).

After about six weeks of hard labor, the honeybee worker has literally worked herself to death. Workers that develop late in the summer can live through the winter because they rest during the dormant season.

THE WORKERS

Nearly all the thousands of honeybees in a hive are workers—sterile females that cannot reproduce. Like the queen and drones, they go through the stages of egg, larva, and pupa within the cells of the comb. From the moment they step forth as adult honeybees until they die, they spend all the daylight hours at work.

Some stay in the comb to clean empty cells, bring food to the young, make beeswax for more combs, and, within their bodies, change the nectar into honey that is stored in the combs. On hot days they might provide air-conditioning by fanning their wings to move the air within the hive. Or, these workers might guard the entrance against enemies.

Others work outside, gathering pollen and nectar to provide the raw material for the colony's food. They buzz from flower to flower, packing pollen from the blossoms into special baskets on their hind legs. They also bring home nectar in honey sacs—a second stomach, or reservoir—within their bodies.

INSIDE THE HIVE

A honeybee hive is divided into parts, each with its own purpose. In one area there are cells full of growing larvae. Nearby are cells with beebread and others with honey for the nurses that tend the larvae. In one area of the nursery are larger cells that contain the larvae of drones. Near the bottom of the nursery are big peanut-shaped cells where a few queens develop. At the top of the hive is the main storehouse of honey, where most of the inside workers spend their time making and storing the staple food for the colony.



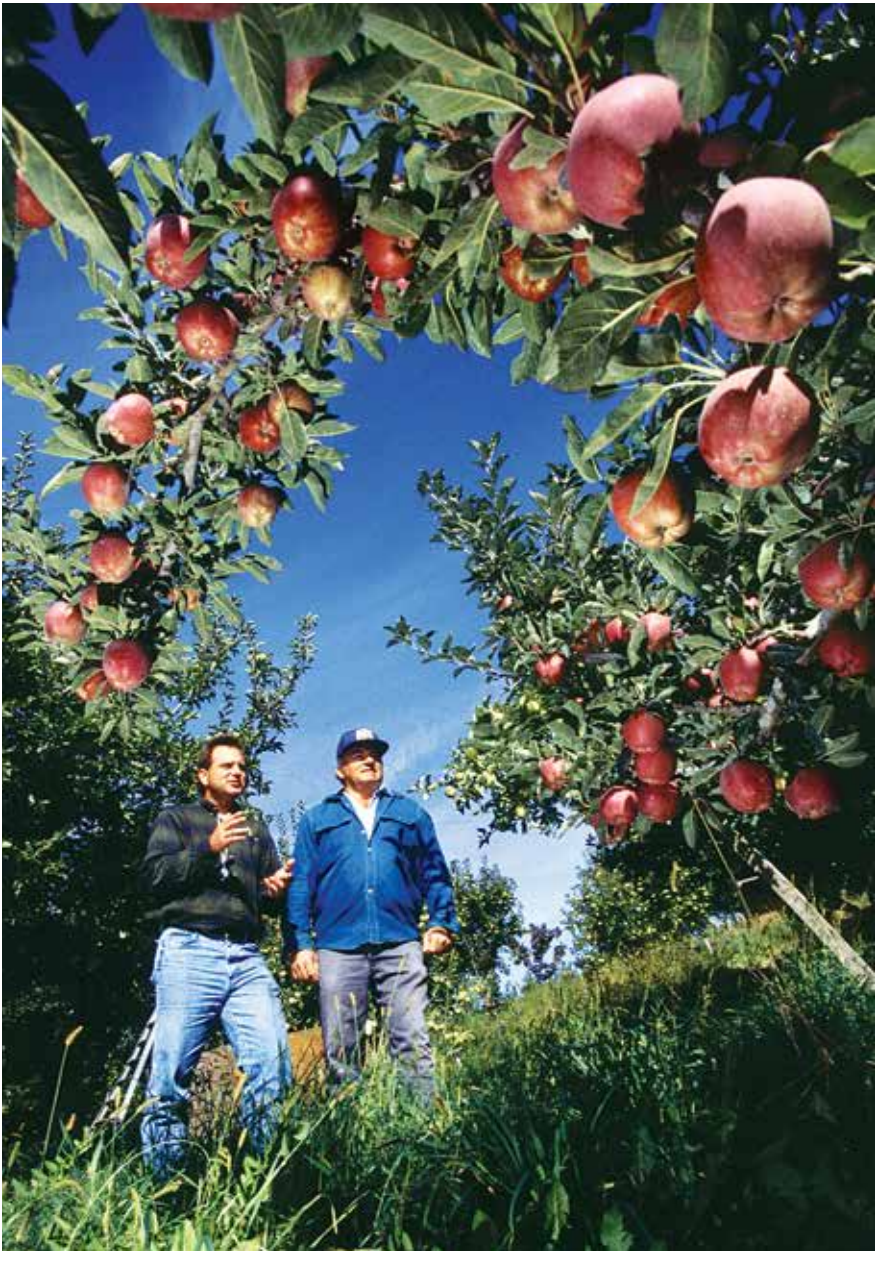
Bee Ordeals

In the U.S., the bee population has decreased significantly over the past several decades. Beekeepers across the country have tried to help by providing bees with manufactured supers (framed boxes) that serve as hives where they can thrive. Mites are believed to be a major cause of population decline as well as natural habitat destruction. Tracheal mites and varroa mites were discovered in bees in the U.S. in 1984 and 1987.

Colony collapse disorder, or CCD, is another reason for population decline. CCD occurs when the majority of worker bees in a colony disappear and leave behind a queen, plenty of food and a few nurse bees to care for the remaining bees and the queen. Its direct cause, however, is not known. Insecticide use, disease, mites, environmental stresses, and malnutrition are some of the possible causes of this syndrome. Many scientists believe it is likely a combination of several of these factors.

Honey in the Hive

There is an easy way to find out about how much honey is stored in a hive or honey super. Just check the honey stores in the brood chamber. A deep frame full of honey will weigh approximately 6 pounds. The bees will need 10 of these. Two shallow frames will equal one deep frame.



Insects and Humans

We often think of insects as pests that bite, sting, or make us itch, or as the makers of pleasant sounds on a summer night. They are much more than that. Some insects are very useful to us. Others are highly destructive and dangerous to human health.

Helpful Insects

Insects are valuable to us in several ways. They help by

- Pollinating plants
- Producing useful materials such as honey, silk, dyes, and beeswax
- Conserving soil and water
- Controlling harmful insects and weeds
- Getting rid of wastes
- Being subjects of scientific studies
- Being food for animals and some plants

Pollinators

Honeybees are so important as pollinators that many fruit growers rent hives during the blossom season of their trees to ensure pollination. Although honeybees are by no means the only pollinators in the insect world, they are particularly good at it because they usually travel among blossoms of the same tree or plant and, therefore, are very efficient.

Many other insects are pollinators: other bee species, butterflies, moths, wasps, beetles, and some species of flies—especially the flower or syrphid fly. Several species of wild bumblebees are the only pollinators of red clover in North America. Without them no red clover (and few related species that are important as animal feeds) could be grown here.

Because they pollinate crops such as clover and alfalfa that cattle feed on, bees are important to the production and consumption of meat and dairy.



Squash bee

Producers

Honeybees produce about 200 million pounds of honey for beekeepers in the United States each year. They also make about 4 million pounds of beeswax, which is used in lubricants, ointments, furniture polish, candles, and other articles.



Silkworm cocoons are slightly larger than a nickel.

Silk, another insect product, is made chiefly in China, Japan, and India by the larva of a particular moth, *Bombyx mori* (L.).

Other insects produce such useful materials as dyes, medicinal products, and the resinous substance called lac that is used in making shellac.

Soil and Water Conservationists

The important role that ants play in water conservation, by digging and making tunnels in the earth, has been mentioned already. Other insects, such as certain beetles and wild bees that nest in the ground, have the same effect.

Insects also improve the soil when they feed on decaying plants and animals. They return *organic* (living or once-living) matter to the earth faster than it would break down without them. Their excrement also provides good fertilizer for the soil. Beetle larvae, ants, flies, termites, earwigs, and some cockroaches also are important in soil and water conservation.

Predators and Parasites

The predators and parasites of the insect world help us by preying on other insects that spread human diseases or destroy valuable plants. Dragonflies and damselflies, ground beetles, ladybird beetles, syrphid flies, praying mantids, and the aphid lion (the larva of the lacewing) are important predators. They seek out and destroy such insect pests as the mosquito, the aphid (which kills plants by sucking out their juices), scale insects, mealybugs, and mites that feed on plants.



Hornworm with cocoons of a wasp parasite

Among the helpful parasites are fly maggots (especially of the family *Tachinidae*) and various species of the ichneumons that were mentioned earlier. Usually, the insects do their deadly work by depositing their eggs on or in the body of the prey. The parasite's larvae eat the host insect's body gradually rather than killing it with just a few bites as predators do.

Insects also are useful in controlling undesirable weeds. Occasionally, certain insects are introduced into an area to kill off a destructive weed. The U.S. Department of Agriculture, for example, introduced chrysolina beetles from Australia into grazing land in the West that was being overrun by Klamath weed. Within a few years, the beetles had Klamath weed under control.

Some predators of harmful insects also destroy beneficial insects but, overall, these predators are helpful to us.

Scavengers

Insects serve as nature's garbage disposers. Many of them feed on decaying animals and animal dung that, if left alone, would breed disease-producing organisms or prevent plant growth. The list of insects providing this sanitation service is long. Dung beetles, carrion beetles, and blowflies are among the more common and important scavengers.



Margined carrion beetle

Today, scientists use insects in *toxicology* (the study of poisons), *physiology* (the study of the bodily processes of organisms), and cancer research.



Mediterranean fruit fly

Subjects of Scientific Studies

Because many insects, such as the common fruit fly *(Drosophila)*, have many generations in a year, they are important in such sciences as *genetics*, the study of heredity (how traits pass from one generation to another), and *genomics*, how genes regulate body functions in health and disease. They also are valuable in studies of pollution problems and of ecology—the relationship of living things to their surroundings.



Food

Many birds and some mammals live almost entirely on insects. Insects are the major part of the diet of frogs, toads, salamanders, lizards, spiders, some snakes, fish, and even some unique plants, such as the Venus flytrap and other sundews, and pitcher plants.

Venus flytrap



Some people say insects make tasty snacks, like these mealworm larvae.

Some people use insects as food. In South Africa, some people roast termites and eat them by the handful, like popcorn. Some people in Mexico make a cake from the eggs of water boatmen. In Australia, grubs are roasted and eaten by the Aborigines.

The Web of Life

Studying insects can help you discover how closely connected all living things are. If every insect in the world died tomorrow, many fruits would disappear. Wildflowers would become rare or extinct because, like fruit trees, they depend on insects for pollination. Many songbirds that eat insects would die; game fish and some mammals would disappear. There would be no more honey or silk. We can never foresee all the consequences of pulling a strand from the web of life.

Harmful Insects

A sting from a hornet or bite from a horsefly can be a painful reminder that some insects are harmful. But the chief ways in which insects harm us can go far beyond bites or stings.

- They carry disease-producing organisms.
- They consume stored grains and other foods.
- They destroy crops, as well as forest and shade trees.
- They are household pests.



Mosquito

Disease Carriers

Many insects transmit the germs that cause disease. Mosquitoes are the worst offenders. They carry the organisms that cause the deadly West Nile virus, malaria, yellow fever, encephalitis, and many other tropical and subtropical diseases. Malaria alone kills more than 1 million people and makes more than 300 million people clinically sick every year. Every case is transmitted by one of only a few mosquito species, all of which are in the single genus *Anopheles.*

Several other insects, such as blackflies, tsetse flies, sand flies, and assassin bugs, are serious pests in other parts of the world because they transmit disease. In the United States, sickness can be transmitted by such disease carriers as fleas, lice, ticks, deerflies, and horseflies.

Biting flies, mosquitoes, and bugs of several species, as well as the housefly, are responsible for diseases in animals. Some are parasites, living in and on the host animal. Among the diseases and conditions these insects transmit are anthrax, botulism, tularemia, swine erysipelas, heartworm infestation, and swamp fever. Some insects do not carry diseases but kill or cripple an animal by living in its flesh. Among these are the botflies and screwworm fly. Some of these diseases affect people, too.



The harmless-looking housefly spreads more than 100 human diseases, including typhoid, tuberculosis, dysentery, and cholera.

Crop Destroyers

The damage insects do to useful trees, crops, and other plants and to stored grain runs into tens of billions of dollars each year in the United States alone. Wherever there is organic material, you can be sure some insect is either in it or trying to get into it.

Among the insects that take a huge toll by their feeding are corn borers, grasshoppers, corn earworms, Hessian flies, chinch bugs, aphids, leafhoppers, tussock and codling moths, scale insects, borers such as the elm bark beetle (which also transmits Dutch elm disease), and other beetles. A few species of aphids and leafhoppers spread crop-plant diseases, causing hundreds of millions of dollars in crop losses each year in the United States alone.



Corn earworm



Click beetle

Bark beetles are small (less than ¼ inch), hard-bodied beetles that bore through the protective bark of a tree to lay their eggs in the moist phloem (inner bark) and feed on this living tissue, cutting off the tree's ability to transport nutrients. Bark beetles survive in trees that are stressed, diseased, or injured, either by human activity or during storms or wildfires. When beetle populations are low, healthy trees often produce enough resinous pitch to drown and "pitchout" the beetles that attempt to enter. When trees are stressed, they may be unable to produce sufficient amounts of defensive pitch. In some years, more trees are killed by bark beetles than by fire.



Termite damage

Household Pests

You can probably find a few unwelcome guests in your home. Some ants will visit occasionally if you leave sweets on the table. Cockroaches will nibble on uncovered food and, if nothing better is around, will chew the bindings off books and magazines. Silverfish and book lice also enjoy eating starched shirts and rayon curtains. The larvae of clothes moths and carpet beetles make meals of woolen and mohair garments, furniture, feather dusters, silk stockings, and other dried animal products.

A termite queen can live for 50 years or longer.

Perhaps the most destructive household pests are termites, carpenter ants, and other wood-destroying insects such as powder-post beetles and carpenter bees. Left uncontrolled, these insects can cause serious damage to a house and furniture. Carpenter bees cause damage to wooden structures by drilling circular holes to create shelters and tunnels in which to rear their young. Termites are particularly damaging because they rarely show on the surface of the wood, which makes it difficult for property owners to know that termites are at work. The termites chew from the inside until only a shell remains. Rarely, termites will excavate an opening when swarming.

Other beetles, flies, and moths of several species feed on leather, wool, tobacco, spices, drugs, meats, dried fruits, nuts, and cereal products.

Controlling Harmful Insects

The best insect controls are **natural** ones provided by animals and other insects. Predators—including birds, small mammals, spiders, and especially other insects—destroy far more harmful insects than are ever destroyed by artificial means. Insects prey on one another, and birds, skunks, shrews, moles, snakes, and lizards are constantly on the lookout for insects.

Biological control—introducing predators, parasites, or forms of life such as bacteria that will destroy an insect pest—was introduced in the late 1800s, when California citrus growers were being wiped out by an insect called the cottony-cushion scale. The vedalia ladybird beetle (*Rodolia cardinalis* Mulsant) was imported from Australia to eat the cottony-cushion scale, and within two years the pest was completely controlled.

Another kind of biological control is sterilizing the males so that no eggs hatch. This was first done successfully in 1954 against a parasite called the screwworm fly that, in its larval stage, lives in and feeds on the flesh of living livestock. Three and a half billion male screwworm flies (males can mate repeatedly; females mate only once in their lives) were sterilized by X-rays and released over Florida, Georgia, and Alabama, the hardest-hit states. In less than a year the screwworm fly menace was virtually wiped out in the Southeast because so few young were hatched.

New synthetic insect-growth-regulating hormones are sometimes spread as liquids, as granules, or in plaster pellets in



Spiders, like this crab spider, feed on harmful insects. Spiders eat grasshoppers and locusts that destroy crops; caterpillars that damage plants; and disease-carrying flies and mosquitoes.

the habitats where the larvae of pest or disease-carrying species live. These hormones slow or stop the insects' development and sometimes kill them. These materials are very safe for all animals except arthropods.

Another way to keep the insect population within bounds is **cultural control.** This is largely a matter of common sense. It involves, for example, sanitation. You know that garbage and filth attract the common housefly and many other insects. Getting rid of such breeding material is an excellent control measure.

On the flip side, some nonnative insects, such as loosestrife weevils and beetles, have been used to counterattack nonnative plants like the purple loosestrife.

For farmers, cultural control also means planting more than one crop. Many varieties of insects depend on one kind of plant for their entire food supply. If there is plenty of that plant, the insects will thrive; if it disappears, they die off.

Soil cultivation in the fall is another method of control that farmers use. Cultivation destroys insect larvae and pupae buried in the earth by crushing them or exposing them to the surface cold.

Mosquitoes and other insects whose larvae live in water—breathing air through a sort of snorkel at the surface—can be controlled by spreading light oil over their breeding ponds. The oil enters or jams the breathing system and suffocates the larvae.

Lastly, there is **chemical control.** Insecticides have been extremely important, particularly since World War II, when DDT was introduced. DDT alone was credited with saving 5 million lives by controlling mosquitoes, lice, flies, and other disease carriers. However, it was later discovered to be very harmful to the environment.

In the 1960s, the public (including many scientists) became increasingly alarmed about the side effects of insecticides including DDT and related compounds. Many insecticides persist for long periods in nature, killing not only harmful insects but also useful ones, as well as birds and small animals. Pesticides can build up over time in soil or water and *bioaccumulate* in natural food chains (including that of humans); such pesticides are now banned. In addition, some of the insects brought under control by new insecticides are now resistant to them and are thriving once more.

For these reasons, many scientists believe that the future of insect control will be in *integrated pest management* (IPM). This approach uses all environmentally sound techniques in combinations that are compatible with local conditions. Monitoring the pest or disease-carrying species; using biological, cultural, sanitary, and other control methods; and resorting to chemicals only when no other effective method is available (and then using the lowest effective chemical dose possible) are the basics of IPM.

The hemlock woolly adelgid is an example of integrated pest management. These aphid-like insects (order *Hemiptera*) attack North American hemlocks. Biological control is via introduction of the beetle *Laricobius nigrinus,* and chemical control occurs either by foliage spray of insecticidal soap or by root or trunk injection of the Imidacloprid, which is taken up by the tree and moves through the sap to be ingested by the adelgids.



Scientists use this flight intercept trap to help them study adult red oak borers.


Spotted lanternfly

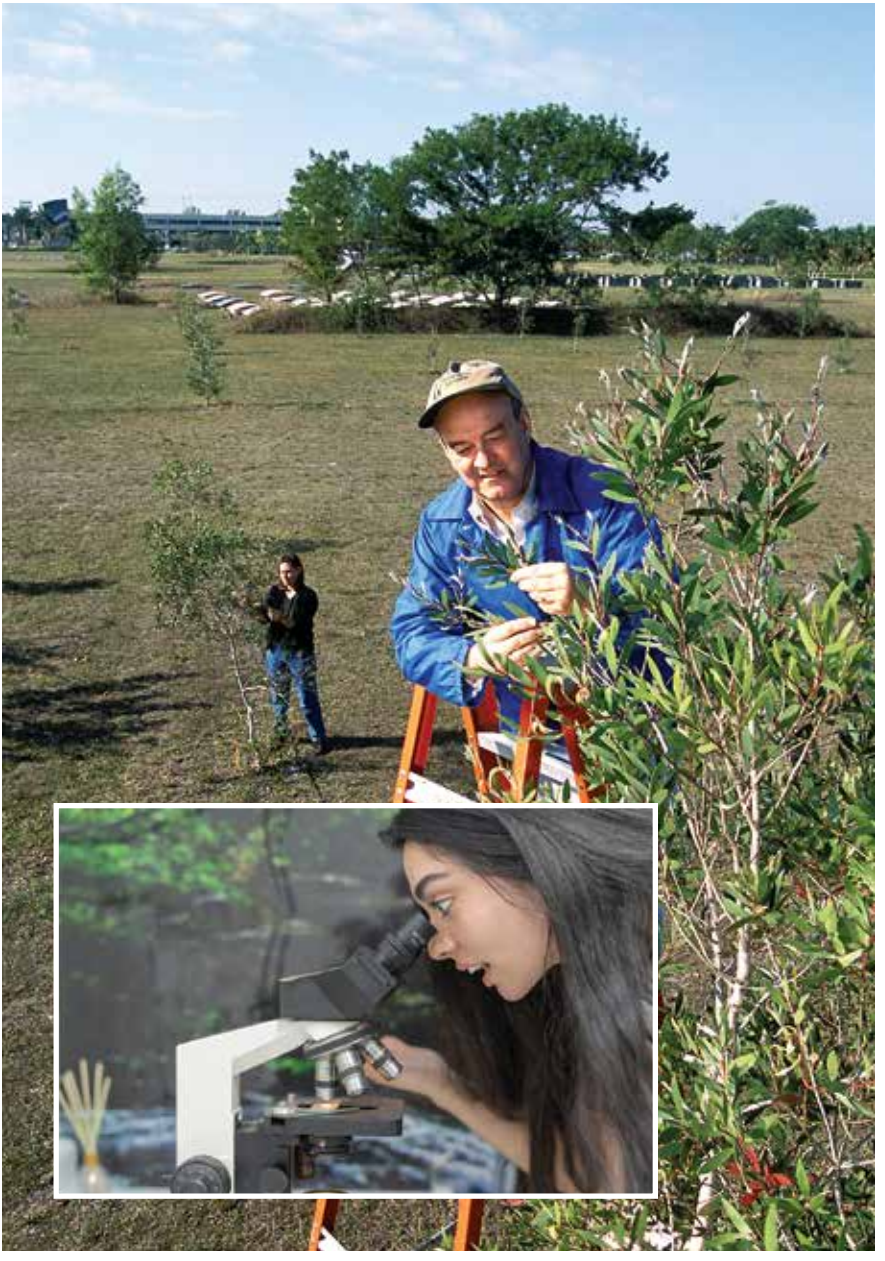

Hessian fly


Boll weevil

Keep Out!

Many of the worst insect pests in the United States, including the boll weevil, Japanese beetle, spongy moth, spotted lanternfly moth, Hessian fly, and imported cabbageworm, came here from other countries. Some of these nonnative invasive species, such as fire ants and Africanized honeybees, are dangerous to both people and wildlife. For this reason, quarantines are set up to try to keep foreign pests out.

At the borders and chief points of entry into the United States, agricultural quarantine inspectors examine baggage and cargo for pests that might be imported accidentally on ships, planes, or other vehicles. Within the United States, there are also agriculture-related laws that limit the transport of fresh fruits and vegetables across state lines.



Careers in Entomology

People who study insects, either as a career or as a hobby, are entomologists. Tens of thousands of amateur entomologists have provided valuable information on insect distribution, identification, life cycles, behavior, habits, and more. Professional entomologists have a variety of career choices, including controlling harmful insects, raising bees, teaching, consulting with farmers and homeowners, enforcing quarantines and regulations, doing insect surveys, selling insecticides, or researching insect identification, classification, biology, ecology, and behavior. They might work for private companies, universities, or government agencies.



Beekeeping is one of many hobbies or professions an entomologist could choose.

The Wide World of Entomology

The work of entomologists can prevent the spread of disease, help farmers grow crops, save endangered species, and help solve crimes. Here are some examples of what entomologists can achieve and where they find employment.

Preventing Epidemics of Disease

Entomologists do research to combat insects that transmit malaria, yellow fever, plague, river blindness, sleeping sickness, and other diseases such as typhus, typhoid fever, and Lyme disease. *Medical entomologists,* who specialize in studying and stopping the spread of insect-borne diseases, work for the United Nations; the World Health Organization; the U.S. Department of Defense; the Centers for Disease Control; federal, state, and local public health departments; mosquito abatement agencies; and universities.



A crop duster sprays pesticide on a crop of peas near Walla Walla, Washington.

At least one-sixth of the human race suffers from insect-borne diseases.

Protecting Crops and Other Vegetation

Entomologists work to reduce the crop losses that insects cause, which can help to relieve some of the food shortages that exist in many parts of the world. Entomologists also work with foresters to battle the insect pests that injure trees, destroy timber, and damage the biological riches found in forests. *Plant protection entomologists* study insect pests and figure out ways to protect crops, trees, flowers, and other plants from attack and injury by insects. These entomologists work for the Department of Agriculture, the Forest Service, the Department of the Interior, universities, nature centers, conservation agencies, and private industries.

Saving Endangered Species

By identifying endangered insect species and studying their habitats, *conservation entomologists* can help rebuild threatened ecosystems. Many are involved in education and outreach programs at natural history museums, nature centers, zoos, conservation agencies, and extension offices. They encourage people to appreciate insects.



Solving Crimes

Forensic entomologists help in police investigations by examining insects that inhabit decomposing remains. For example, insects can help establish the time of death. Among the first insects to arrive on a newly dead body are blowflies, and a female blowfly usually lays eggs within a very short time after arriving. The eggs develop into larvae, then pupae. A researcher who knows how long it takes blowfly eggs to reach these different stages can estimate the time of the victim's death.

Few people are employed full-time as forensic entomologists. Most are affiliated with colleges or universities, teach entomology or biology, and do research. Some work as consultants to law enforcement and judicial agencies, or train crime-scene technicians to recognize, collect, and properly preserve the evidence that insects provide. Other forensic entomologists might concentrate on food or other product contamination cases, on insect problems in hospitals or nursing homes, or the effects insects have on structures.

Insects can help investigators determine whether a murder victim's body was moved after death. If the insects found on the body are different from those that live where the body was discovered, that gives investigators an important clue.

Preparing for a Career

Acquainting yourself as early as possible with the science of entomology will help you to recognize the variety of career choices and begin to match your values, interests, aptitudes, abilities, personal traits, and desired lifestyle to your career decision.

For a career in entomology, you must have a thorough understanding of math and science. Begin now to take all the biology, zoology, botany, ecology, chemistry, math, statistics, genetics, and physics courses you can. Also develop your writing skills. Study foreign languages if you are interested in traveling abroad.

Get hands-on experience in entomology and biology by volunteering at a museum, science center, or zoo. Seek summer positions with universities, state experiment stations, or government agencies that work with insects. Join an entomology club. Getting to know people who share your interest in insects can help you decide whether you want to make entomology your career.

In college, you will study basic and applied entomology, as well as ecology, genetics, microbiology, biochemistry, and statistics. A bachelor's degree that includes coursework in entomology should qualify you to work for government agencies, chemical companies, or pest management industries. Advanced degrees are required, however, for many positions in entomology. You will need a master's or a doctoral degree to teach, conduct research, or work in extension services.

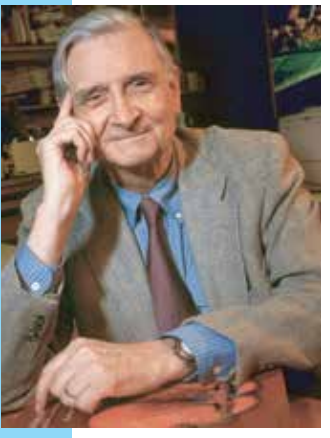
E.O. Wilson, A Scouting Story



Among the world's most influential scientists, Edward Osborne Wilson found the subjects that would become his life's work while he was a Scout. "The Boy Scouts of America seemed invented just for me," he wrote in Naturalist, his bestselling autobiography. "The 1940 *Handbook for Boys*, which I purchased for half a dollar, became my most cherished possession."

That handbook was filled with information about outdoor life, but what truly caught Wilson's attention were sections on zoology and botany with "page after page of animals and plants wonderfully well illustrated, explaining where to find them, how to identify them."

"The public schools and church had offered nothing like this," he continued. "The Boy Scouts legitimated Nature as the center of my life."



He recalled the impact of the Insect Life merit badge. The requirements invited him to show an examiner the natural surroundings in which certain insects lived, find specimens of the insects, and tell of their habits and of the nature of their fitness for their particular surroundings. While earning the merit badge, Wilson became hooked on bugs.

He received a doctorate in biology from Harvard University in 1955. Field research in many parts of the world established him as an expert in the study of ants. He expanded on what he learned from them to encompass many species and to develop sweeping theories of biodiversity and sociobiology that have helped scientists understand the foundations of entire societies.

Wilson received many awards for his work, including two Pulitzer Prizes for General Nonfiction (for *On Human Nature* in 1979, and *The Ants* in 1991).

And it all began with Scouting.

Insect Study Resources

Scouting Literature

Animal Science, Bird Study, Collections, Environmental Science, Forestry, Gardening, Mammal Study, Medicine, Nature, Plant Science, Public Health, Reptile and Amphibian Study, Soil and Water Conservation, and *Veterinary Medicine* merit badge pamphlets

With your parent or guardian's permission, visit Scouting America's official retail site, **scoutshop.org**, for a complete list of merit badge pamphlets and other helpful Scouting materials and supplies.

Books and Brochures

Arnett Jr., Ross H. *American Insects: A Handbook of the Insects of America North of Mexico,* 2nd ed. CRC Press, 2000.

Arnett Jr., Ross H., and Richard L. Jacques Jr. *Simon and Schuster's Guide to Insects,* 2nd ed. Fireside Books, 1981.

Berenbaum, May R. *Ninety-Nine Gnats, Nits, and Nibblers.* University of Illinois Press, 1989.

———. *Ninety-Nine More Maggots, Mites, and Munchers.* University of Illinois Press, 1993.

Bland, Roger G., et al. *How to Know the Insects.* McGraw-Hill, 1978.

Chu, H.F., and Laurence K. Cutkomp. *How to Know the Immature Insects.* McGraw-Hill, 1992.

Cranshaw, Whitney and David Shetlar. *Garden Insects of North America.* Princeton University Press, 2018.

Dashefsky, H. Steven. *Insect Biology: 49 Science Fair Projects.* Tab Books, 1992.

Dunkle, Sidney W. *Dragonflies Through Binoculars: A Field Guide to Dragonflies of North America.* Oxford University Press, 2000.

Eisner, Thomas. *For Love of Insects,* 2nd ed. Belknap Press, 2005.

Eisner, Thomas, Maria Eisner, and Melody Siegler. *Secret Weapons: Defenses of Insects, Spiders, Scorpions, and Other Many-Legged Creatures*. Belknap Press, 2007.

Evans, Howard E. *The Pleasures of Entomology*. Smithsonian, 1985.

Holldobler, Bert, and Edward O. Wilson. *The Ants.* Belknap Press, 1990.

Kavanagh, James. *Bugs & Slugs: A Folding Pocket Guide to Familiar North American Invertebrates.* NBN Press, 2017.

Lehmkuhl, Dennis M., et al. *How to Know the Aquatic Insects.* McGraw-Hill, 1979.

Milne, Lorus J. *National Audubon Society Field Guide to North American Insects and Spiders.* Knopf, 1980.

Mound, Laurence, and Stephen Brooks. *Insects.* Sagebrush, 2003.

National Audubon Society. *National Audubon Society Field Guide to North American Butterflies.* Chanticleer Press, 1981.

Opler, Paul A. *Peterson First Guides: Butterflies and Moths.* Houghton Mifflin, 1998.

Peterson, Roger Tory. *Peterson First Guides: Insects,* 2nd rev. ed. Houghton Mifflin, 1998.

Turpin, Tom. *Insect Appreciation,* 3rd ed. Kendall Hunt Publishing Co., 2002.

West, Larry, and Julie Ridl. *How to Photograph Insects and Spiders.* Stackpole Books, 1994.

White, Richard E. *A Field Guide to the Beetles of North America.* Houghton Mifflin, 1998.

Wilsdon, Christina, et al. *National Audubon Society First Field Guide: Insects.* Scholastic, 1998.

Winston, Mark L. *The Biology of the Honey Bee.* Harvard University Press, 1991.

Wright, Amy Bartlett. *Peterson First Guides: Caterpillars.* Houghton Mifflin, 1998.

Zim, Herbert S., and Clarence Cottam. *Insects,* rev. and updated ed. St. Martin's Press, 2002.

Organizations and Websites

American Beekeeping Federation
480 Town Center St. N, PMB #253
Mooresville, IN 46158-1379
317-503-0583
abfnet.org

Bee Culture
623 West Liberty St.
Medina, OH 44256
800-289-7668
beeculture.com

BugGuide.net
Iowa State University
2310 Pammel Dr.
Ames, IA 50011-1031
515-294-7401
bugguide.net

Carolina Biological Supply Company
800-334-5551
carolina.com

Entomological Society of America
3 Park Place, Suite 307
Annapolis, MD 21401-3722
(301) 731-4535
entsoc.org

Journey North Arboretum
University of Wisconsin-Madison
journeynorth.org

Leave No Trace
P.O. Box 997
Boulder, CO 80304
lnt.org

Monarch Watch
monarchwatch.org

The Natural History Museum
"The glimmering world of glow-worms"
Cromwell Road
London SW7 5BD
nhm.ac.uk/discover/the-glimmering-world-of-glow-worms.html

National Museum of Natural History
Department of Entomology
P.O. Box 37012, Smithsonian Institution
Washington, DC 20013-7012
naturalhistory.si.edu/research/entomology

Natural Resources Conservation Service
833-ONE-USDA
nrcs.usda.gov

University of Kansas
2021 Constant Avenue
Lawrence, KS 66047
785-864-4441

Xerces Society for Invertebrate Conservation
855-232-6639
Xerces.org

Acknowledgments

For reviewing and suggesting updates to this edition of the pamphlet, Scouting America thanks Nathan Brockman, Reiman Gardens, Iowa State University, Director of Entomology, Entomologist; Suse Bell, SA Outdoor Ethics & Conservation Committee; Gary Vaughn, National Wilderness and Wild & Scenic Rivers Specialist USDA; Michael Huneke, National Program Manager – Forest Service USDA; Stephen Scannell, SA Outdoor Ethics & Conservation Committee; and Perry Leong, National Merit Badge Subcommittee.

Scouting America is grateful to all the men and women serving on the National Merit Badge Subcommittee for the improvements made in updating this pamphlet.

Scouting America is grateful to those who have contributed to previous editions of the *Insect Study* merit badge pamphlet, upon which this edition is closely based. We are grateful to: Dr. John A. Jackman, Texas A&M University; Gary A. Dunn, M.S., Young Entomologists' Society; Robert D. Hall, Ph.D., J.D., University of Missouri; the Entomological Society of America for permission to adapt material from the society's website (entsoc.org); writer and editor Deborah Lightfoot Sizemore; Timothy Ebert, Ph.D.; Lt. Col. Harold J. Harlan; and Gary A. Dunn.

Photo and Illustration Credits

David T. Almquist, University of Florida, Bugwood.org, courtesy—page 29 *(bark beetle)*

Stephen Ausmus, USDA Agricultural Research Service, Bugwood.org, courtesy—page 86 *(inspecting leaves)*

Scott Bauer, USDA Agricultural Resource Service, Bugwood.org, courtesy—cover *(potato beetle);* pages 58 *(adult Colorado potato beetle),* 74, 78 *(Mediterranean fruit fly),* 81 *(termite damage),* and 85 *(Hessian fly)*

Joseph Berger, Bugwood.org, courtesy—cover *(ladybird beetle);* pages 28 *(housefly),* 48, 56 *(blue-winged olive mayfly),* 64, and 80 *(housefly)*

Ronald F. Billings, Texas Forest Service, Bugwood.org, courtesy—page 69 *(Texas leafcutter worker ant)*

Charles T. and John R. Bryson, Bugwood.org, courtesy—page 11 *(Eastern tiger swallowtail)*

David Cappaert, Michigan State University, Bugwood.org, courtesy—pages 5 *(top),* 14, 15 *(ant),* 16 *(bee),* 21 *(eastern forktail damselfly),* 23 *(Delaware skipper),* 26 *(praying mantis),* 27 *(mature calico pennant dragonfly),* 30, 49, 56 *(whitetail dragonfly),* 77 *(margined carrion beetle),* 81 *(click beetle),* and 83

Clemson University—USDA Cooperative Extension Slide Series, Bugwood.org, courtesy—pages 12 *(cockroaches, silverfish),* 28 *(camel cricket),* 57, and 85 *(boll weevil)*

Whitney Cranshaw, Colorado State University, Bugwood.org, courtesy—pages 63, 69 *(harvester ants),* 75, and 81 *(corn earworm)*

Carl Dennis, Auburn University, Bugwood.org, courtesy—page 71

Arnold T. Drooz, USDA Forest Service, Bugwood.org, courtesy—page 39 *(hibiscus)*

Maria Eisner, Cornell University, courtesy—page 10 *(cat flea)*

Susan Ellis, Bugwood.org, courtesy—pages 24 and 61 *(black swallowtail larva)*

Susan Ellis, forestryimages.org, courtesy—page 21 *(june beetle)*

Chris Evans, River to River CWMA, Bugwood.org, courtesy—page 39 *(milkweed, phlox)*

Wendy VanDyk Evans, Bugwood.org, courtesy—page 39 *(snapdragon)*

Getty Images—pages 8, 11 *(firefly)*, 13 *(butterflies),* 27 *(snow fleas)*, 37, 85 *(spotted lanternfly)*, and 86 *(inset)*

Peggy Greb, USDA Agricultural Research Service, Bugwood.org, courtesy—page 58 *(potato beetle larva)*

James Henderson, Gulf South Research Corp., Bugwood.org, courtesy—page 78 *(Venus flytrap)*

Tom Heutte, USDA Forest Service, Bugwood.org, courtesy—page 39 *(red clover)*

Gerald J. Lenhard, Bugwood.org, courtesy—pages 15 *(black swallowtail adult butterfly)* and 61 *(black swallowtail pupa, butterfly)*

Edward L. Manigault, Clemson University Donated Collection, Bugwood.org, courtesy—pages 16 *(grasshopper)* and 56 *(dragonfly nymph)*

Paolo Mazzei, Bugwood.org, courtesy—page 40

John Moser, USDA Forest Service, forestryimages.org, courtesy—page 12 *(Texas leafcutting ant)*

Jerry A. Payne, USDA Agricultural Research Service, forestryimages.org, courtesy—page 62

J. Scott Peterson, USDA NRCS, forestryimages.org, courtesy—page 38

Herb Pilcher, USDA Agricultural Research Service, forestryimages.org, courtesy—page 12 *(brown stinkbug)*

Dave Powell, USDA Forest Service, Bugwood.org, courtesy—page 39 *(goldenrod)*

John Ruberson, University of Georgia, Bugwood.org, courtesy—cover *(ants and leaf)*

James Solomon, USDA Forest Service, Bugwood.org, courtesy—page 54

Alton N. Sparks Jr., University of Georgia, Bugwood.org, courtesy—page 31

Terry Spivey, USDA Forest Service, Bugwood.org, courtesy—page 39 *(sunflower)*

Tim Tigner, Virginia Department of Forestry, Bugwood.org, courtesy—page 28 *(periodical cicada nymph)*

University of Arkansas Forest Entomology Lab Archive, Bugwood.org, courtesy—page 84

USDA Agricultural Research Service/Stephen Ausmus, courtesy—page 53

USDA Agricultural Research Service/Scott Bauer, courtesy—page 6

USDA APHIS PPQ Archives, USDA Animal and Plant Health Inspection Service, forestryimages.org, courtesy—page 10 *(red fire ant)*

USDA APHIS PPQ Archives, USDA APHIS PPQ, Bugwood.org, courtesy—page 39 *(marigold)*

USDA Natural Resources Conservation Service/Paul Fusco, courtesy—page 10 *(dragonfly)*

USDA/Doug Wilson, courtesy—page 88

E.O. Wilson, courtesy—page 91

Wikipedia.org, courtesy—page 21 *(male cecropia moth)*

Wikipedia/Hectonichus, courtesy—page 11 *(Goliath beetle)*

Wikipedia/J.T. Huber, courtesy—page 11 *(fairyfly)*

Peter Wirtz, Bugwood.org, courtesy—cover *(chrysalis)*; page 60

All other photos and illustrations not mentioned above are the property of or are protected by Scouting America.

John McDearmon—all illustrations on pages 17, 19, 22–23, 27, 36, 50–52, 55–56, 58–59, and 66

Brian Payne—page 87

MERIT BADGE LIBRARY

Though intended as an aid to youth in Scouts BSA and qualified Venturers and Sea Scouts in meeting merit badge requirements, Scouting America's merit badge pamphlets are of general interest and are made available by many schools and public libraries.

Always check scouting.org for the latest merit badge requirements. If a Scout has already started working on a merit badge when new requirements for that merit badge are introduced, *they may continue to use the same pamphlet to earn the badge and fulfill the requirements therein.* In other words, the Scout need not start over again with the revised requirements.

American Business
American Cultures
American Heritage
American Indian Culture
American Labor
Animal Science
Animation
Archaeology
Archery
Architecture
Art
Astronomy
Athletics
Automotive Maintenance
Aviation
Backpacking
Basketry
Bird Study
Bugling
Camping
Canoeing
Chemistry
Chess
Citizenship in the Community
Citizenship in the Nation
Citizenship in Society
Citizenship in the World
Climbing
Coin Collecting
Collections
Communication
Composite Materials
Cooking
Crime Prevention
Cycling
Dentistry
Digital Technology
Disabilities Awareness
Dog Care
Drafting
Electricity
Electronics
Emergency Preparedness
Energy
Engineering
Entrepreneurship
Environmental Science
Exploration
Family Life
Farm Mechanics
Fingerprinting
Fire Safety
First Aid
Fish & Wildlife Management
Fishing
Fly-Fishing
Forestry
Game Design
Gardening
Genealogy
Geocaching
Geology
Golf
Graphic Arts
Health Care Professions
Hiking
Home Repairs
Horsemanship
Insect Study
Inventing
Journalism
Kayaking
Landscape Architecture
Law
Leatherwork
Lifesaving
Mammal Study
Metalwork
Mining in Society
Model Design and Building
Motorboating
Moviemaking
Multisport
Music
Nature
Nuclear Science
Oceanography
Orienteering
Painting
Personal Fitness
Personal Management
Pets
Photography
Pioneering
Plant Science
Plumbing
Pottery
Programming
Public Health
Public Speaking
Pulp & Paper
Radio
Railroading
Reading
Reptile & Amphibian Study
Rifle Shooting
Robotics
Rowing
Safety
Salesmanship
Scholarship
Scouting Heritage
Scuba Diving
Sculpture
Search & Rescue
Shotgun Shooting
Signs, Signals, Codes
Skating
Small-Boat Sailing
Snow Sports
Soil & Water Conservation
Space Exploration
Sports
Stamp Collecting
Surveying
Sustainability
Swimming
Textile
Theater
Traffic Safety
Truck Transportation
Veterinary Medicine
Water Sports
Weather
Welding
Whitewater
Wilderness Survival
Wood Carving
Woodwork

SCOUTING AMERICA

To place an order,
call **800-323-0736** or go to
scoutshop.org











ON THE ROAD TO HIGH ADVENTURE

Discovery is at the heart of Scouting. We believe every adventure helps us uncover a little more about ourselves. Scouting builds the foundations for courage, resilience, and character, preparing youth for a lifetime of leadership. The path is yours to forge. Who knows what you'll discover?

SKU 660197

7 30176 34978 7

35911 2026 Printing

SUSTAINABLE FORESTRY INITIATIVE
Certified Chain of Custody
At Least 30% Certified Forest Content
www.sfiprogram.org
SFI-01042