American Museum of Natural History

Center for Biodiversity and Conservation

# Life in the Leaf Litter

Elizabeth A. Johnson and Kefyn M. Catley
with illustrations by Patricia J. Wynne

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# Life in the Leaf Litter

## Introduction

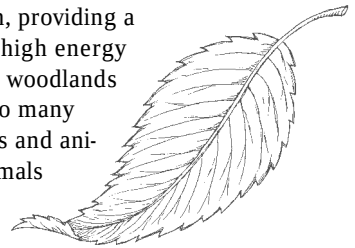
When you think of urban animals, rats, roaches, pigeons, or squirrels might come to mind. But an astonishing variety of animal species live in cities, some native, others introduced from other regions of the world. Many of them live right under our feet.

This booklet will introduce you to some of the tiny animals (all of them *invertebrates* or animals with no backbones) with which we share our city. We will focus on the ones that live in the woods, on the forest floor; the invisible creatures you walk past unknowingly every time you visit one of our city parks.

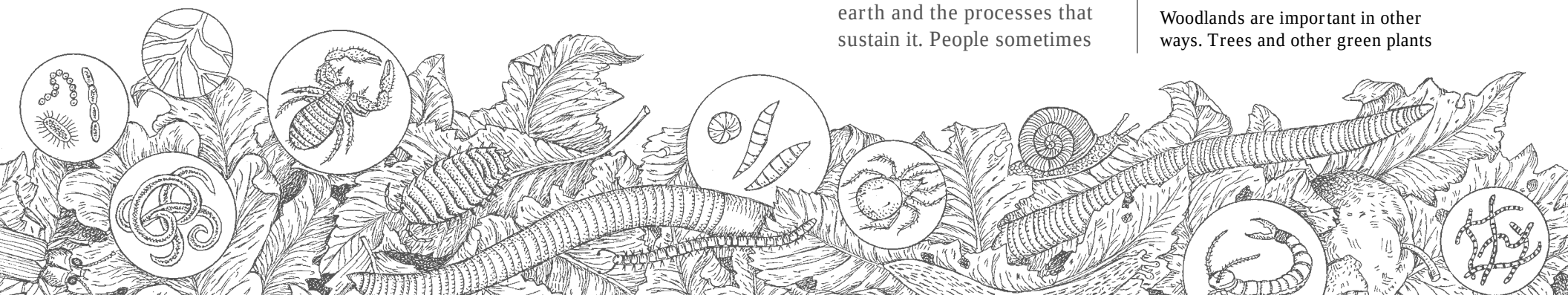
These small animals, along with all the rest of the plants, animals, and habitats in the city, make up the region's *biodiversity*. Biodiversity includes all life on earth and the processes that sustain it. People sometimes think of biodiversity as something remote from their daily lives, but it is just as important to conserve the biodiversity in our city environments as it is to save distant rainforests.

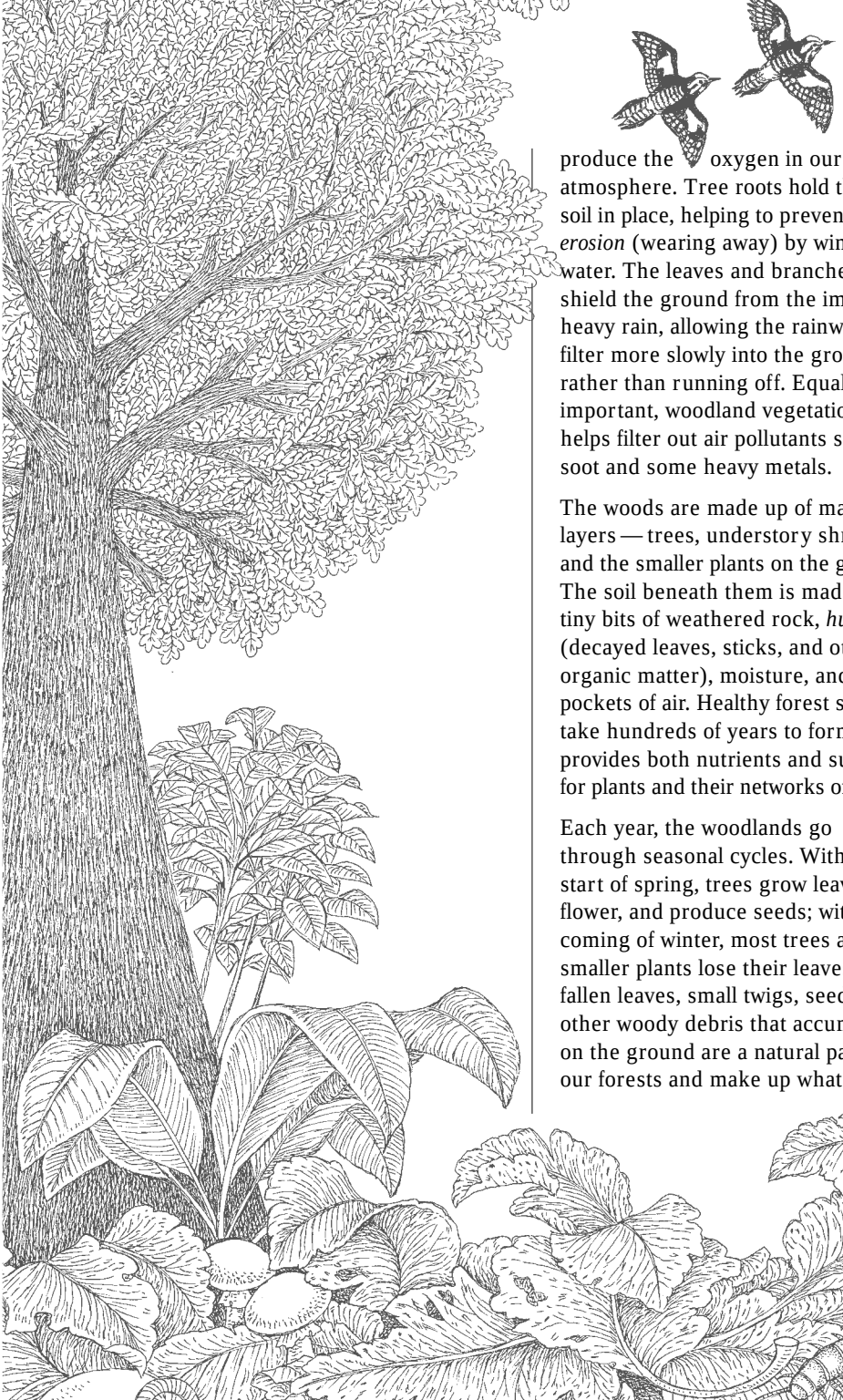
## The City Woodland: Nature Next Door

The woodlands in city parks are important to urban dwellers for many reasons. The trees provide cooling shade in the summer. They are beautiful to look at and restful to wander through, providing a break from the high energy of the city. Park woodlands are also home to many species of plants and animals. Some animals live in the woods all year, while others, such as certain songbirds, stop in the woods to rest and feed during their long spring and fall migrations. For people who live in the city, the woodlands can be a good place to learn about nature.



Woodlands are important in other ways. Trees and other green plants





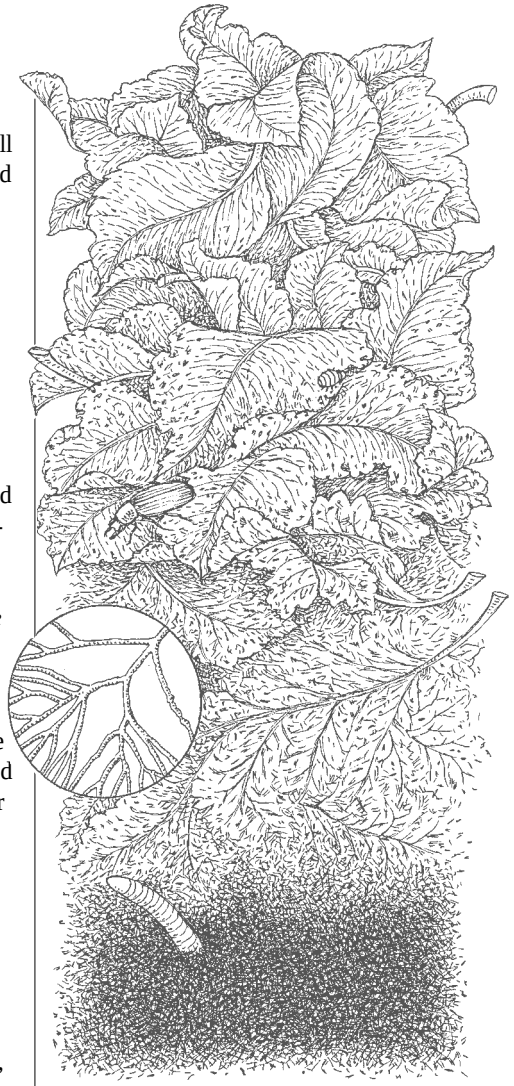
produce the oxygen in our atmosphere. Tree roots hold the soil in place, helping to prevent soil *erosion* (wearing away) by wind and water. The leaves and branches shield the ground from the impact of heavy rain, allowing the rainwater to filter more slowly into the ground, rather than running off. Equally important, woodland vegetation helps filter out air pollutants such as soot and some heavy metals.

The woods are made up of many layers — trees, understory shrubs, and the smaller plants on the ground. The soil beneath them is made up of tiny bits of weathered rock, *humus* (decayed leaves, sticks, and other organic matter), moisture, and small pockets of air. Healthy forest soil can take hundreds of years to form and provides both nutrients and support for plants and their networks of roots.

Each year, the woodlands go through seasonal cycles. With the start of spring, trees grow leaves, flower, and produce seeds; with the coming of winter, most trees and smaller plants lose their leaves. The fallen leaves, small twigs, seeds, and other woody debris that accumulate on the ground are a natural part of our forests and make up what is called *leaf litter*. This layer of litter provides nesting material for birds and squirrels, hiding places for small woodland mice and salamanders, and protected spots for seeds to escape notice by hungry birds. It also enriches the soil and keeps it moist so new plant seedlings can grow.

The leaf litter layer is full of life: it provides both food and shelter to bacteria, fungi, and tiny invertebrates — an amazing community of living creatures. Some of these animals (such as earthworms, snails, and millipedes) feed on the litter, breaking it up into smaller pieces. This makes it easier for other organisms like bacteria and fungi to *decompose* (chemically convert) the tiny litter pieces into soluble chemicals and minerals, such as various forms of nitrogen, calcium, and sulfur. These nutrients are then recycled and used again as food by the trees and other plants growing in the woods.

According to Richard H. Yahner in *Eastern Deciduous Forest: Ecology and Wildlife Conservation*, the trees in a hectare (more than 2 acres) of temperate woodland can produce between 1,500 and 5,000 kilograms (more than 5 tons!) of leaves, twigs, insect *frass* (excrement) and other debris every year. Imagine what woodlands might look like if this were not "taken care of" by these decomposers and allowed to accumulate undisturbed!



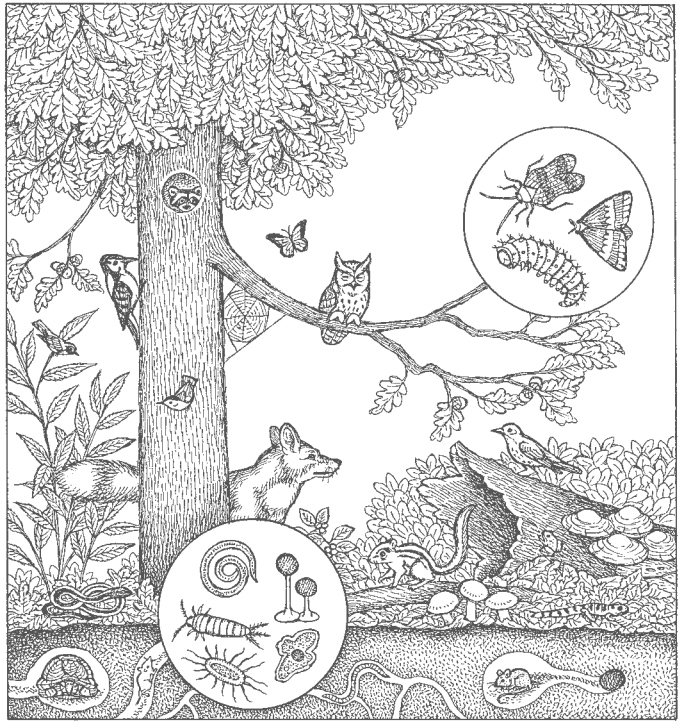
**The process of leaf breakdown, decomposition, and soil formation can take many years.**

Each spring the woodland trees put out leaves. New plants sprout from the nutrient-rich soil. The cycle begins again. Without the richly diverse community of invertebrates

providing ecological services like nutrient cycling, the soil would soon be depleted of nutrients and plants could not grow.

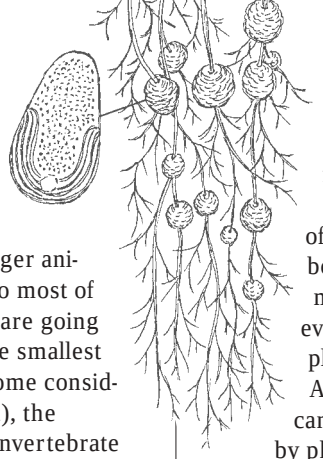
Not only are these tiny leaf litter animals valuable in creating good woodland soil, they themselves become food for other forest animals. In other words, they become part of the forest food web. Salamanders, turtles, and mice feed on earthworms and insects, and they, in turn, are eaten by birds or larger mammals. *Larvae* (the immature forms of some insects) that are eaten by forest birds also live in the leaf litter. Together, these leaf litter microorganisms and invertebrates, the soil and decaying plant matter in which they live, the plants that grow in the soil, and the larger animals living in the forest all make up the woodland *ecosystem*. (An ecosystem is the sum of all the living organisms in a particular environment and their interactions with each other, as well as with the physical environment around them — the rocks, soil, weather, and landscape.)

Each component of the ecosystem has a role to play in the environment. Plants, algae and some bacteria are producers, able to convert the sun's energy into food — a process called *photosynthesis*. Consumers are those animals that feed on producers or other animals to survive. Of consumers, the animals that eat only plants are called herbivores. Predators are those animals that hunt other animals to eat. Scavengers eat dead plants and animals. The decomposers are mainly bacteria and fungi that feed on dead plants and animals and break them down chemically into nutrients.



**The forest ecosystem: Energy from the sun passes from plant to animal, and from animal to animal. As each is eaten in turn and ultimately decomposed, their nutrients are returned to the soil.**





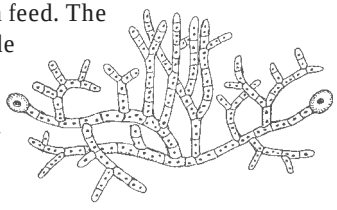
## Life in the Leaf Litter Layer

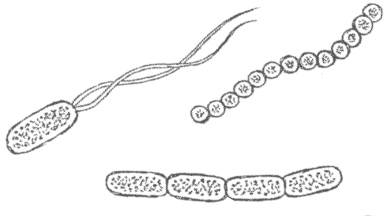
Since plants and larger animals are familiar to most of us, in this booklet we are going to introduce you to the smallest creatures (the ones some consider the most important), the microorganisms and invertebrate animals that live in the leaf litter beneath the forest trees. Scientists throughout the world are making new efforts to study these organisms, and there is still much to be learned about them.

The smallest of these are the bacteria, fungi, protozoans, algae, and viruses. Most are so tiny we need a microscope to see them. Although each is important in the soil ecosystem, bacteria and fungi are the primary organisms capable of *decomposition*, the chemical breakdown and cycling of nutrients. In fact, 80 to 90 percent of the decomposition of dead plant and animal matter is accomplished by bacteria and fungi.

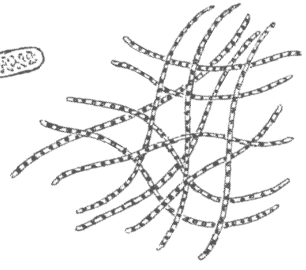
Bacteria are the most numerous living things on the planet. They are found in most environments — from the soils of forests and deserts, to boiling hot springs and in mountain-top ice, and even inside the bodies of plants and animals. Although some bacteria can produce their own food by photosynthesis or other chemical means, most feed on other organisms, including other bacteria. Bacteria secrete enzymes that chemically dissolve their food, making it easier to absorb.

Fungi include mushrooms and yeasts. They get their food by absorbing nutrients from the environment around them, similar to the way bacteria feed. The fungal body is made up of many slender threads (*hyphae*) that grow together in a mycelium. Each of these individual filaments can absorb nutrients. Fungi are one of the most important components in our forest soils, since they are the only organisms capable of decomposing the tough lignin in logs and fallen branches. They also serve as food for creatures that inhabit the soil, such



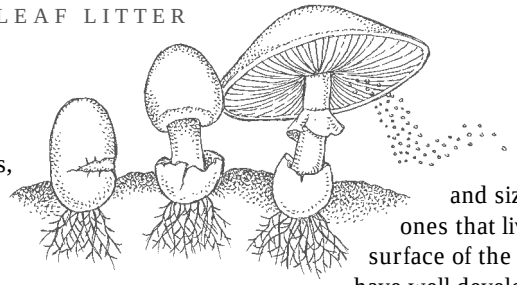


**There are many kinds of bacteria in soil and leaf litter.**



*Top:* **Nitrogen-fixing bacteria live on the root nodules of some plants (legumes such as peas, for instance). These bacteria help convert nitrogen from the air into a chemical form the plants can use.**

*Above:* **Fungal mycelium with reproductive cells.**

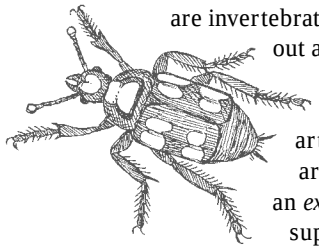


Mushrooms release spores which will soon develop into new mycelia.

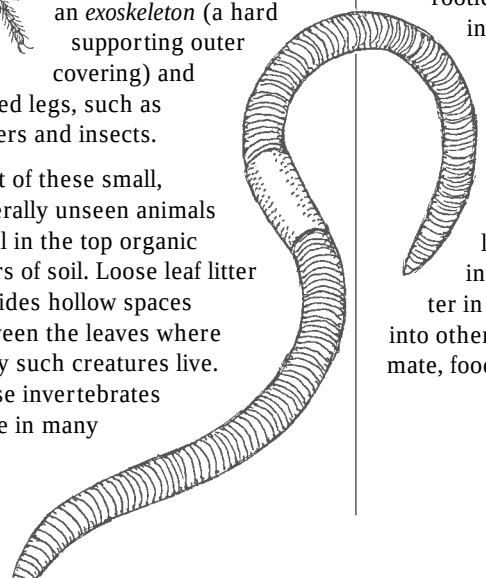
as mites, springtails, many beetles and nematodes.

Mycorrhizal fungi are a special group of fungi that live in close association with plant roots. They are very important to life in the forest, since they help plant roots absorb vital nutrients such as phosphorus and nitrogen from the soil. In fact, many plants could not live without mycorrhizae. In return, the plant gives the fungus the nutrients it makes by photosynthesis in a process called *mutualism*, a "you scratch my back, I'll scratch yours" arrangement.

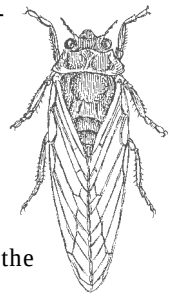
Most of the animals in the woodlands are invertebrates, those animals without a backbone. These include earthworms, slugs and snails, and arthropods. Arthropods are invertebrates with an *exoskeleton* (a hard supporting outer covering) and jointed legs, such as spiders and insects.



Most of these small, generally unseen animals dwell in the top organic layers of soil. Loose leaf litter provides hollow spaces between the leaves where many such creatures live. These invertebrates come in many shapes and sizes. The ones that live on the surface of the ground have well-developed eyes and legs and readily move about among the leaves in search of food and shelter. Often, they will move deeper into the litter during the drier summer months. In contrast, those animals living deeper in the soil tend to be smaller and more worm-like. Since they live in an environment without light, many have no eyes.



Some animals, such as springtails (Collembola), spend their entire lives in soil and litter. However, many groups of arthropods are found in the leaf litter only at certain times in their lives. Some bees use the litter and soil habitat for nesting. Cicadas spend their entire larval stage underground, feeding on plant rootlets. Other insects, such as certain moths and bees, spend the winter hibernating under the protective leaf layer. When the adult insects emerge from the litter in spring, they often move into other nearby habitats to find a mate, food, or new nesting sites.



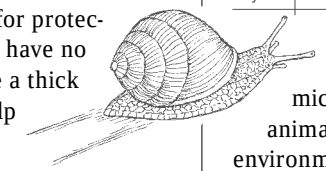


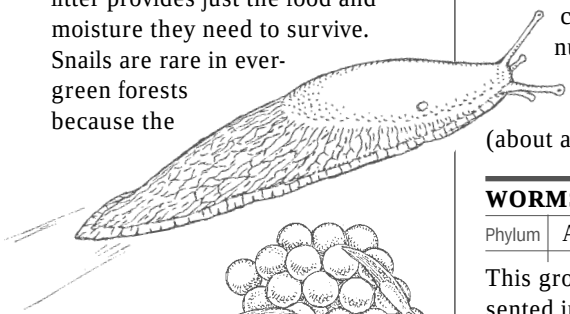
**Here are some of the more common leaf litter animals you might find in your city woodlands.**

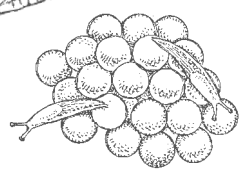
## SLUGS AND SNAILS

| Phylum | Mollusca | Class | Gastropoda |
|---|---|---|---|

There are approximately a thousand snail species within North America alone. Snails have coiled shells into which they retreat for protection, whereas slugs have no shell. Both produce a thick layer of slime to help them travel from leaf to leaf. Most species are found in environments that can provide them with a plentiful food source, moisture, shelter and usually a source of lime, which provides the calcium snails need to develop their shells. For these reasons, many snails and slugs are common in leaf litter, where they hide by day, emerging to feed on leaves and fungi at night. The leaf litter provides just the food and moisture they need to survive. Snails are rare in evergreen forests because the acid soils prevent them from developing shells, whereas slugs can be common there.





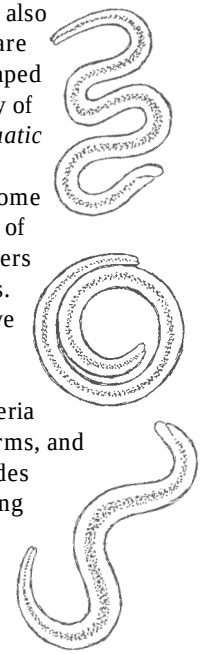


Slug eggs, shown here with newly emerged young, are commonly found in leaf litter.

## ROUNDWORMS

| Phylum | Nematoda |
|---|---|

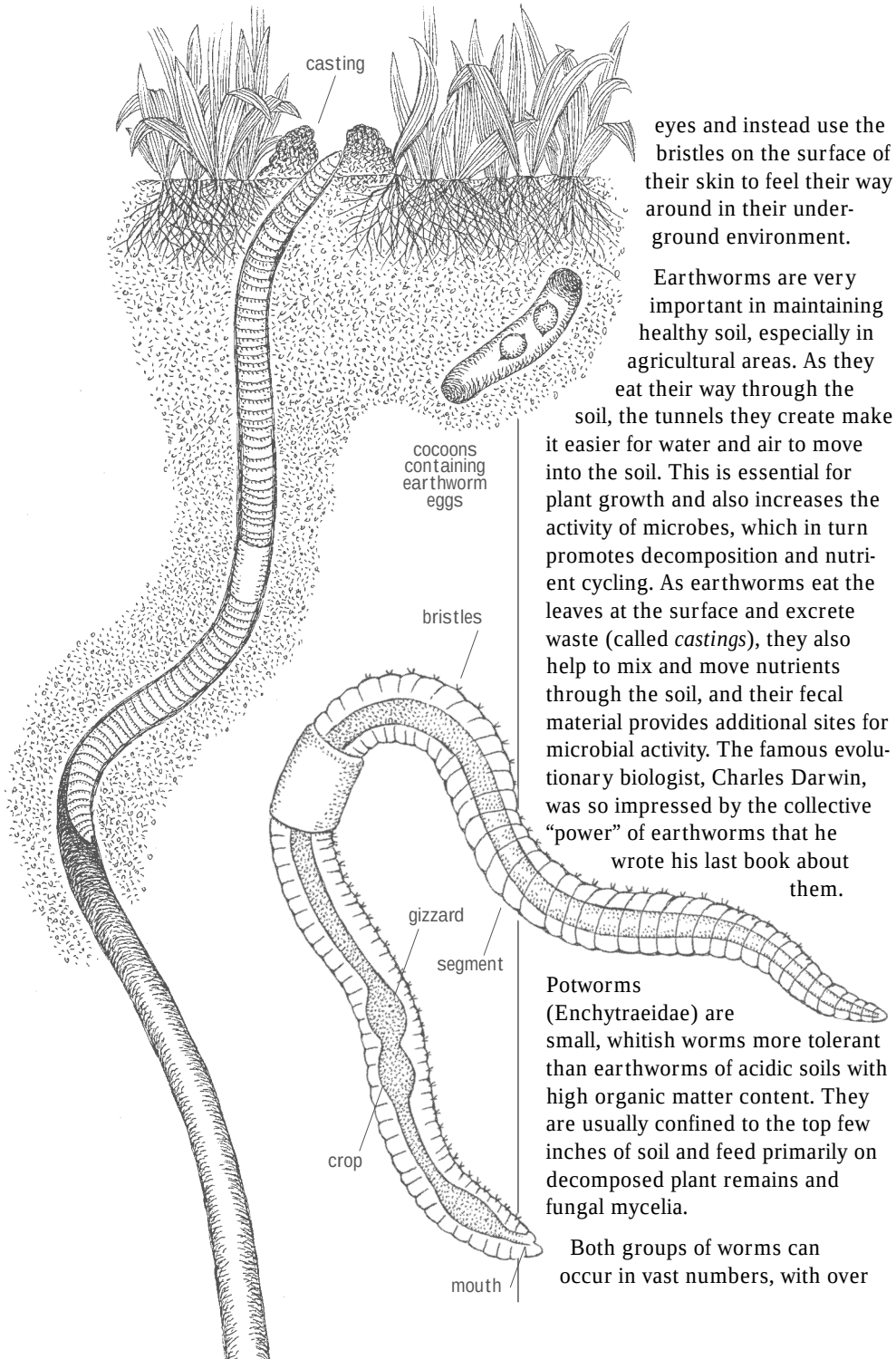
Most roundworms, also called nematodes, are microscopic, worm-shaped animals found in a variety of environments. Many are *aquatic* (living in water) rather than *terrestrial* (living on land). Some roundworms live in the guts of other animals, while still others live inside the roots of plants. The ones that live in soil have a critical role to play in recycling dead organic materials. Generally, they feed on bacteria and fungi, on small earthworms, and other roundworms. Nematodes can occur in staggering numbers, sometimes millions per square meter (about a square yard).



## WORMS

| Phylum | Annelida | Class | Oligochaeta |
|---|---|---|---|

This group of invertebrates is represented in the leaf litter community by earthworms and potworms. Earthworms (Lumbricidae) are long and slender. Some, such as nightcrawlers, can grow to be quite large, and many are capable of burrowing deep into the soil. They have no




eyes and instead use the bristles on the surface of their skin to feel their way around in their underground environment.

Earthworms are very important in maintaining healthy soil, especially in agricultural areas. As they eat their way through the soil, the tunnels they create make it easier for water and air to move into the soil. This is essential for plant growth and also increases the activity of microbes, which in turn promotes decomposition and nutrient cycling. As earthworms eat the leaves at the surface and excrete waste (called *castings*), they also help to mix and move nutrients through the soil, and their fecal material provides additional sites for microbial activity. The famous evolutionary biologist, Charles Darwin, was so impressed by the collective "power" of earthworms that he wrote his last book about them.

Potworms (Enchytraeidae) are small, whitish worms more tolerant than earthworms of acidic soils with high organic matter content. They are usually confined to the top few inches of soil and feed primarily on decomposed plant remains and fungal mycelia.

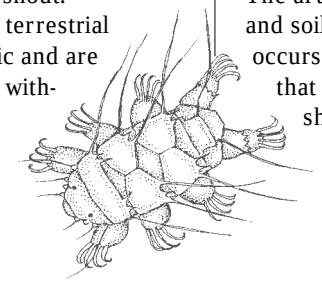
Both groups of worms can occur in vast numbers, with over 8,000 enchytraeids and 700 lumbricids found in a square meter of meadow soil.

The earthworms you might find in an urban park in the Northeast today are all recent immigrants from Europe and Asia. They were brought here accidentally in ship ballast and in the soil of potted plants. Although earthworms were once native to the northeastern United States, the glaciers of the Ice Ages pushed the range of the original worms further south. Our "latest arrivals" thrive in our city park woodlands, feasting on leaf litter. In fact, they are consuming so much that they are removing the leaves before other decomposers, like fungi, can feed on them. This is resulting in a thinner organic layer in some city parks and less food and shelter for other forest floor inhabitants. City park managers are now studying this problem to find a way to balance the earthworm populations.

## WATER BEARS

Phylum | Tardigrada

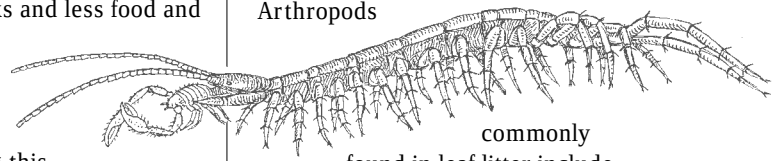
Water bears are microscopic animals with four pairs of clawed, stumpy legs and a conical snout. Tardigrades, even terrestrial species, are aquatic and are unable to function without a film of water surrounding them. Without moisture they dry out completely and shrivel up; they remain in this state, alive but motionless, until they again have access to water. In dry leaf litter they are only found as warty eggs and cysts. Water bears are very sensitive to lack of oxygen, soil compaction, and soil particle size, which restricts the depth to which they are found (5-10 cm). Soil species feed on algae, bacteria, protozoa, rotifers, nematodes, and organic detritus. They in turn serve as food for a variety of predators.



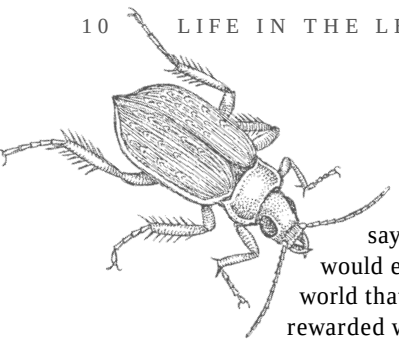
## ANIMALS WITH JOINTED LEGS

Phylum | Arthropoda

Arthropods, the largest and most diverse group of animals on earth, are characterized by a hard exoskeleton and jointed legs. Arthropods commonly found in leaf litter include crustaceans (sowbugs), chelicerates (such as spiders and pseudoscorpions, daddy longlegs, and mites), myriapods (millipedes, centipedes, and symphylans), and hexapods (proturans, double-tails, springtails, and insects).



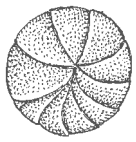
The arthropod fauna of leaf litter and soil is so incredibly diverse, and occurs in such enormous numbers, that it is difficult to describe, and should be experienced first-hand. Howard Ensign Evans, in his book *Life on*



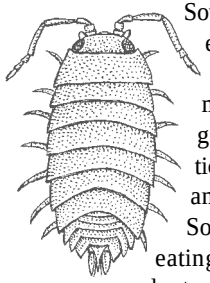
*a Little Known Planet*, says of those who would explore this world that "they will be rewarded with an array of animals a good deal stranger than those to be found in books on prehistoric life." In terms of sheer numbers of individuals, springtails are impressive; 40,000 to 50,000 individuals typically occur in a square meter of leaf litter and soil. Species richness is also impressive, with more than 40 species of Collembola occurring in temperate deciduous woodland or undisturbed grassland. Mites are found in even larger numbers and with similar species richness. If we scale up these numbers, Evans (1993) estimates an acre of English pasture supports 666,300,000 mites, 248,375,000 springtails, 17,825,000 beetles and 135 million other assorted arthropods!

### SOWBUGS

| | |
|---|---|
| Subphylum | Crustacea |
| Order | Isopoda |



This group is composed of what we know as sowbugs.



Sowbugs have hard, flattened exoskeletons, and seven pairs of legs. They are mostly dull brown or slate gray in color. Characteristically, they have two pairs of antennae, one long, one short. Sowbugs are scavengers, eating mostly dead or decaying plant material like rotting wood. A distant relative of crabs and crayfish, they are the only crustaceans adapted for life on land. They use gills (*pleopods*) to breathe; these need to be kept moist, so sowbugs are mostly active at night and in damp environments. One group of isopods, the pill bugs, will curl into a tight ball when disturbed.

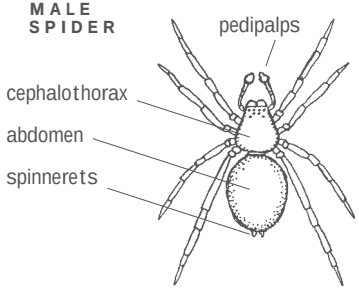
### SPIDERS, HARVESTMEN, PSEUDOSCORPIONS, MITES

| | |
|---|---|
| Subphylum | Chelicerata |
| Class | Arachnida |

#### Spiders

| | |
|---|---|
| Order | Araneae |

Spiders are a dominant predatory group in the leaf litter. They have four pairs of legs and a body divided into two parts, the cephalothorax and abdomen. Although all spiders produce silk, only some use it to build webs to catch their food, which consists mainly of insects. Other spiders sit in hiding and wait for their prey to pass by. Even with eight eyes, most spiders still don't see very well. To help sense their environment for moving prey, they have specialized hairs (*setae*) on their legs. Spiders also possess special appendages called *pedipalps*, used for handling prey,




and, in adult males, doubling as a reproductive organ.

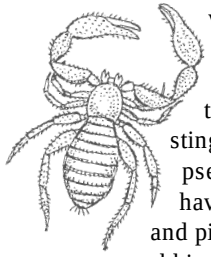
Because their diet consists mostly of insects, spiders are very important in controlling insect populations. Web-spinning spiders that live on the ground use the dried leaves in leaf litter to anchor their webs. Free-hunting spiders also thrive on small invertebrates that live in the leaf litter. Some common spider families which occur in leaf litter include jumping spiders (Salticidae), line weaving spiders (Linyphiinae) dwarf spiders (Erigoninae), Hahniidae, wolf spiders (Lycosidae), sac spiders (Clubionidae), and crab spiders (Thomisidae). Many spiders overwinter in the litter layer, sheltered from cold and wet.

#### Pseudoscorpions

| | |
|---|---|
| Order | Pseudoscorpiones |

Pseudoscorpion, life size

Animals in this order have four pairs of walking legs like spiders, but they superficially resemble scorpions or very small lobsters, hence their name. Unlike scorpions, they do not have a stinging tail. However, pseudoscorpions do have powerful "jaws" and pincer-like claws for grabbing prey, which they subdue with help from the poison glands in their jaws. They feed on springtails, mites and any smaller invertebrate they can catch.



Pseudoscorpions can be found in a variety of habitats: in soil, ground litter, under tree bark, in caves, in host nests of larger organisms, on rock or mud surfaces. From time to time they engage in a unique form of transportation called *phoresy*. In this behavior, the pseudoscorpion attaches itself to a larger animal host and allows itself to be transported around (a great way to save energy!).

#### Harvestmen

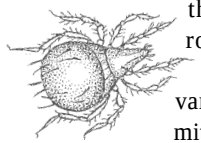
| | |
|---|---|
| Order | Opiliones |

These animals are sometimes called daddy longlegs because most have extremely long, stilt-like legs and a small, rounded, compact body. The kind you are most likely to find on the surface of the ground have long legs that enable them to crawl over and through the thick leaf litter. Harvestmen living deeper in the litter have much shorter legs. These animals are predators, feeding on both live and dead animal matter, unlike spiders that take only live prey. They have stink glands for protection, and can secrete toxic substances to deter predators, but are not known to be poisonous to people. In desperate situations, harvestmen can "release" part of a leg to escape. The wound heals quickly, but the lost leg will never grow back.

## Mites

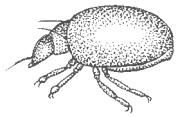
Order | Acari

Common in leaf litter, mites are small (less than 1 millimeter) but very abundant. In fact, there can be several hundred thousand individual mites in a square meter of woodland soil. They have short legs and unsegmented bodies. Slow-moving, they eat decaying plant material, mold, or other smaller soil organisms, thus playing an important role in the leaf litter food web. Mites in turn are fed upon by a variety of predators such as larger mites, spiders, and centipedes.

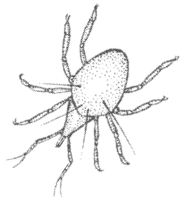


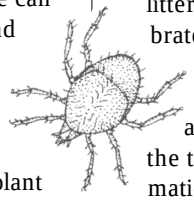
There are three categories of soil and leaf litter mites:

The oribatid mites are best represented by the moss and beetle mites. Oribatids live in soil and are very numerous. They are dark-colored with hard, shiny "shells." They eat a variety of leaf litter material, including bacteria and yeast, algae, fungi and rotting wood.



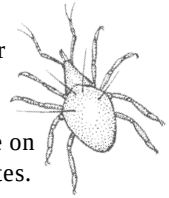
ORIBATID





MESOSTIGMATID MITE

Mesostigmatid mites are free-living predators in the soil and litter, eating other small invertebrates like springtails, other mites, bacteria, and fungi. They are lighter-colored than oribatids and are distinguishable from the third group, the prostigmatids, by having their *stigmata*, or breathing holes, on the sides of their bodies. The prostigmatids have their breathing holes at the base of their mouthparts. They eat nematodes, other smaller arthropods and algae, fungi, and bacteria. Some prostigmatids live on other animals as parasites.



PROSTIGMATID

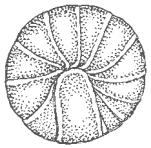
## Millipedes, Centipedes, and Symphylans

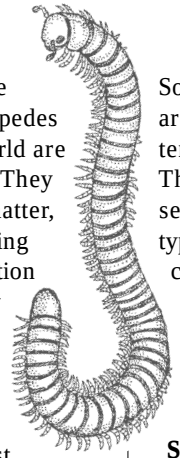
Subphyla | Myriapoda

### Millipedes

Class | Diplopoda

Adult millipedes have long, segmented bodies with two pairs of legs per segment. Most of the more than 10,000 species of millipedes currently known in the world are herbivores or scavengers. They consume decaying plant matter, moss, and fungi, contributing significantly to the production of humus. Long-lived, they have the potential to survive 10 years. Millipedes live in the upper soil layer and in leaf litter, under rocks, logs or bark in moist environments, and are usually active at night. Generally, they are found most abundantly in soils rich in calcium, which they need for building their exoskeletons. As a protective mechanism, many millipedes can exude a smelly, cyanide-based liquid that can burn skin if handled. Their thick exoskeletons also provide protection from predators, and some millipedes can roll themselves into a ball for extra protection.

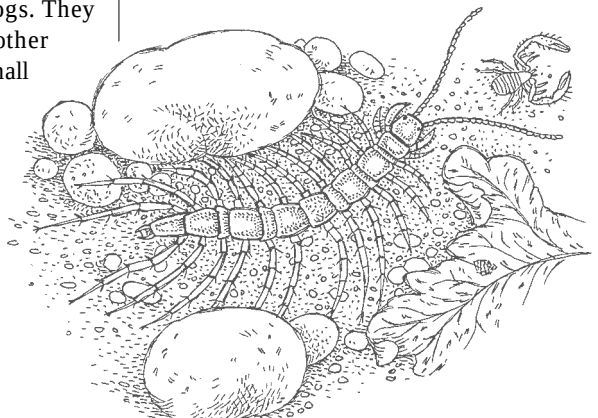




### Centipedes

Class | Chilopoda

Centipedes can be found in leaf litter and soil, under rocks and logs. They are voracious predators of other invertebrates, especially small earthworms. Centipedes have pincers just behind their heads on the first body segment, which they use to pierce their prey and inject their poison.



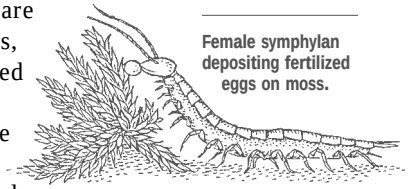
Stone centipede in pursuit of a pseudoscorpion.

Soil centipedes (Geophilomorpha) are slender and worm-shaped, and tend to be found deeper in the soil. They have no eyes but rely on many sensory hairs to help them find prey, typically small earthworms. Stone centipedes (Lithobiomorpha), in contrast, live on the leaf litter surface. Active and efficient hunters, they eat small insects, which they catch with poison pincers.

### Symphylans

Class | Symphyla

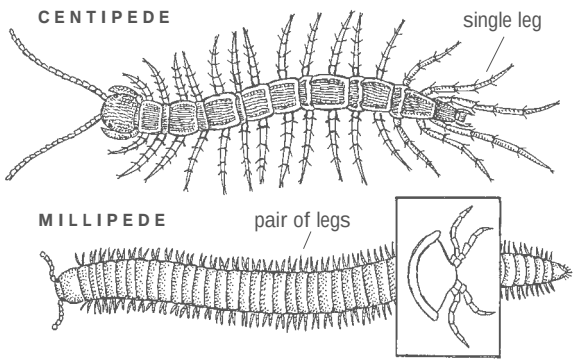
These invertebrates are often mistaken for either centipedes or millipedes. They do look like small centipedes, and in fact are often referred to as "garden centipedes." Symphylans are tiny, colorless, and well-suited to life underground in the soil pore spaces around plant rootlets. They have no eyes, but instead have many sensory cells at the tips of their antennae and at the base of the third to last pair of legs. Unlike centipedes and millipedes,



Female symphylan depositing fertilized eggs on moss.

### How to Tell Millipedes from Centipedes

Look closely! Millipedes usually have two pairs of legs for each body segment; centipedes always have only one pair.



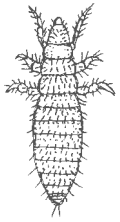
their terminal body segments carry a pair of silk-producing spinnerets, which spin silken threads used to deter predators. Most species are omnivorous and can feed on either plant or animal matter, preferably live organisms and finer plant rootlets, which explains why some species are considered serious crop pests. They are capable of consuming 20 times their own weight of vegetable matter in 24 hours.

### Proturans, Double-tails, and Springtails

Subphylum | Hexapoda

#### Proturans

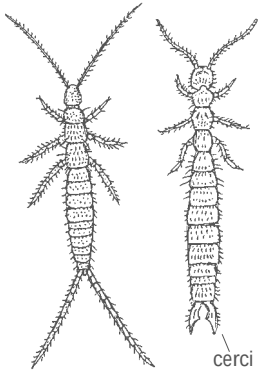
Order | Protura



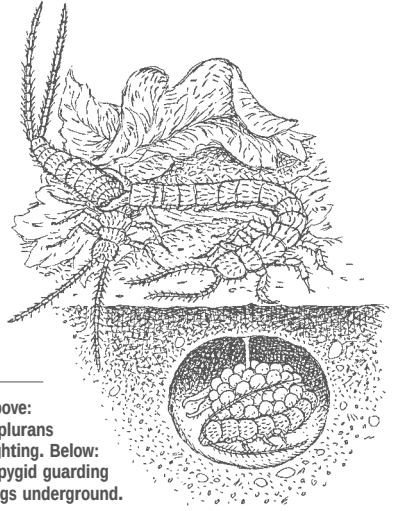
Proturans are very small, delicate animals (0.5-2 mm) lacking eyes and antennae. Instead, their forelegs, which have many sensory structures, function as antennae. They require moist soil and humus, feeding on decaying organic vegetation, fungal mycelia and spores.

#### Double-tails

Order | Diplura




This is a group of wingless *hexapods* (animals with six legs) without eyes or scales. They are whitish or yellowish, with long, slender, beaded antennae and a pair of "tails" often used as feelers; hence they are often called "double-tails." Most Diplura live in moss,

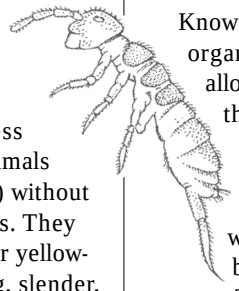


Above: Diplurans fighting. Below: Japygid guarding eggs underground.

under stones, or in deeper litter and moist soil pore spaces. Of the 70 species present in North America, most are herbivorous, eating decaying vegetation. One family, the Japygidae, has pincer-shaped appendages called *cerci*, which make them look like immature earwigs. Despite being blind, japygids are very efficient predators of other small soil animals, using their antennae to locate prey.

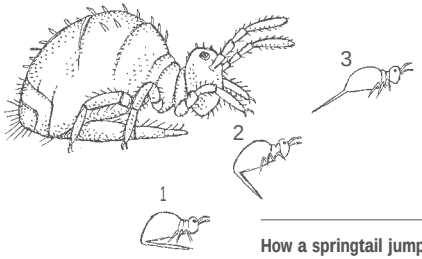
#### Springtails

Order | Collembola



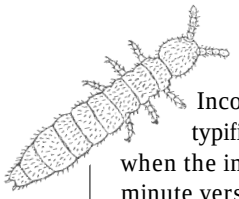
Known for the forked springing organs on their abdomens that allow them to jump away from their enemies, springtails play an important role in the decomposition process. They have six legs, are wingless, and seldom grow bigger than one centimeter. There are several groups of springtails: some live on the surface of the leaf litter, others deeper down in the soil. Springtails found on the surface are larger, richly pigmented, with dense scales or hairs, compound eyes, and long, well-developed springing organs. Those that live deeper in the soil are smaller, colorless, with reduced eyes or no eyes, short antennae, and no springing organ.

Springtails live about a year, feeding on fallen leaves, other detritus, algae, and fungi, converting them into humus. Some eat the fecal pellets of other soil animals, while still others eat small nematodes. Together with mites, springtails make up the most abundant group of leaf litter invertebrates.

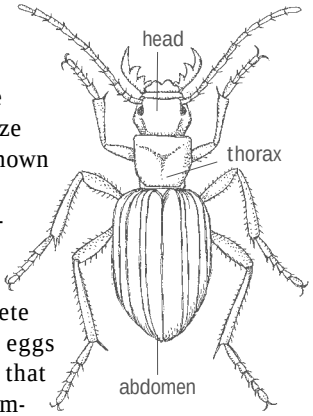



How a springtail jumps.





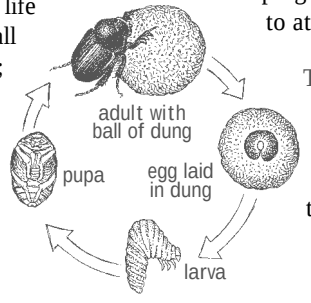
Incomplete life cycles, as typified by crickets, occur when the insect egg develops into a minute version of the adult (called a *nymph*) and grows through successive moults into a full-size adult. Many well-known groups of insects, including flies, beetles, bees, and butterflies and moths, have complete life cycles in which eggs develop into larvae that do not usually resemble the adults. These larvae in turn develop into *pupae* (a growth stage between the larva and the full-grown adult) from which the reproductive adults finally emerge.




### Insects

Class | Insecta

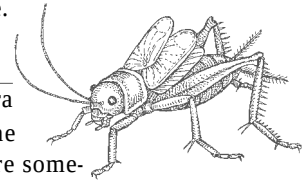
Insects are characterized by having three body parts, the head, thorax and abdomen. The head bears sensory and food-gathering structures. Typically, the thorax has wings and six walking legs; the abdomen holds the reproductive, digestive and excretory systems. The life cycles of most insects fall into two distinct groups; those with incomplete and those with complete metamorphosis.




Life cycle of a dung beetle—complete metamorphosis.

#### Crickets

Order | Orthoptera

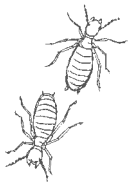


Field crickets of the family Gryllidae are sometimes found hiding in leaf litter. They construct burrows in the soil where they store and later consume green plant material. Occasionally young cave crickets of the family Gryllacrididae can also be found. Crickets are well-known for the chirping sounds made by males to attract a mate.

#### Termites

Order | Isoptera

Termites play a vital role in the decomposition of wood, both on the

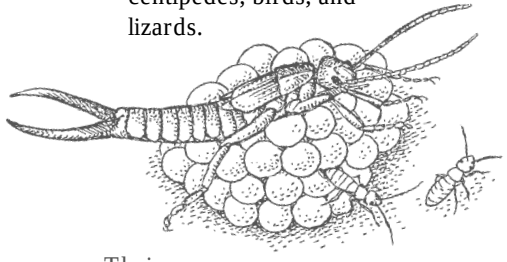


forest floor and in standing but decaying trees. While some termites live above ground in dry locations, many live in moist underground habitats in wood buried or lying on the soil. They are able to convert the cellulose in dead plant material with the help of microorganisms (protists) that live in their gut. These small protists secrete the enzymes that digest the cellulose.

### Earwigs

Order | Dermaptera

Nocturnal creatures, earwigs hide by day, coming out at night to feed. They have shortened, leathery wings, and pincers on their abdomens that they use for defense or predation. Many earwigs eat dead plant matter in the leaf litter. Others eat fresh plant fragments, or fungal spores, algae, lichen, and moss. Some species are even carnivorous, feeding on insects and spiders. Earwigs, in turn, are preyed upon by many other animals, such as beetles, spiders, centipedes, birds, and lizards.



### Thrips

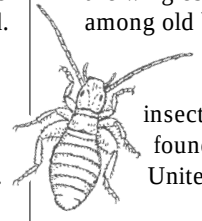
Order | Thysanoptera

Thrips are very small insects with sucking mouthparts. Those found in leaf litter mostly feed on fungal spores and hyphae, or on small arthropods. Some are wingless, but if winged the wings are fringed with long hairs. Many species are pests of plants and are often found in flower blossoms.

### Book Lice

Order | Psocoptera

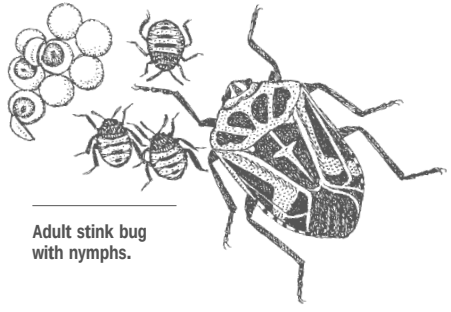
Book lice feed on algae, lichen, organic detritus, fungal spores and mycelia. Most outdoor species are winged, while indoor species are wingless and often found among old books and papers, feeding on molds and fragments of dead insects. Sixty species are found in leaf litter in the United States.



### True Bugs

Order | Heteroptera

Being primarily plant feeders, true bugs are not often found in leaf litter. Of those that are, however, some families, like stink bugs (Pentatomidae), may only be overwintering there, while others are predators, feeding on other arthropods with their stylus-like beaks. A few feed on fungal mycelia. True bugs found in the leaf litter are: jumping ground bugs (Schizopteridae) which are active jumpers when disturbed; lace bugs (Tingidae) which, although plant feeders, are often found in the litter; minute pirate bugs (Anthocoridae), which prey on other small arthropods; seed bugs (Lygaeidae), which feed on seeds, and flat bugs (Aradidae), which feed on the sap of fungi.



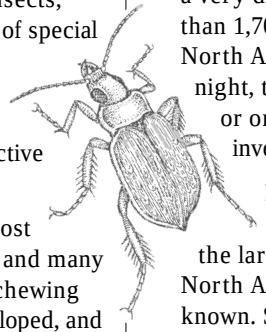
Adult stink bug with nymphs.



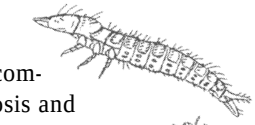
### Beetles

Order | Coleoptera

Beetles are a very diverse group of insects, accounting for more known species than any other living thing on the planet. There are more than 300,000 described species of beetles in the world, with over 30,000 in North America alone. Like other insects, adult beetles have three pairs of jointed legs and one pair of antennae. However, unlike other insects, adult beetles have a pair of special front wings called *elytra*. These wings, along with a hard exoskeleton, form a strong protective armor for this insect.



Beetles are found in almost every terrestrial habitat, and many are even aquatic. Their chewing mouthparts are well developed, and beetles feed in a number of ways. Some feed on a large variety of plant parts, both living and dead. Others are predators, many are scavengers, some are fungal feeders, and some are even parasitic.

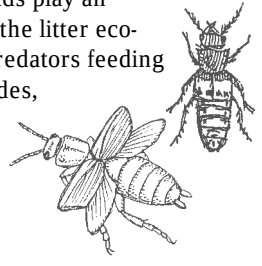


Beetles undergo complete metamorphosis and many of their larvae are encountered in the leaf litter. All beetle larvae have jointed legs on the thorax and they will have some parts which are soft, while other parts are covered by hard plates (or *sclerites*). Larvae of ground beetles (Carabidae) and rove beetles (Staphylinidae) are elongated, white to yellowish with well-developed plates on the back of the head, thorax, and abdomen, with exposed membranous sections in between. Often the abdomen ends in two "tails" (or *urogomphi*). Scarab beetle larvae (Scarabaeidae) are whitish, grub-like and usually comma-shaped, but have jointed legs on the thorax.

The beetle families most common in leaf litter are described below.

**Ground Beetles** (Carabidae) are a very diverse group, with more than 1,700 species known from North America. Most active at night, the adults are predaceous or omnivorous, feeding on any invertebrates they can catch.

**Rove Beetles** (Staphylinidae) make up the largest family of beetles in North America, with 3,100 species known. Staphylinids play an important role in the litter ecosystem as agile predators feeding on mites, nematodes, Collembola, and insect larvae. Some species are

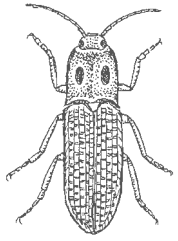


also known to feed on decomposing organic matter and fungi. Rove beetles can be recognized by their very short elytra.

**Featherwing beetles** (Ptiliidae) are the smallest known beetles, being 1 millimeter or less in size. They feed on fungal hyphae and spores.

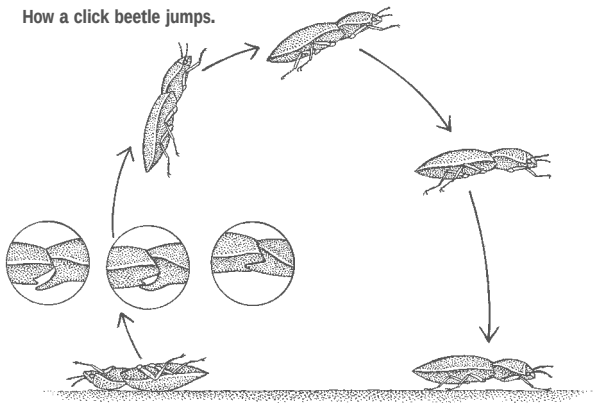
**Short-winged mold beetles** (Pselaphidae) are small beetles (0.7- 4.5 millimeters) that prey on worms, Collembola, insect larvae, mites, and symphylans. There are over 700 known species, found mainly in leaf litter.

**Weevils** (Curculionidae). Almost all weevils in this very large family are plant feeders, and some are serious pests of cultivated crops. Those found in leaf litter are mostly nut or acorn weevils of the subfamily Curculioninae, and have very long snouts.

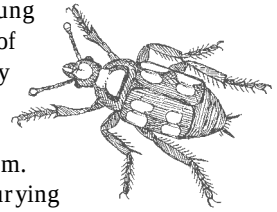


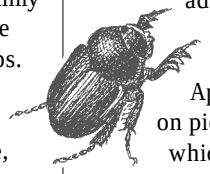
**Click beetles** (Elateridae) are also commonly found on the forest floor. They are called click beetles because of the sound they make when they flip their bodies over. They are able to arch and snap their bodies to right themselves if turned upside-down or if attacked by predators. The larvae are called wire worms and are found in rotting wood. Because wood is so nutrient-poor, click beetles take five to seven years to mature from larvae to adult.

How a click beetle jumps.



Two other families of beetles often encountered in the leaf litter are carrion and dung beetles, both of which can play important roles in the litter ecosystem. Carrion, or burying beetles (Silphidae) dig beneath the bodies of small dead animals, burying the carcasses before laying their eggs on them. Both adults and larvae feed on such carrion. Dung beetles (Scarabaeinae, Aphodiinae) lay their eggs on pieces of animal dung, which they often roll large distances and then bury, ensuring a food supply for their larvae. This behavior is also important in returning nutrients to the soil.



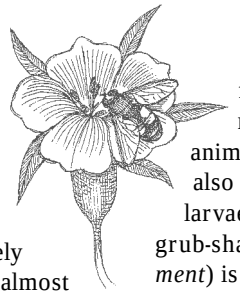


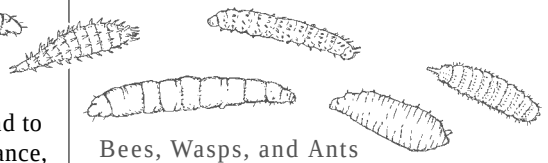


## True Flies

Order | Diptera

One of the largest groups of insects (25,000 species known from North America), flies are extremely abundant and are found in almost every habitat, even, occasionally, in leaf litter. Adult flies found there are likely to be laying eggs, or perhaps have just emerged from pupae. There are also some leaf litter flies that are parasitic on other insects. Best known are the humpbacked flies, the Phoridae.





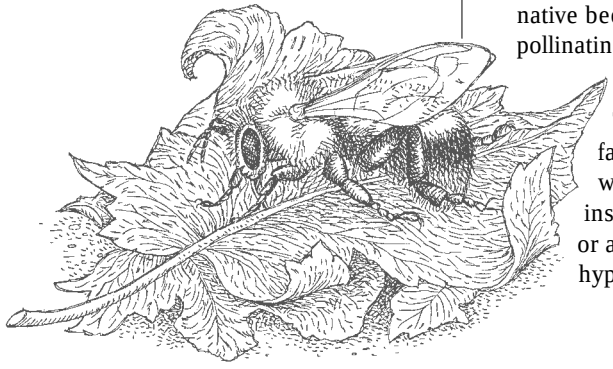
We tend to think of flies as a nuisance, or be concerned about how some species transmit diseases, but fly larvae play an essential role in decomposition. Fly larvae of many different families live in the leaf litter and soil, including fungus gnats and other families of tiny midges, crane flies, dance flies, horse flies, house flies, hover flies, fruit flies and many others without common names. While most feed on decaying organic material (both plant and animal) and fungi, some are also predators. In general, fly larvae are elongated, cigar- or grub-shaped. The skin (or *integument*) is usually soft, pliable, and often whitish in color. All fly larvae lack jointed legs on the thorax, unlike most beetle larvae. Some may have fleshy prolegs (but not jointed legs), while others have raised ridges or creeping welts along their bodies that allow them to move about.

## Bees, Wasps, and Ants

Order | Hymenoptera

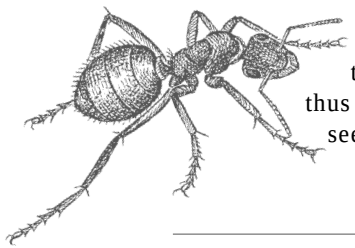
Many species of bees and wasps build their nests in the ground, beneath the litter layer. Of these, most of the native bees are solitary and do not build large hives as do the honey bees that were introduced from Europe. The thick litter layer also provides protection from the winter cold for hibernating wasps and bees. Wasps are important insect predators, and native bees are responsible for pollinating many of our woodland wildflowers.

There are numerous families of parasitic wasps which are parasites of insect eggs, larvae, pupae or adults. Some are even hyperparasites (parasites of



parasites!) and have fascinating life cycles. Though not regular inhabitants of the leaf litter, when found there they will have been looking for hosts to lay their eggs on, or perhaps have just emerged from the egg themselves. The most common family found in leaf litter is the Trichogrammatidae. The genus *Trichogramma* has been used successfully as a biological control agent for insect pests.

Ants (Formicidae) are true social animals; they live in highly organized colonies and communicate by chemical means. Depending on species, ants can be farmers, hunters, collectors or even slaves of other ants. They feed on a variety of food, including dead plants and insects. Ants play a very important role in soil ecology by aerating and enriching the soil as they build their colonies. In addition, many forest plants such as violets and wild ginger depend on ants for seed dispersal. As the ants collect seeds to eat, they may accidentally drop some on the return trip to their nest, thus spreading the seeds around.



Scientists have identified 38 species of ants in New York City's Central Park.

## CONSERVING LEAF LITTER

### Human Impact on Leaf Litter Invertebrates

A healthy layer of leaves on the forest floor is a vital component of every woodland. The leaf layer protects and nourishes the soil, enables rainwater to filter into the ground, harbors seeds, and provides hiding places for woodland animals. Without it, the woodlands would be unable to exist and reproduce.

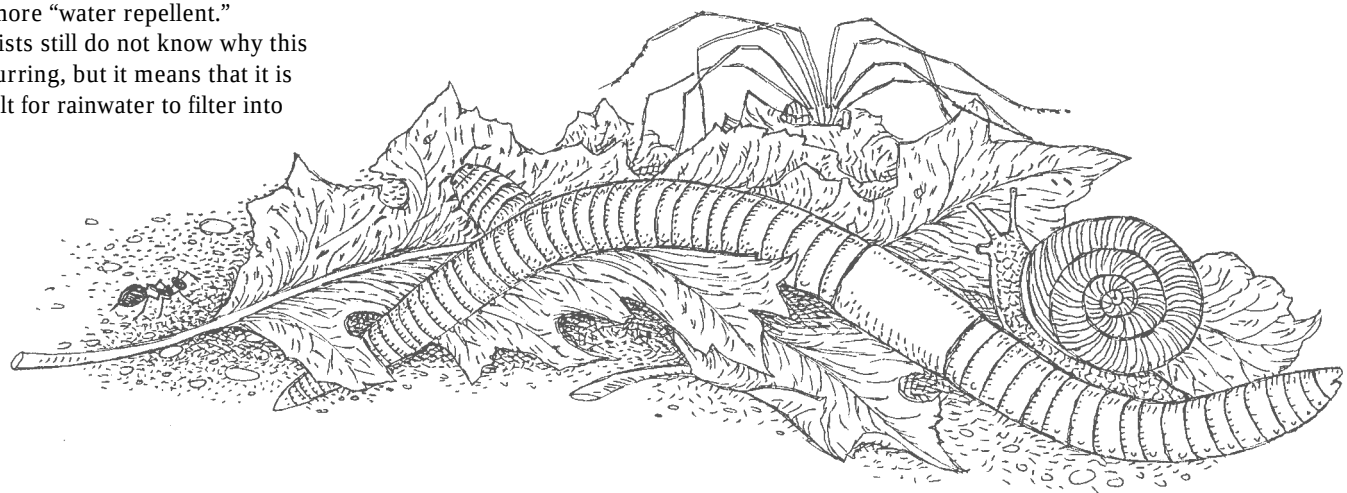
What creates a good litter layer? Plenty of litter — the natural kind — leaves, sticks, and seeds, and a healthy population of leaf litter animals (without too many earthworms), and loose, moist soil.

Sometimes these ingredients are hard to find in a city park. Environmental pollutants and acid rain are known to affect the terrestrial world of leaf litter invertebrates. Some pollutants are making city soils more "water repellent." Scientists still do not know why this is occurring, but it means that it is difficult for rainwater to filter into the soil, so that plants and animals have trouble getting the water they need to survive. City habitats are also subject to warmer air temperatures, which affect soil temperature and the amount of moisture in the soil.

Users of park and city woodlands, wittingly or not, have a large impact on the fascinating, diverse and fragile community of largely unseen litter invertebrates. People destroy habitat (if not the animals themselves) by compacting the soil when they walk on the leaf litter. Worse still, some people ride their bicycles and other vehicles over it. When soil is compacted, the pore spaces in the soil collapse, making it difficult for water to penetrate and making air less available to the roots of plants. This inhibits plant growth and affects the root growth of trees. The root systems become shallower, with greater lateral growth. This means that some trees could be more easily uprooted in a strong wind, and roots near the surface can be more easily damaged. Soil compaction from human foot traffic also increases soil erosion by increasing surface runoff.

The use of pesticides and other poisons, as well as the introduction of non-native plants, can change the chemistry of the soil, which will eventually affect life in the leaf litter. Native plants are those that have originated in a particular habitat. Non-native invasive species were brought or spread from somewhere else. In addition to their effects on soil chemistry, the leaf litter produced by these non-native plants may be unpalatable to soil organisms. Invasives can also out-compete and crowd out native plant species from an area.

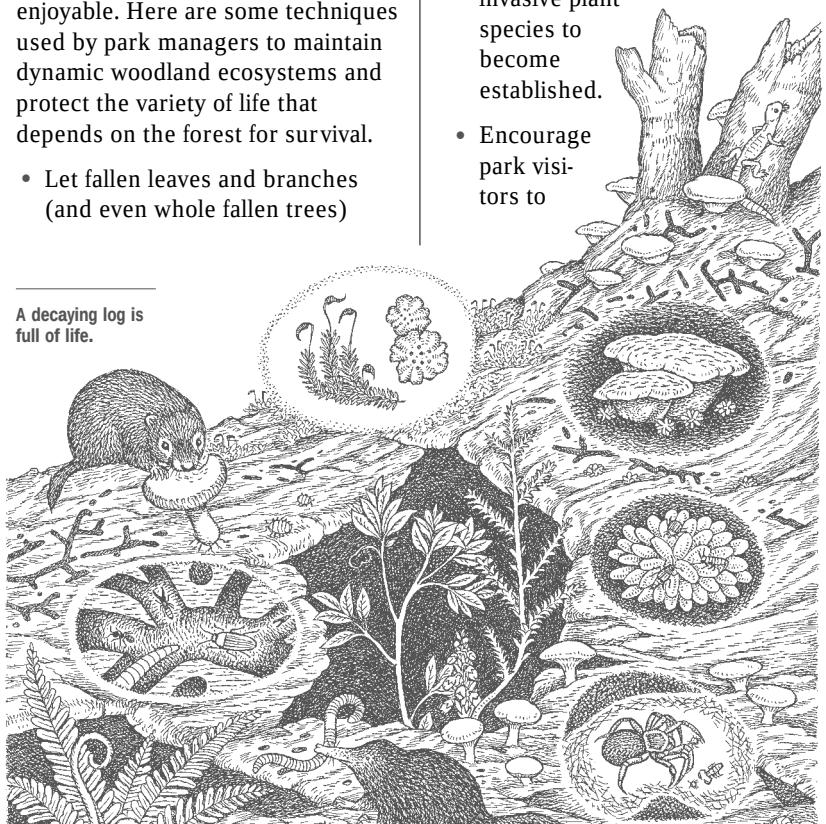
Fortunately, even in a city environment, there is much that we can do to protect this fragile community of creatures.



## Park Managers to the Rescue

Park managers work to keep the park healthy and natural, safe and enjoyable. Here are some techniques used by park managers to maintain dynamic woodland ecosystems and protect the variety of life that depends on the forest for survival.

- Let fallen leaves and branches (and even whole fallen trees) decompose where they fall. "Leaving" leaves and other organic matter around and under trees allows them to become part of the soil and provide nutrients for other plants and the trees themselves in the coming year. Fallen trees also provide habitat for many of the animals and microorganisms that live in the leaf litter.
- Minimize soil disturbance in woodlands. Cultivating the soil could harm plant and animal life because it disturbs soil formation and the natural layering of the leaf litter. Soil disturbance may also allow the seeds of non-native invasive plant species to become established.
- Encourage park visitors to stay on the trail. Put up signs where people might otherwise go off-trail and trample on the leaf litter and all the invertebrates that live in it.
- Minimize use of pesticides or chemicals such as lawn and garden fertilizers that could disrupt the chemical balance of the soil.
- Use deicing salts sparingly; these salts may melt pavement ice in winter, but pollute the soil. Use other deicers like $CaCl_2$ (calcium chloride) rather than NaCl (sodium chloride).
- Encourage restoration projects that use native plants and control non-native invasive species.
- Foster research and education about the complex relationship of soil and the living organisms in the woodland.



A decaying log is full of life.

## What You Can Do to Help

Park visitors can also help protect the amazing diversity of life in our city woodlands in the following ways:

- Appreciate the natural, unmanicured look of your woodlands and parks. Leave the organic materials, fallen foliage, twigs and branches around and under trees undisturbed.
- Avoid unnecessary trampling on the fragile soil. Stay on designated trails.
- Don't drop litter on the litter. Keep parks and woodlands free from trash. Materials such as plastics and glass disrupt the normal functioning of the soil.
- Clean up after your dog and keep dogs away from trees. Because their urine is acidic and very concentrated, it can burn through tree bark. Dog droppings also pollute the soil.
- When fishing near woodland areas, take any extra bait home. Please don't release worms into the wild.
- Plant native species in your own garden; this will encourage the proliferation of the native leaf litter invertebrates. Avoid introducing invasive species (which might colonize nearby parklands) into your garden.
- When possible, minimize your driving. Cars and other machinery contribute to air pollution. Auto emissions contribute to acid rain, which leaches some of the important nutrients needed for plant growth out of the soil. These emissions stimulate plants to produce a protective waxy layer on their leaves, which may make the leaves less digestible to soil animals. The pollutants may also cause the soil surface to become water repellant, thus affecting seed germination and seedling survival.
- Volunteer. Support park activities that help protect biodiversity.

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(The classification used in this book is based on the Integrated Taxonomic Information System. See the ITIS web site at *http://www.itis.usda.gov.*)



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