Backyard Monsters
Teacher's Guide

Dear Educator,

Welcome to *Backyard Monsters*!

The enclosed materials have been designed to provide an educational and enjoyable experience for you and your students. This guide includes background information; vocabulary; student pre-/post-visit materials; a Museum visit worksheet; and references. These materials are most appropriate for grades 2–6 and may be adjusted for other grade levels.

References to California Content Standards are included where appropriate. Bold lettering indicates glossary words.

If you have questions related to this guide, please call the Museum Education Department at 619.255.0202 or email cradford@sdnhm.org.

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Classroom Activities

Live Insect Study

Suggested Grade Level: all grades

Objectives: to observe and record insect behavior; to chart and analyze daily rhythms of patterns in behavior.

California Science Content Standards:

Life Science

K—2a, c	observing, identifying major structures
1—2a, b, c	needs of plants and animals
2—2b, d	life cycles, individual variations; adaptation
3—3a	adaptation
4—2a	energy and food chains
5—2a	animals have special structures
6—5a	energy and food chains
7—5a	organisms have levels of organization

Investigation and Experimentation

K—4a	observation and interpretation
4—4a	differentiate observation from inference

Materials: live crickets, aquarium with lid, food and water, shelter, heat and light source

Introduction

Live insects are wonderful, low-maintenance classroom pets. Live specimens provide unique opportunities for observation and behavioral studies. Crickets are an excellent choice for classroom study; they are active, interact with each other, and make interesting sounds.

Assign individuals or groups of students to observe and record cricket behavior at specific times during the day. Chart your results over several weeks and look for patterns or rhythms. You can use the chart below as a class or individually.

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Behaviors to Record and Study

Eating:	What are they eating? How are they eating?
Drinking:	What are they drinking? How are they drinking?
Hiding:	What are they hiding from?
Singing:	When do they sing? How do they sing?
Moving:	How far do they move? Measure or map cricket activity.
Other questions:	Can you tell individual crickets apart?

Directions for Care

Crickets may be purchased at most pet stores or ordered from a biological supply company. A large jar with a ventilated cover makes a good home for a small number of crickets. An aquarium with a screen cover works well for a larger colony. Place dry sand or soil in the bottom of the container. Make a "hiding place" for your crickets out of a cardboard tube or empty egg carton.

Crickets need a steady supply of fresh water, but drown easily even in a shallow water dish. Place a small sponge or cotton ball in a shallow jar lid and keep it wet to provide a safe water supply. Dry dog food is a good basic diet for crickets. Supplement this with fresh fruit and vegetables such as apples, lettuce, carrots, etc.

Crickets thrive in a warm environment with natural light, but direct sunlight is probably too warm. A small heating pad or heat strip for your aquarium can be purchased at a pet store. Keep the aquarium clean. Remove dead crickets, uneaten food, and accumulated droppings.

Other insects recommended for the classroom: ants, cockroaches, praying mantis, mealworms, silkworms, termites, painted lady butterflies.

Insect observed: _____			**Observed by: _____**		
	date/time	date/time	date/time	date/time	date/time
Eating					
Drinking					
Singing					
Moving					
Hiding					
Other					

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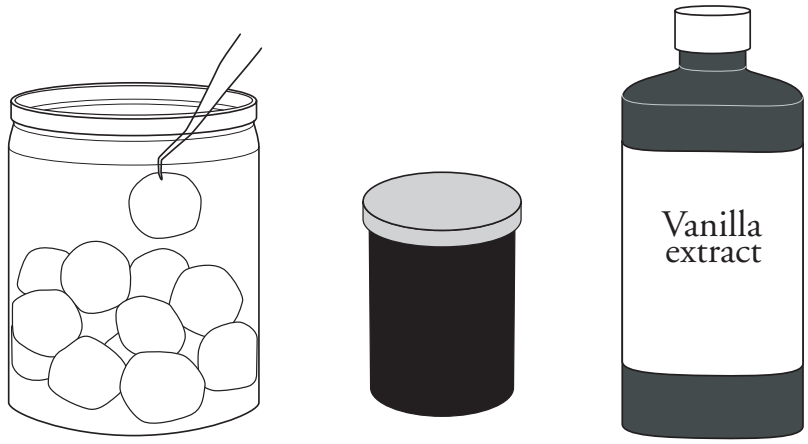
Scent Messages

Suggested Grade Level: K–2

Objectives: to explore the idea of scent as means of identification; to find a partner using smell as a clue.



California Science Content Standards:
Investigation and Experimentation
K—4a observation
2—4c, g comparing, following oral instructions

Materials: one film canister with lid for each pair of students, cotton balls, four different scents: vanilla, almond, lemon, peppermint, banana, etc.

Introduction
Insects communicate powerful and detailed messages using the sense of smell. Ants recognize other members of their colony by smell rather than sight or sound.

Explain to the students that some insects, like ants, do not find their friends by sight. Have the children cover their eyes and see if they can figure out a way to find a buddy. Some of them may say they can talk and find their buddy. Tell them that ants can't talk. Can they think of another way?

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Directions
Before class, divide the canisters into four groups, one for each scent. In each canister, place a cotton ball containing several drops of flavoring. Place the lids on the canisters and shake them so that the smell gets on the lids.

Mark the lids and canisters in an inconspicuous way so that you can find mates easily, but students cannot.

Pass out the prepared film canisters to half the group; pass out the lids to the canisters to the other half. Suggest that they now have a way to find a buddy without using talking or seeing. Tell students to sit down when they have found a partner with a matching scent. Continue the activity until everyone has found a buddy. Try this activity again, this time asking students to form larger and larger ant "colonies" with each round of the activity until all the "ants" with the same scent have found each other.

Blending In and Standing Out

Suggested Grade Level: 2–3

Objectives: to identify reasons for different kinds of insect coloration; to color or decorate insect pictures to show blending in or standing out.

California Science Content Standards:
Life Science

1—2a, b	needs of plants and animals
2—2c	inherited characteristics
3—3a	organisms have different structures
4—3b	survival and environments

Investigation and Experimentation

1—4a, b	recording observations
2—4c	comparing

Materials: copies of caterpillar illustration below, crayons, paints or magic markers, scissors, tape

Introduction
Insects have an incredible range of colors and patterns. Different insects have different colors and patterns for different reasons. Ask the following questions and decide if each insect should blend in or stand out.

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Should an insect stand out or blend in if its goal is:

- to sneak up on other insects, grab them and eat them?
- to advertise to hungry birds that it tastes bad?
- to attract another insect for a mate?
- to avoid being noticed and eaten?

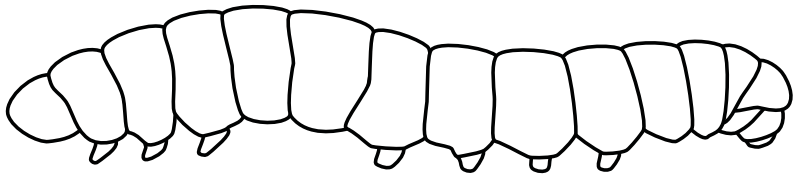
Blending In: Camouflage
Being able to hide is of unique importance to insects since they are often smaller and move slower than their enemies. In order to survive in their natural habitat, insects have developed mystifying ways of blending into the background. Camouflage is also an advantage for insect predators.

Activity
"Camouflage" the caterpillar below with crayons and art supplies to match colors and patterns in your classroom. Choose a different "home" for each caterpillar (insect) and color it to match. Cut out the insects carefully. Have half of the class go out of the room while the others tape their insects up around the classroom. Remind the students not to cover up their insects completely, but to leave part showing. Have the students in the hall return and find the camouflaged insects. Reverse roles and discuss the advantages of camouflage.

Standing Out: Warning or Attracting Colors
Standing out has survival advantages for insects that need to be noticed. Flashy insects attract mates more easily. Many toxic or bad-tasting insects are brightly colored as a warning to birds that might eat them. Some tasty insects imitate the colors of unpalatable ones to fool predators.

Activity
Color the insects again. This time choose colors that make them stand out. Cut out the insects. Divide the class into two groups. Give each group a turn at displaying their insects and let the other group find the insects. How long does it take to find these insects compared to the camouflaged insects?

Note: Magazine and newspaper cutouts of insects may replace the caterpillar illustration.



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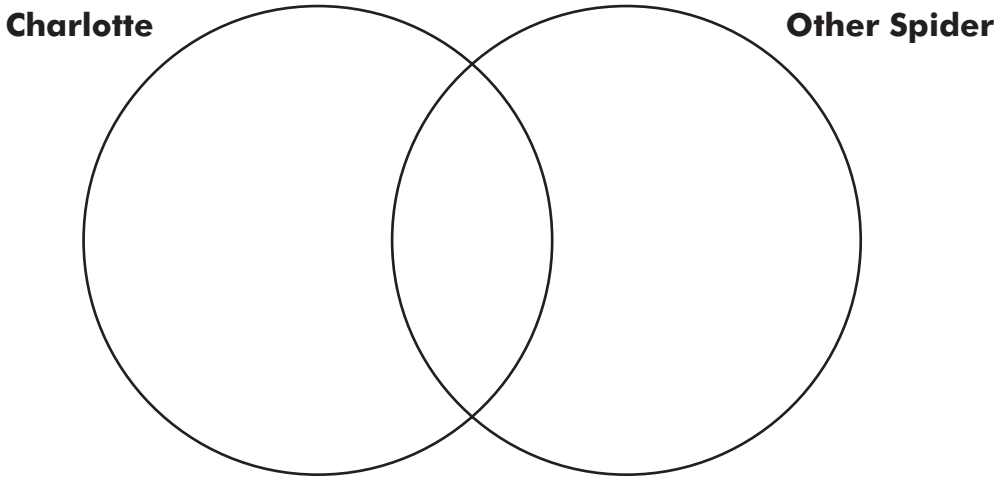
Reading and Writing Activities

Suggested Grade Level: 4–5

Charlotte's Web
Read *Charlotte's Web* as a class or individually. Have students write down facts about spiders they find or hear in the story. Each student can keep a spider facts journal, or at the end of each reading session ask for any facts noted by the children and record them on a spider facts chart. Look for distinctions between fact and fantasy. When you finish the book, have the children organize the facts. Students may use this information to write and illustrate their own non-fiction book about spiders. Or, have individuals or cooperative groups research another type of spider (perhaps the black widow) for comparison to Charlotte. Use the Venn Diagram below to show differences and similarities between the two spiders.

Joyful Noise
Joyful Noise: Poems for Two Voices by Paul Fleischman contains interesting information about insect behavior and offers an opportunity to practice group reading skills. Read a poem from *Joyful Noise*. Divide the class into two groups, one for each voice. One group reads the left side of the page and the other the right side. As they read, the students will discover that both groups read in unison at times. As an extension of this activity, have the students write their own "two-voice" poem to be practiced and read to the class.



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Arthropod Classification

Suggested Grade Level: 4–5

Objectives: to identify the characteristics of familiar arthropods; to classify arthropods based on their characteristics.

California Science Content Standards:
Investigation and Experimentation
4—6e interpret graphs
5—6a, 6g classify objects, using charts

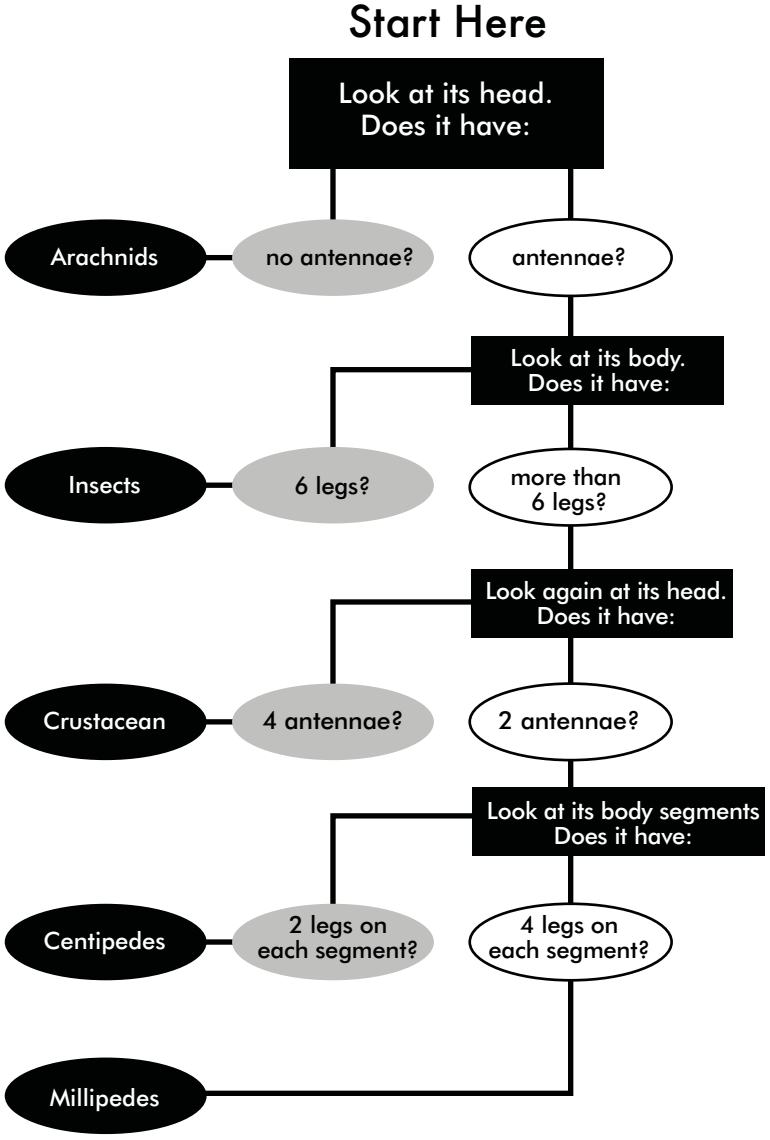
Materials: pictures of arthropods or actual specimens, copies of flow chart (next page)

Directions
If you have access to a collection, use actual specimens. The Museum's *Nature to You* Loan Program is an excellent way to access a collection. Contact *Nature to You* at loanprogram@sdnhm.org. Or collect pictures of arthropods from magazines, newspaper, or other sources. Photocopy pictures of arthropods from books. Try to find examples of all the major kinds of arthropods:

- *insects*—beetles, butterflies, ants, bees, flies, grasshoppers, termites, fleas.
- *arachnids*—spiders, ticks, mites, scorpions
- *crustaceans*—crabs, shrimp, crayfish, sow bugs.
- *millipedes*
- *centipedes*

Classify the arthropods you find. Have students make their own system of classification or use the Arthropod Flow Chart on the next page. The flow chart is a key to the major groups of arthropods. Each step in the chart presents "either/or" choices for classification. Follow the pathways through the chart to classify your specimens.

Arthropod Classification Chart



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Newsworthy Arthropods

Suggested Grade Level: 6–8

Objectives: to collect information regarding the impact of insects on human life; to debate insect-related issues.

California Science Content Standards
Investigation and Experimentation
6—7d, e communicating data
7—7b, c collecting and communicating data
8—9b evaluating data

Materials: magazine and/or newspaper articles about insects

Introduction
Arthropods are often in the news. Recent stories have featured West Nile virus, ticks that transmit Lyme disease, and white flies that ruin crops. Keep in mind that insect news—like insect activity—is seasonal; news of North American insects is less likely in the winter.

Most of the news you hear about insects in news publications and broadcasts is negative. Discuss this trend with your students. Why is this so? Are insects nothing but trouble? Point out that bad news is often more dramatic than good news; also that insects are generally viewed as pests. Look in nature and science publications (*National Geographic*, *National Wildlife*, *Science News*, *Natural History*) for good news about insects.

Directions
Direct students to watch the news and scan newspapers and magazines for articles that provide information about the impact of insects. Collect articles for display in your classroom. Post articles under Good News or Bad News headings.

Compile questions concerning insects. As a writing activity, the questions (or dilemmas) can be a starting point for persuading, convincing, editorializing, or presenting a point of view. Questions may be answered orally as part of a debate or discussion. Questions may be addressed by the whole class, cooperative groups, or individuals.

Some examples of insect dilemmas:

- It is estimated that one third of the world's human food supply is lost to insects. Should chemical pesticides be used more widely to reduce this loss?
- Insects are a widespread and nutritious food source for many animals and some human cultures. Do you think insects are an acceptable food source for humans?
- Scientists believe that millions of undiscovered insect species exist worldwide, especially in tropical rain forests. How important is it to identify all of the Earth's species? What kinds of research do you think are more important? Is space exploration more important? Is mapping the human genetic code more important?
- Some insects are currently endangered species. Is saving an endangered insect as important as saving an endangered mammal?
- Years of human effort have not eliminated one single insect pest. If we had the power, should we destroy pest species? Is it right to cause the extinction of a species?
- The majority of our most serious insect pest problems were spread from continent to continent by human travel. Should travel be restricted between continents to prevent this problem? How would you suggest this problem be addressed?

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Exhibition Overview

Backyard Monsters invites visitors to step into a world where insects tower over humans and blades of grass are the size of trees. Giant robotic insects up to 96 times their normal size, all with lifelike colors and movements, dominate the exhibition. Your student will come face to face with an animated 11-foot-tall, 22-foot-long tarantula, a 19-foot-wide monarch butterfly, a pair of giant fighting beetles and more (For biological information on the robotic insects see addendum on page 16).

Visitors will also discover hundreds of exotic and fascinating insects and arachnids from around the world. There are also live insect displays that feature some of San Diego's native insects.

Backyard Monsters also features interactives that will give visitors the chance to take a mechanical insect for a walk, build a bug, make a bug rubbing and more! The exhibition is designed to be educational while capturing the attention and imagination of both children and adults.

A Crash Course in Entomology

Why study insects?
Entomology is the study of insects. Insects may be small, but they are very significant. At any given time it is estimated that a billion billion (1,000,000,000,000,000,000) insects populate the planet. Over one million different species of insects have been discovered, and there is evidence that as many as 30 million more remain unidentified.

Insects have an ancient and critical role in the Earth's environment. Throughout history and across cultures, insects continue to have a powerful impact on human activity.

What is an insect?
An insect is an animal that has:

- An **exoskeleton** (external skeleton)
- A segmented body divided into three distinct body regions: **head, thorax,** and **abdomen**
- Six jointed legs
- Usually two **antennae** and two **compound eyes**
- Two pairs of wings (in adult stage), although there are exceptions with no wings or only one pair

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Museum Visit

Backyard Monsters Insect Discovery

1. I am nocturnal. I have four pairs of legs and no bones. I also have a pair of leg-like appendages called _____. I have _____ main body parts.

Who am I? _____

2. I am a predator. I may look like I'm praying, but I am probably looking for prey. I have very large _____ _____ on a head that can turn.

Who am I? _____

3. I am an arachnid, but not a spider. I have _____ legs. The tip of my abdomen has a _____.

Who am I? _____

4. I live in the Philippines. My curved horns look impressive, but are not dangerous. I have _____ pairs of wings. I am the _____ beetle known to exist.

Who am I? _____

5. I am one of the most beautiful insects. I eat milkweed. I am known for my long winter _____ to _____.

Who am I? _____

6. I live by ponds and slow streams. My long wings allow me to fly very fast forward and backward. I have _____ mouth parts. I prey on _____.

Who am I? _____

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Answers to Museum Visit
1. pedipalpi, two, Mexican Red-knee Tarantula
2. compound eyes, Praying Mantis
3. eight, stinger, scorpion
4. two, largest/heaviest, Atlas Beetle
5. migration, Mexico, Monarch Butterfly
6. chewing, mosquitoes/gnats, Dragonfly

Resources
Sources for Other Activities
Braus, Judy, editor. *Ranger Rick's NatureScope: Incredible Insects*. National Wildlife Federation, Washington, D.C. 1989. Grades K–5.

Braus, Judy, editor. *NatureScope Incredible Insects Discovery Pac*. National Wildlife Federation, Washington, D.C. 1988.

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Imes, Rick. T*he Practical Entomologist*. Fireside, 1992. Grades 7 and up.

Kramer, David. *Animals in the Classroom*. Addison-Wesley, Menlo Park, CA. 1989. Grades K–7.

Mound, Lawrence. *Eyewitness Books: Insect*. Alfred A. Knopf, New York. 1990.

Whalley, Paul. *Eyewitness Books: Butterfly & Moth*. Alfred A. Knopf, New York. 1988.

Books and Stories for Children

Aardema, Verna. *Why Mosquitoes Buzz in People's Ears*. Dial Press, New York. 1975.

Coville, Bruce. *The Prince of Butterflies*. Harcourt Children's Books. 2002.

Fleishman, Paul. *Joyful Noise: Poems for Two Voices*. The Trumpet Club, New York. 1988.

Howe, James. *I Wish I Were a Butterfly*. Gulliver Books. 1987. Grades Pre-K–2.

London, Jonathan. *Dream Weaver*. Silver Whistle Books. 1998. Grades Pre-K–3.

Videos

Eyewitness Insect Video. All ages.

Organizations

Entomological Society of America: www.entsoc.org.

National Wildlife Federation: www.nwf.org

World Wildlife Fund: www.worldwildlife.org.

Credits

This teachers' guide was edited by Carol Radford for the San Diego Natural History Museum with support from Adventure Edutainment, LLC.

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Addendum
Descriptions of Insects Featured in Backyard Monsters

Mexican Red-knee Tarantula
Species: *Brachypelma smithi*
Description
Tarantulas range in size from a body length of one to three inches and a leg span of five to 10 inches. The overall body coloration of the Mexican Red-knee Tarantula ranges from earth-brown to black.

Anatomy
Tarantulas, including the Mexican Red-knee Tarantula, have two main body regions: the cephalothorax and the abdomen. The cephalothorax contains the spider's brain, central nervous system, and parts of the circulatory and digestive systems. Their mouth is located on the underside of the cephalothorax.The abdomen houses most of the spider's internal organs, such as silk glands, reproductive, excretory, and respiratory systems.

The hairs on tarantulas are highly sensitive. Each contains a nerve which transmits signals to the spider's brain. They have eight tiny clustered eyes and can see only a few inches.

Two appendages called chelicerae are used for burrowing. They also house the spider's poison glands. The pedipalpi are the auxiliary legs of the spider which serve as "feelers"—detecting touch and chemical perception. In males, the last segment of the pedipalpi is used in reproduction. Four pairs of legs are attached to the cephalothorax. The spinnerets, two organs at the rear of the spider, are used in silk manipulation.

Range and Habitat
Tarantulas are found in most tropical and subtropical regions of the world. In the western hemisphere, they live mostly in tropical America, Mexico, and the southwestern United States. Tarantulas can be spotted on the open areas of hillsides, along the edges of cultivated land, and in the sparse expanses of deserts. They are nocturnal—active at night and sluggish in the day. Tarantulas hibernate through the winter in regions that have cold seasons.

Food
Tarantulas catch their prey with their jaws and inject them with venom. Tarantulas eat other spiders and large insects like grasshoppers, along with small snakes, lizards, toads, and baby mice.

Life Cycle
Mature male tarantulas live no more than one year; whereas, the female lives as many as 10 to 15 years after reaching maturity.

Females lay from 500–600 tiny yellowish-green eggs on a bed of silk carpet. The silk is gathered up into a loose egg sac, which females guard for six or seven weeks until the tiny, white tarantula babies hatch.

Praying Mantis
Species: *Tenodera aridifolia sinensis*
Description
The praying mantis is 65 to 85 mm (2 1⁄2 to 3 1⁄2 inches) in length, including its wings. It is tan to pale green in color. Mantids are camouflaged—probably more to deceive prey than to protect themselves. The mouth parts are comprised of strong, toothed mandibles which are adapted for biting. Mantids may fly or jump when disturbed but mostly walk with gentle swaying movements.

Habitat and Range
They are found in meadows and gardens on tall herbs, flower clusters, and shrubs. Mantids, in general, are found in warmer parts of the world in temperate to tropical climates. This insect was introduced from China around 1896 as a beneficial insect. Mantids are sold commonly in nurseries for garden pest control, and now occur in California and other western states.

Food
Mantids eat large caterpillars, butterflies, flies, bees, wasps, and day-flying moths: they are exclusively carnivorous.

Life Cycle
This species spends the winter in egg masses along stems exposed above the snow. Nymphs hatch in late spring, disperse in the wind, and then are solitary. The Greek word mantis means prophet or soothsayer and refers to the insect's behavior of sitting with its front legs folded.

Monarch Butterfly
Species: *Danus plexippus*
Anatomy
Monarch Butterflies have a wingspan range of three to four inches. The upper sides of the Monarchs' wing are bright burnt-orange with black veins and black margins speckled

with white dots. The forewing tips are black interrupted by larger white and orange spots. The undersides of the Monarch Butterflies' wings are paler, duskier orange. One black spot appears between the males' hind wing cell and margin. Females' wings are darker with smudged black veins.

Range and Habitat
Monarch Butterflies are found throughout North America, from southern Canada to Mexico. The brightly colored insects do not exist in Alaska or on the Pacific Northwest Coast. However, the butterflies have established themselves in Hawaii and Australia. The Monarch is one of the few butterflies in the United States that migrate both north and south on a regular basis. In the fall, Monarchs in great numbers in the North begin to congregate and move southward. Mid-western and eastern Monarchs continue south all the way to central Mexico, where they spend the winter. Western Monarchs fly to the central and southern coast of California. They return to the north in the following spring.

The Monarchs that reappear in the spring, however, are the offspring of those that departed in the fall. The insect reproduces on its wintering ground or after a short northward flight in spring.

Food
The Monarch Butterfly is part of the family of Milkweed Butterflies. They feed on milkweed.

Life Cycle
The life cycle of the Monarch progresses from an egg, to a caterpillar, to a chrysalis, to a butterfly—complete metamorphosis. The Monarchs' eggs are pale green. The caterpillar is off-white with black and yellow stripes and is about two inches (5cm.) in length. The chrysalis is pale green accented with glistening gold.

Scorpion
Order: *Scorpionida*
Description
Scorpions are members of the Arachnid family. North American scorpions vary in length from 1.5–5 inches (4 to 13 cm). There are two eyes in the center of the cephalothorax and between two and five eyes on each side. The pedipalps look like pincers or claws. The cephalothorax is broadly joined to the abdomen. The last five segments of the abdomen are narrow like a tail with a stinger at the end. This "tail" is usually held curved upward.

Habitat/Range
Occurring worldwide, scorpions in the United States are found mostly in the South and West. They are usually found in desert areas and are nocturnal—they spend the day under rocks, logs, old boards, or underground burrows.

Food
Scorpions feed on spiders and insects using their pincers to capture the prey. The stinger may be used to inject venom to subdue victims.

Life Cycle
Females give birth to live young which they carry on their back for about two weeks.

Most North American scorpions are not dangerous to humans. The sting causes swelling and irritation somewhat like a bee sting. However, the species Centruroides sculpturatus, found in Arizona can be fatal.

Atlas Beetles
Species: *Chalosoma atlas*
Description
The Atlas Beetle is one of the largest and heaviest beetles known to exist. Its body is black with the upper part of the beetle's head featuring two long outer horns and one smaller center horn.

The body of a beetle, along with other insects, is formed of three distinct regions: the head, the thorax, and the abdomen. The head bears the eyes, the mouth parts, and a pair of antennae; the thorax bears three pairs of legs, and usually two pairs of wings. The reproductive organs are usually concealed within the tip of the abdomen.

The antennae function primarily as organs of smell or taste, and also serve as organs of touch. In some groups they may serve other functions. For example, in certain aquatic beetles they help circulate air under the body for use in breathing. The large antennae of some long-horned beetles apparently help them maintain their balance.

Habitat
The Atlas Beetle is mainly found in Malaysia. Beetles live in a great variety of habitats on land and feed on many different plant and animal materials. Beetles often occur under bark or in rotting wood or plant materials; some are common on the ground or beneath objects on the ground. Some occur in fungi, dung, or carrion; some are aquatic; and a few are parasitic on various animals. Many beetles fly at night and are attracted to lights.

Beetles are the largest order of living things—about 290,000 species.

Dragonfly/Common Green Darner
Species: *Anax junius*
Description
This species is about three inches long and has a four and a quarter inch wingspan. It is characterized by two sub-equal pairs of net-veined wings, strong chewing mouth parts, large compound eyes and a plain green thorax. The wings spread horizontally when at rest. They do not walk: they use their legs for perching and for catching and handling prey.

Habitat
Dragonflies are found by semi-permanent ponds, lakes, sheltered bays, slow streams, and still water with emergent vegetation.

Range
Dragonflies, including the Common Green Darner, are widely distributed in temperate and tropical zones in North America, Mexico, Costa Rica to Panama, West Indies, Bermudas, Hawaiian Islands, Tahiti, and China.

Food
Dragonflies are commonly called "mosquito hawks" because they destroy mosquitoes, gnats, and other pests.

Life Cycle
Eggs are inserted beneath the water on soaked stems of reeds or other floating sticks. Slender green and brown nymphs are active climbers on submerged pond vegetation and move by ejecting water from the respiratory chamber. The nymphs are notoriously cannibalistic, but mostly feed on other small animals.

The large size of these dragonflies and their activities has given rise to superstitions about them. They have been called: devil's darning needles, snake feeders, snake doctors, and green darners. They do not sting: the larger forms give small harmless bites.

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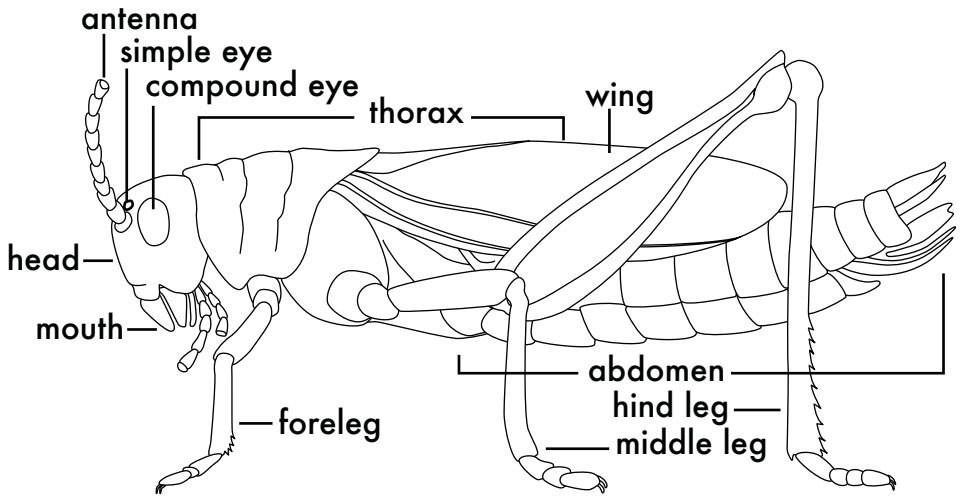
Grasshopper

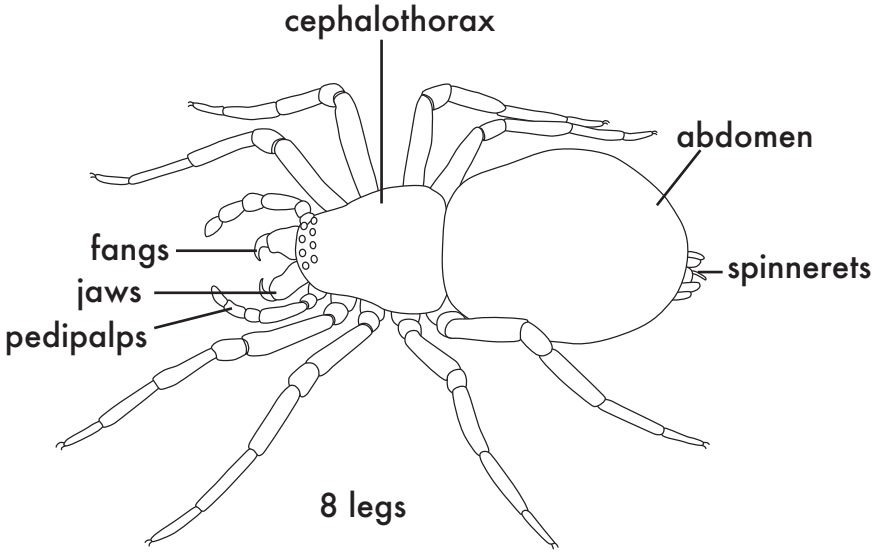


What types of animals are related to insects?

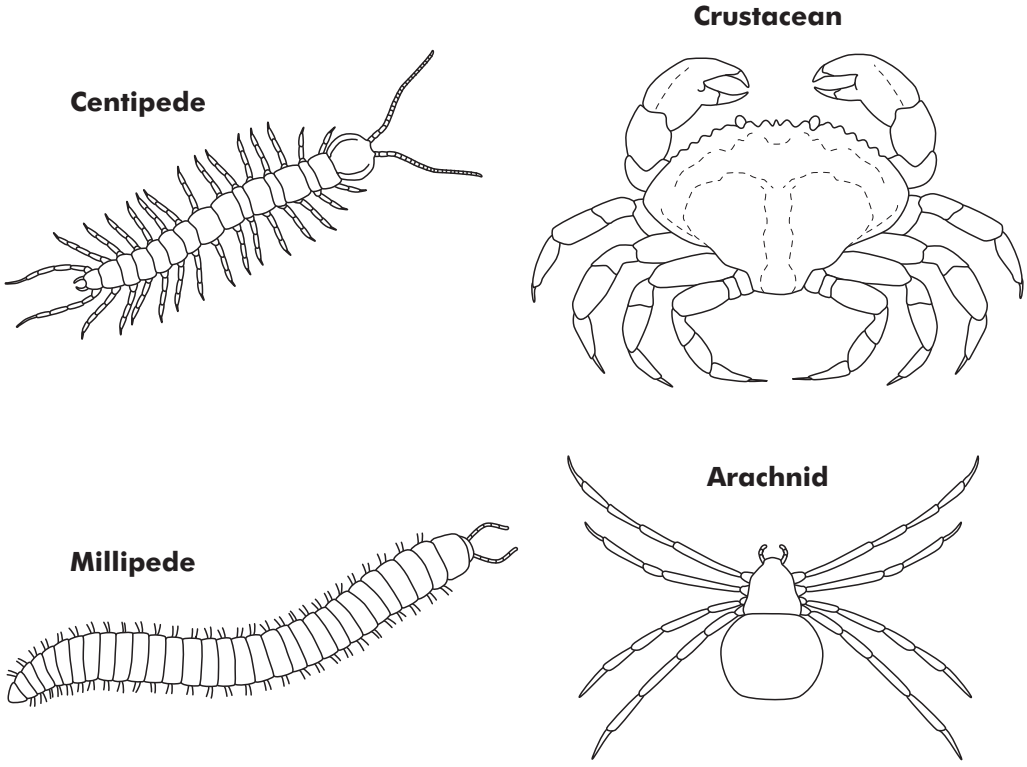
Insects are **arthropods**, animals with exoskeletons and jointed appendages. In addition to insects, the most familiar arthropod groups are:

- **Arachnids**: spiders, ticks, mites, scorpions
  - Arachnids have eight walking legs, no antennae, and two body regions

Spider



- **Millipedes**
  - Millipedes have two pairs of legs on each region, 25 to 100 regions, and two antennae
- **Centipedes**
  - Centipedes have one pair of legs on each region, a few to 177 regions, and two long antennae
- **Crustaceans**: crabs, shrimp, crayfish, sow bugs.
  - Crustaceans have many legs (number varies), two pairs of antennae which may or may not be visible, and are mostly aquatic



How are insects classified?
Insects are classified by their body structures, development patterns, chemistry, and other characteristics.

How do insects develop?
Insects undergo metamorphosis to change from egg to adult. Metamorphosis simply means "change in form" and there are three types of insect metamorphosis.

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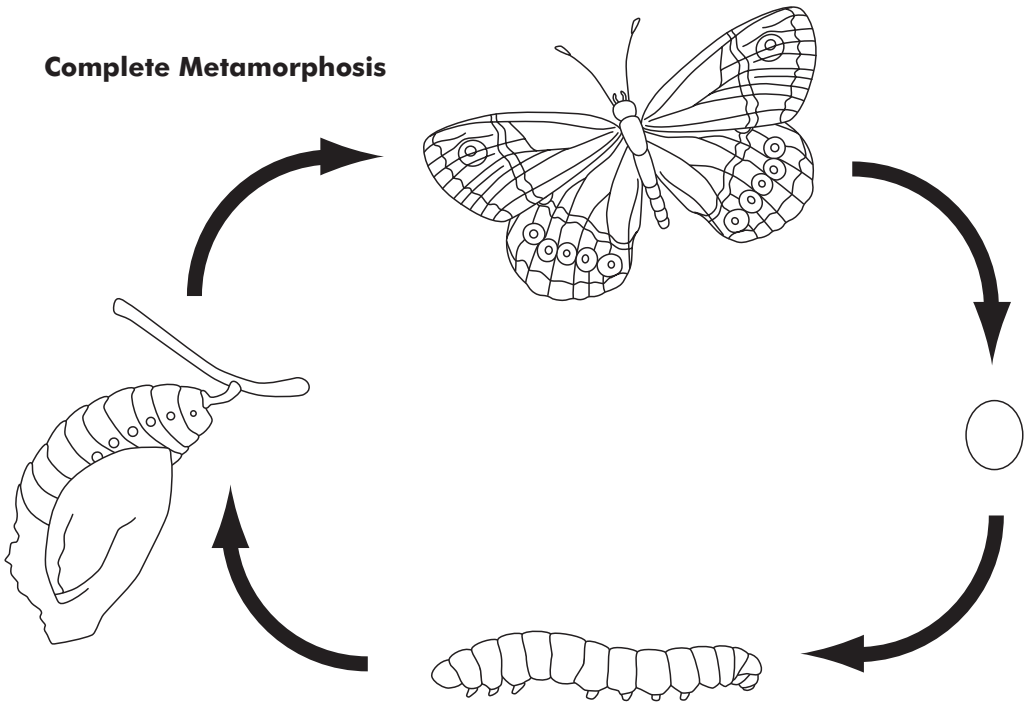
In gradual metamorphosis, insects grow from an egg to a nymph to an adult. The change from nymph to adult is very slight—the major difference is size. Example: Silverfish.

Incomplete metamorphosis also entails three stages: egg, nymph, and adult. In this type of metamorphosis, the nymphs are often wingless. Example: Harlequin bug.

With complete metamorphosis, insects pass through four stages: egg, larvae, pupa, and adult. The most familiar example of complete metamorphosis is the monarch: egg, larva (caterpillar), pupa, butterfly.

Complete Metamorphosis



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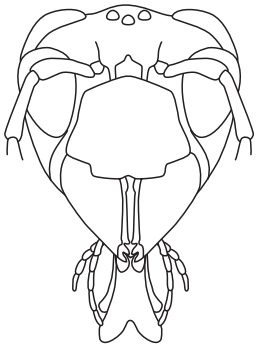
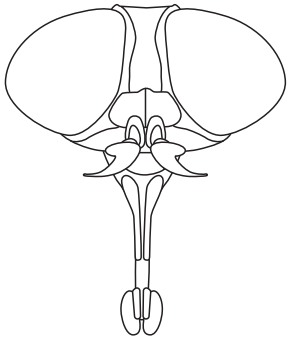
How do insects eat?
The diversity of insect mouth parts enables them, as a group, to exploit many food sources. Many insects use **mandibles** for chewing, while others have specialized mouthparts for piercing or sucking. For example:

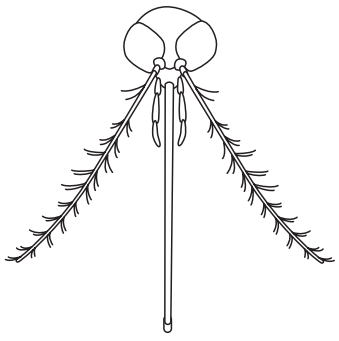
- Grasshoppers have jaws that work like clippers to snip up leaves.
- Butterflies and moths form a long tube with their mouthparts to draw up nectar from flowers like a drinking straw. It coils up when not in use.
- A house fly's mouth parts work like a sponge to mop up liquids.
- Mosquitoes draw out blood with mouth parts that pierce the host's skin.



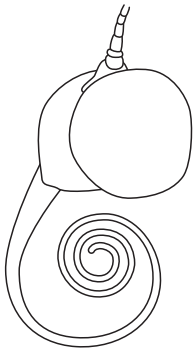
biting



lapping/sponging



piercing/sucking



sucking

How do insects defend themselves?
Insects protect themselves by physical, chemical, or behavioral means. They may fly, run, jump, give off foul odors, taste bad, bite, pinch, sting, armor themselves with hard or spiny exoskeletons, **camouflage** themselves, or feign death.

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Where do insects live?
Insects live everywhere except in oceans. The best places to look for insects are places where there is some moisture—ponds, streams, parks, gardens, vacant lots.

What's the good news about insects?
- Insects are a major source of food for birds, reptiles, fresh-water fish, amphibians, and some mammals.
- Insects pollinate flowering plants including crops. Honeybees alone are responsible for pollinating fruits, vegetables, and other crops that make up a third of our diet.
- Insects recycle nutrients and act as "garbage disposals" in the environment.
- Insects produce an incredible diversity of biological chemicals, most of which have barely begun to be studied. These chemicals may provide cures for diseases and solutions for other serious problems.
- Insects offer a means of controlling other pests without the use of insecticides and other chemicals.
- Insects provide us with important products such as honey, wax, shellac, dyes, and silk.

What's the bad news about insects?
- More people have died from mosquito-borne diseases than in all the wars of history combined. It is estimated that half of all human deaths since the Stone Age have been caused by insect-borne diseases.
- Insects cause billions of dollars of damage to crops and homes annually.
- Insects are our greatest competitors for food, annually devouring as much as a third of all food grown for human consumption. Despite the increased use of insecticides, annual U.S. crop losses to insects have risen from 7% in the 1940s to 13% in the 1980s.

How many insects are there?
Insects account for 73% of all known species of animals! Insects make up an amazing amount of the Earth's animal biomass or total dry weight of animal life. In the Amazon basin, ants and termites alone make up a third of the animal biomass. Over 1.5 million species of insects have been described. Only 1% of all insects are considered to be pests by humans.

More than half of all known species of insects live in tropical forests. Tropical forests are disappearing at a rate of 40 to 50 million acres each year, an area the size of Washington State. There is no precise method of measurement, but it is estimated that as many as 100,000 species of insects are disappearing each year along with the rainforest.

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Glossary

Abdomen—the last part of an insect's or spider's body. The abdomen contains the stomach, heart, and part of the breathing system.

Antenna—sensory organ located on an insect's head. Insects use their antennae to smell, taste, feel, and sometimes to hear.

Arachnid—a group of arthropods which have no antennae, two main body parts, and four pairs of walking legs (spiders, scorpions, mites, and ticks).

Arthropod—a major group of animals characterized by their external skeletons, segmented bodies, and jointed legs. Insects, arachnids, crustaceans, millipedes, and centipedes are all arthropods.

Camouflage—an adaptation that conceals an animal in its environment. The shape, color, markings, or behavior of an insect may camouflage it.

Centipede—centipedes have one pair of legs on each body segment, except for the first one and last two. The head has a pair of long antennae, and the segment next to the head has a pair of poison claws.

Compound Eye—eye made up of individual facets. Each hexagonal facet has its own lens. Dragonflies may have over 25,000 facets in each eye.

Crustacean—the most aquatic group of arthropods (lobsters, shrimp, crabs, sow bugs, and barnacles) are familiar members of this group; many microscopic crustaceans also inhabit fresh and salt water.

Entomology—the scientific study of insects.

Exoskeleton—the hardened outer cuticle or "shell" of an insect.

Insect—arthropods that have three body parts: head, thorax, and abdomen. Insects are the most diverse group of living things.

Invertebrate—a term used to describe any animal lacking a backbone, for example an insect, spider, slug, worm, sea star, etc.

Larva—an active juvenile form of an insect. Examples: caterpillar, maggot, grub.

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Mandibles—the outer mouth parts or jaws of an insect. Insect mandibles move sideways to cut, grind, and grab.

Metamorphosis—the life cycle or development of an insect from egg to adult, involving radical structural changes from one stage to the next. For insects undergoing complete metamorphosis, the sequence is egg/larva/pupa/adult. In incomplete metamorphosis there is no pupal stage; adults develop from larvae called nymphs.

Millipedes—arthropods with rounded bodies made up of 25 to 100 segments. Each segment has two pairs of legs. Millipedes feed on plant and decaying material.

Nectar guides—markings on flowers which direct insect pollinators to the center of the flower where the nectar is stored. For example, the dots on foxglove.

Nymph—the active, growing, feeding stage of an insect displaying incomplete metamorphosis. Familiar examples of insects which have a nymph stage are grasshoppers and dragonflies.

Pheromone—a powerful chemical message which an animal releases into its environment to communicate with others of its own kind. A single pheromone triggers one specific automatic behavior from an animal.

Pollination—the movement of pollen from the male part of a flower to the female part of another flower, an essential step in seed and fruit production. Insects are very important pollinators.

Proboscis—a tube-shaped piercing and/or sucking mouth part. Examples of insects with this kind of mouth part are butterflies and mosquitoes.

Pupa—the resting or inactive transformation stage of an insect that undergoes complete metamorphosis. This stage is often spent in some type of cocoon.

Spiracles—paired lateral openings that lead into the respiratory system; located on segments of the thorax and abdomen.

Thorax—the part of an insect's body between the head and the abdomen. The legs and wings are attached to the thorax.

Vector—an animal which carries and transmits a disease agent. For example, mosquitoes are vectors of malaria.

Vertebrate—a term used to describe any animal having a backbone. Examples: mammal, fish, bird, reptile.