The Life of a Bee

.

Photo Credit: Sam Droege,

Lake Shelbyville Eco-Meet 2025

Varsity

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Overview

INTRODUCTION

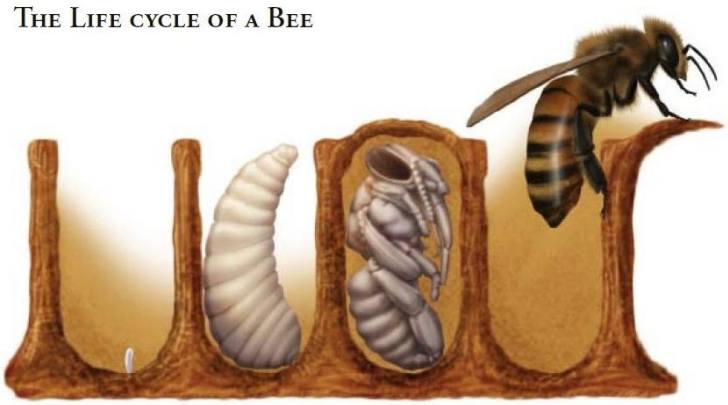
This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 12). Princeton University Press. Kindle Edition.

Interestingly, bees are really just a special kind of wasp. All wasps are divided into two main groups: those in which the ovipositor has evolved to function as a sting, and those in which it has not. Among those with stings are ants and some kinds of wasps; this group is called the *Aculeata*. Within the *aculeates* are two categories, one containing wasps and ants, and one containing the bees—this bee group is known as the *Anthophila*, which means "flower lover." This study guide will focus solely on the *Anthophila* group.

THE BEE LIFECYCLE

This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 14-17). Princeton University Press. Kindle Edition.

One might assume that the life of a bee is spent zipping around, docking at flower after flower for a sip of nectar or a dollop of pollen. After all, that's what we witness in our gardens all summer long. In fact, the majority of a bee's lifecycle is not even seen by us, occurring out of our sight in a carefully built nest. Though most bees live a year (some even longer), they are "adults" hurrying from flower to flower for only three to six weeks of that year. The rest of the time is passed in relative darkness, inside the nest, undergoing a variety of developmental changes. While human offspring pass from baby to toddler to teenager to adult, a bee moves from egg to larva to pupa to adult. It may surprise you to learn that these are the very same phases through which a butterfly passes, and, in fact, many bees even spin cocoons just as butterfly caterpillars do. Because the end product looks so very different from the grub-form that characterized its youth, the growth of a bee (and butterfly) is known as complete metamorphosis.



Credit:

ADULT

A bee emerges from its nest for the first time anytime between February and September, depending on species, and length of the flowering season. With few exceptions, male bees emerge before the females, often up to a week earlier. They wait expectantly near the nest sites from which they emerged, or on flowers close by, for females to make their appearance. When females finally do emerge, males hope to be the first and perhaps only bee to mate with them. Newly emerged females don't have mature ovaries, and many species spend the first few days drinking nectar and eating pollen; the pollen is thought to help speed along the maturation of their reproductive parts. Even before their ovaries have matured, however, female bees can mate and store sperm in their spermatheca, an organ in their abdomens for just this purpose. This stored sperm is kept alive and viable for the remainder of the female's life, and she can use it whenever she is ready to fertilize an egg. Mating just once is enough to provide a lifetime supply of sperm for a female bee. Interestingly, males often appear able to recognize a female that has been mated and will avoid her; likely it is a difference in the odors she emits that gives her away.

Bee mothers (as well as some wasp and ant mothers) have the amazing ability to determine whether each egg they lay will develop into a male or a female bee. When an egg is laid, the female decides whether sperm will be released from her spermatheca as the egg passes by it. Fertilized eggs (an egg plus sperm) develop into female bees, and unfertilized eggs (no sperm) develop into males. This system is called haplodiploidy, referring to the fact that male bees are haploid, containing only genetic material from their mothers, and females are diploid, containing genetic material from both their mothers and their fathers. Eggs are placed in individual nest cells (akin to nurseries) inside nests, and there are often

several nest cells inside a nest. Each egg is provided with a mass of pollen mixed with some nectar, which the larva will ingest upon hatching. Most mother bees never meet their young, dying after they have done all they need to do in order to provide for the offspring that will develop from the eggs they lay.

EGG

Eggs have a soft outer shell (called a chorion). They are usually white, and oval-shaped. Bee species in North America lay eggs that range in size from extremely small (the size of a pinhead) to almost two-thirds of an inch long (a little less than the diameter of a dime). The egg stage is the shortest-lasting stage of a bee's life, with most eggs "hatching" just a few days after having been laid. Hatching isn't the same as in birds, though. The eggshell is so soft that it usually dissolves or is shed rather than cracking open.

LARVA

Once the egg hatches, a bee enters its larval stage. A larva is soft and white with a mouth, tiny nubs where the antennae will someday be, and a caterpillar-like body. These "grubs" do nothing but eat the pollen and nectar their mothers have left them. As they grow, they periodically shed their outer skin, molting into larger and larger grubs. These molts happen five times, and each represents a different larval stage (called an instar). Interestingly, even though larval bees eat constantly and grow continually, they produce very little poop (called frass) until the last larval stage. The last stage of larval development for a bee is known as the prepupa. Bees may remain in the prepupal stage for long periods of time; for example, for an egg laid in the spring, the larval bee might take all summer to develop to its prepupal stage, and then may stay in this stage for all of fall and winter. Some bees may even wait several years in this state before finishing their development and emerging as adults. Just before transitioning to the next stage of their lives, bees defecate, getting rid of all the waste matter from the huge loaf of pollen they've ingested. Then, just like butterflies and moths, some bees spin a silky cocoon around their bodies—a mouth-made sweater to keep them protected as they transform to pupae.

PUPA

The bee pupa looks very much like the adult, with legs, antennae, eyes, and three body sections (but just wing buds—no actual wings). Though the form is similar to an adult, the color is a light gray to milky white, lacking any of the bright colors and fuzzy fur associated with adult bees. The pupal stage in a bee usually doesn't last long. In a short period the wings grow and stretch out, fur sprouts from the body, and the bee becomes a fully formed adult. It then chews and digs its way out of its nest and commences life as an adult.

WHERE DO BEES LIVE?

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If you believe everything you see on TV, you might think that bees live in hives that dangle from tree branches, tempting hungry bears. In fact, 70% of bees nest in holes in the ground, dug gopher-style by a single female bee.

Those bees that don't nest in the ground choose preexisting holes (including hollowed-out twigs, pock-marks in rocks, abandoned beetle burrows, tiny holes in bricks, and even empty snail shells). A few kinds build nests on the outside of structures, using rocks and mud they collect and cobble together. Even hive bees prefer not to nest in something so exposed as a blob hanging from a tree branch. Honey bees and bumble bees, the two hive bees in North America, typically choose crevices in rocks, hollow tree stumps, or mouse and rabbit burrows for their colonies.

Bee hive in log. Credit: http://natureintoaction.com/2013/03/08/the-honey-bee-factory/dead-tree-

A bee nest contains anywhere from one to several dozen nest cells. Each nest cell serves as a chamber, analogous to a nursery, for a single developing bee. For bees that nest in the ground, the nest is carefully excavated and prepared before the female lays any eggs in it. Generally the nest site is a sunny south- or east-facing patch of exposed earth. At the spot she deems to be just right, a female bee wets the ground, either with water she has

gathered, or with her own saliva. Once it is softened, she uses her legs and mandibles (jaw) to worry the surface. As it gives, she shovels the dirt away, burrowing deeper and deeper into the earth and leaving a mound of dirt behind her. Inside, the nest is either one long tunnel with nest cells at the very bottom, or a tunnel with several side branches and offshoots, each of which may contain one or a few nest cells.

The female uses the tip of her abdomen (specifically a structure called the pygidial plate) to tamp the walls of her excavated nest until they are smooth, maybe applying a little mud, extra soil, or some other substance to get it just so. Some bees paint the walls with a waxy or cellophane-like material produced with a special gland on the female's abdomen (called the Dufour's gland) to keep out moisture and any bacteria in the soil. Other bees line their nests with pieces of leaves, the hairs that often coat plant leaves, or even flower petals. When the nest meets her satisfaction, the bee gathers pollen and nectar from flowers and carries them back with her scopa (pollen-collecting hairs) and in her crop (nectar stomach), respectively. The bee then mixes or layers the pollen and nectar together in the nest cell and, finally, lays an egg somewhere near this "loaf."

Bee nesting in the ground. Credit: http://blogs.cornell.edu/

Bees that nest in preexisting cavities similarly prepare for their offspring. They may modify the cavity as needed, either packing in mud or rocks to shrink the diameter of the tunnel, or chewing at the insides to widen it to the right volume. Many cavity-nesting bees construct nest cells all in a row. In such cases, each egg, and its pollen loaf, is sealed off from its siblings by a wall or partition built by the mother between the cells. The walls can be made of packed together soil, pebbles, resin, bits of plant foliage, or sawdust left from digging into the wood around the nest. Finally, the tunnel, either with a series of cells, or with just one cell, is back-filled with debris or soil and the entrance capped, often with mud or plant materials.

BEE SOCIALITY

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Even as well-known as they are, honey bees and bumble bees make up less than 1% of all bee species, and their life history is hardly illustrative of bees at large. Honey bees and bumble bees are highly social, meaning they live in hives with a queen and workers that divide up the various duties necessary to keep the hive thriving. In contrast, most North American bees are solitary, with each female bee building her own nest, gathering the food resources to feed her offspring, and laying all the eggs. There are also bees that, though solitary, share nest constructing and guarding duties to some extent, or live close together but maintain the solitary lifestyle. In fact there are many cooperative strategies, most of which don't involve a queen bee, and it appears that different types of sociality have arisen more than once in different bee lineages.

SOLITARY

The vast majority of the bees native to North America are solitary. Rather than dividing household chores, as honey bees do, each individual female builds her own nest. Like all individualists, she selects her nest site based not on what other bees are doing, but on habitat characteristics that are important to her (e.g., soil type, cavity size, surrounding vegetation). As a solitary bee, she also gathers all the resources she needs to provide for her offspring (like a worker honey bee), and lays all the eggs (like a queen honey bee)—she is the full package. A mother solitary bee never meets her young, dying soon after she has built her nest, loaded it with pollen, nectar, and eggs, and sealed it shut.

Aggregation of bee nests. Credit: http://davotrip.blogspot.com/2009_08_01_archive.html

AGGREGATIONS

Some solitary bees nest in aggregations; though each nest is built and maintained by a single bee, many nests can be found close together, often with several hundred, or even several thousand, nests in the same area. The largest aggregations are found among bees that nest in the ground. Sometimes these aggregations may persist in one area for several years or even several decades. Why bees

nest in aggregations is not entirely known. Nesting aggregations might form because a particular area has desirable characteristics that are hard to find elsewhere. There is also evidence that nesting in aggregations may lessen the chances of any one bee being picked off by a predator, or attacked by a parasite. With so many bees flying in the same area, a neighbor is always nearby to chase away ne'er-do-wells.

COMMUNAL

Other species of solitary bees nest communally, with several bees sharing the same nest entrance. Think of it as the hymenopteran equivalent of city dwellers in a high-rise apartment complex. Though all inhabitants share the same foyer and revolving doors, they live separate lives once inside. Forty or more bees may share the entrance to a nest (most often in the ground), but within the nest each bee has her own nest cell or cells that she prepares for her own eggs.

Communal Bees. Credit: http://abugblog.blogspot.

SEMISOCIAL

Semisocial bees use the same nest and also cooperatively provide for the offspring in it. Working together to prepare one nest cell at a time, they fill it with pollen and nectar, lay an egg, and close the nest cell off before moving to the next. This work is divided up, so that some bees gather the pollen and build the nest cells, and some bees just lay eggs. The size of the bee appears to be a major factor in deciding who stays home to lay eggs and who leaves the nest, with smaller individuals doing the foraging. Generally the bees are all the same age, possibly even sisters. Many species of sweat bees (called *Lasioglossum*) in the United States and Canada cooperate in this way. As with all social types described above, semisocial mother bees and their aunts never meet the offspring for which they provide, dying after the nest and its cells are completed. The designation semisocial means "halfway social," as these bees live much like social bees, but their colonies are not as complex and they last for just one generation.

EUSOCIAL

Eusocial bees are the pinnacle of sociality (*eu-* means “true” or “well done” in Greek, thus these bees are “perfectly social”). In addition to sharing a nest and dividing the duties of nest maintenance and offspring care, eusocial bees actually meet their young, and the mother bee works alongside her daughters. A eusocial colony of bees, therefore, has three unique qualities: all individuals share a nest, they split nest-making and reproductive responsibilities, and they comprise a mother and all her daughters (meaning that the mother meets her offspring).

Eusocial Bees. Credit: Sarah

There are several examples in the United States and Canada of eusocial bees, including honey bees, bumble bees, and some kinds of sweat bees. Honey bees are the only highly eusocial bees, though; bumble bees and sweat bees are thought of as primitively eusocial. There are several differences, in terms of both appearance and behavior. A queen honey bee (the egg layer) looks different from her workers (the housekeepers)—she is bigger, with a swollen abdomen and no pollen-collecting appendages. She cannot survive without her workers, and new colonies are started by several hundred bees working together. Behaviorally, honey bees are capable of advanced communication, and their hives are often gargantuan, with several thousand individuals living and working together.

In contrast, bumble bee and sweat bee queens differ from workers only in size. They are fully capable of existing on their own, and in fact they build the founding nest by themselves. In it, they lay a batch of eggs which they carefully nurture to adulthood. Once the daughters are mature, the bumble bee or sweat bee mother stays home, giving up the duties of nest care and taking on the sole responsibility of laying eggs. Her daughters, the worker bees, take over the duties of building additional nest cells and providing their younger sisters with pollen and nectar or honey. Neither bumble bees nor sweat bees are capable of advanced communication, and colonies tend to be small, with only 50 to a couple hundred individuals. Sweat bee nests may be even smaller than this, with fewer than a dozen members.

WHAT DO BEES EAT?

This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 21-22). Princeton University Press. Kindle Edition.

The nutritional needs of a bee are met almost entirely by flowers. Adult bees eat a little pollen and a lot of nectar, and they feed their larvae a lot of pollen, often mixed with a little nectar. Pollen provides bees with an excellent source of protein, as well as chemical compounds important in the process of egg development in females. When females collect pollen from flowers, they store it in special tufts of stiff hairs on their abdomen or on their legs—these tufts are called scopa. They use their four front legs to scrape pollen from the flowers, scooping it to their two back legs and packing it into these hairs. Any pollen that inadvertently sticks to another part of the body is generally scraped off during elaborate grooming sessions and shoved to the scopal hairs. Many bees carry the pollen dry, but others will mix it with nectar, making a pollen "dough" to take back to the nest. A few bees mix the pollen with floral oils before carrying it home. In addition to the bees that carry pollen on their scopa, one group of bees (known as *Hylaeus*) carries its pollen in a crop—a "stomach" of sorts—and then regurgitates it back at the nest.

Notice the pollen caught in the hairs on the body of this bee pollinating a flower. Credit: https://beependent.wordpress.com/pollinatio

Bees have many adaptations to aid them in harvesting pollen from flowers. The hairs on the body of a bee are electrostatically charged, so that pollen naturally sticks to it, a charge that builds up as the bee flies. Other adaptations include special hairs on other body parts. For example, bees that collect pollen from the flowers of cat's eye (*Cryptantha*) often have hooked or wavy hairs on their faces. When they stick their heads into the very narrow floral tubes on these flowers, the pollen sticks to the hooked hairs on their faces. Once they back out of the flower they can move the pollen from their faces to their scopa. Similarly, some bees that collect from these tiny flowers have pollen-collecting hairs on the underside of their faces. Bees that collect oil instead of nectar to mix with pollen have thick pads of hair for sopping it up.

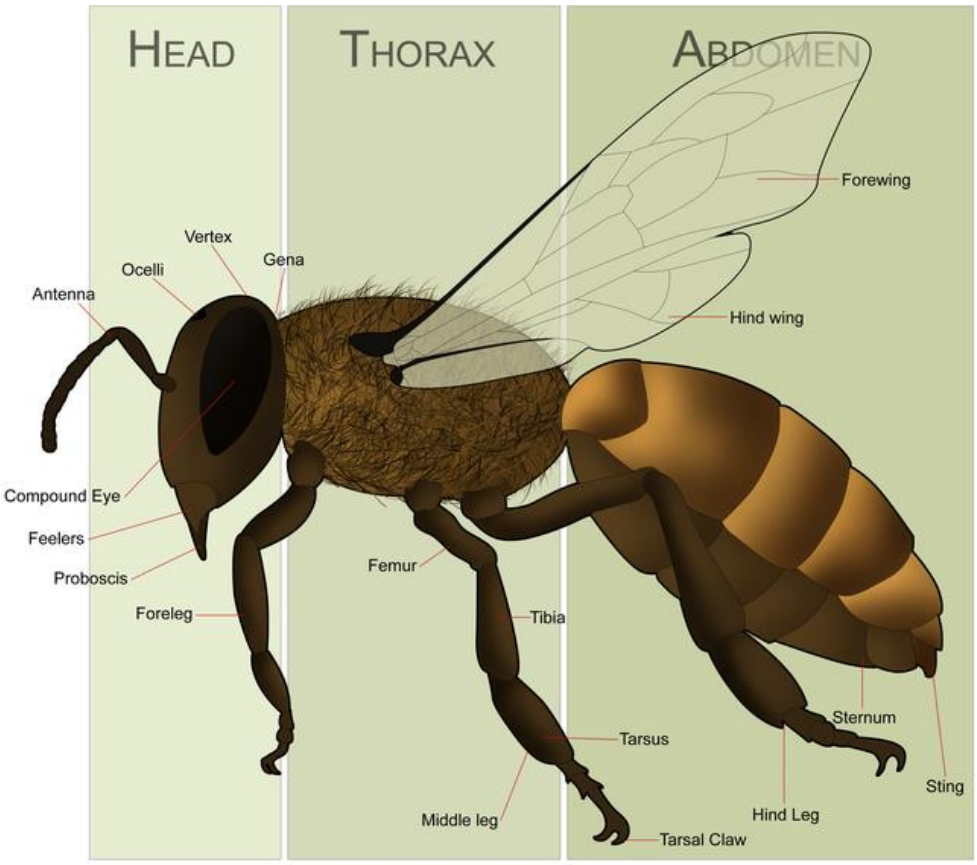
Bees have also evolved behavioral adaptations to aid in gathering pollen. As an example, many plants in the potato family (*Solanaceae*), including tomatoes, potatoes, chili

peppers, tomatillos, and eggplants, keep their pollen inside anthers (pollen-holding structures) that work like salt shakers. The pollen stays securely inside until the anthers are tipped upside down and shaken. Only some bees know how to shake the anthers; they will hang below the flower and buzz their flight muscles to vibrate the pollen loose. This process, known as buzz pollination, is an essential step in the pollination of many plants. Interestingly, honey bees do not know how to buzz pollinate and are, therefore, not very effective pollinators of some of our tastiest foods.

Nectar provides bees with important carbohydrates in the form of sugars, as well as amino acids. Bees use their tongues to either suck or lap up nectar. Some bees have very long tongues, giving them the ability to probe deep into flowers with long necks, like beardtongues (*Penstemon*). Other bees have very short tongues, which they use to sop up nectar from shallow flowers like those in the sunflower and carrot families (*Asteraceae* and *Apiaceae*, respectively). Some bees are very particular about the pollen they collect for their offspring, limiting themselves to just a few plant species, even when many plant species may be available. These picky bees are known as specialists. No matter where they are found, they always specialize on the same flowers, and it appears to be an inherited trait—the female offspring of a specialist bee collects pollen from the same species of flowers her mother did, even though they never met.

A BEE'S BODY

This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 27-34). Princeton University Press. Kindle Edition.



Credit:

THE BODY

Important features include the shape, which may be flattened or very thick. The abdomen may be rounded or more oval-shaped. The head may be small or extremely robust. Hair patterns and colors can also be important. Their placement on the abdomen and thorax are often diagnostic. The "skin" of a bee is called the integument and is marked with small indentations. The patterning of these small marks is often very important in species identification.

THE HEAD

Many important appendages are found on a bee's head, including the antennae, the mouthparts (tongue), the mandibles (jaw), and two sets of eyes.

ANTENNAE

The antennae are attached to the bee's head in antennal sockets. If you look closely at the segments of the antennae under a microscope, you can see they are covered with microscopic hairs and little pits. The hairs and pits are called sensilla, and bees use them to "smell" the world around them. The sensilla act as tiny sensors, capable of processing the many chemical compounds in the air, especially the fragrances produced by flowers.

MOUTHPARTS

Taken together, the mouthparts of a bee are called the proboscis, and they consist of many jointed pieces. Bees fall into one of two categories based in large part on the features of their proboscis: they are either short-tongued, or long-tongued. Interestingly, the tongue is not actually the feature most indicative of a long-tongued bee—it is instead four tiny segments that run next to the tongue called the labial palps. In long-tongued bees the first two segments (those closest to the bee's head) are much longer than the second two. In short-tongued bees all the segments are more or less the same length. In both cases the labial palps are sensory organs for "tasting" the world. In the long-tongued bees, the tongue can be folded from base to tip into roughly three parts that collapse into the shape of a Z. Quite often the proboscis is so long that even when folded up, it extends the full length of the underbelly. When the proboscis of a long-tongued bee is extended, its other pieces can be folded together to form a straw for sipping. When the bee wiggles its tongue within this straw, it can suck nectar up toward the mouth. This kind of tongue is very porous and has special hairs that aid in sopping up minute amounts of nectar from inside flowers. Short-tongued bees lap or dab at nectar more than suck it up. In addition to slurping nectar, bees use their tongues for "painting" the lining inside their nests, for a little bit of grooming, and for communicating— many of the chemical receptors used by bees to understand their environment are on their tongues (the rest are on the antennae and the feet).

MANDIBLES

The bee equivalent of the opposable thumb is the mandible. As a pair, these "jaws" are like small pinchers and span the lower section of the face. The mandibles are very important to many bee activities, including sparring with enemies, building nests, filling a nest with leaves, carrying pebbles, and hanging onto a plant stem. At the tip of the mandibles (the end farthest from the connection to the face) are a number of teeth. Some

bees have very simple mandibles with few teeth, whereas others have many teeth that may be pointed or rounded.

EYES

A bee has two types of eyes. Near the top of the head are the simple eyes, known as ocelli, that each have just one lens. There are three ocelli, with two near the back of the head and one just forward of those. Bees use these eyes for orientation, triangulating on the position of the sun in the sky and using this information to guide them to and from their nests. The compound eyes are more visible, with one on each side of the head, and are comprised of thousands of individual lenses. Through these many lenses, bees see color, shapes, and light. Each lens sees the same view from a slightly different angle, and a bee must compile all these images in order to create a picture of the world around it. Because the lenses are so tiny and because none sees a very big slice of the world, bees are fairly near-sighted and cannot make out sharp images from great distances. However, bees are very good at sensing movement, because they process the images they see so quickly. A bee eye processes images 15 times more quickly than our own eyes do. This speedy processing influences how bees perceive flowers. It makes rounded objects hard to see, whereas those with edges and points, which appear to flicker across a bee's field of view as the insect moves, are much more easily recognized. This is why bee-pollinated flowers often have many-pointed petals. Bees have three color receptors behind each lens, and each responds to a different wavelength of light (representing a different color). Bees' eyes are most in tune to green, blue, and ultraviolet light, while they are much less sensitive to red hues. As a result, bees regard the world much differently than we do, picking up on floral cues that are completely invisible to us. For example, flowers often have ultraviolet stripes or "guides" on their flowers indicating the most direct route to floral rewards like nectar and pollen. Our eyes, which do not perceive ultraviolet light, cannot see these guides.

THE THORAX

The middle section of a bee's body, complete with wings and legs, is called the thorax.

WINGS

Bees have two wings on either side of their bodies, known as the forewing (the one toward the head of the bee) and the hind wing. The wings hook together with minute hooks

on the front edge of the hind wing. Wings are supported by a series of veins; the spaces between them are so distinctive on a bee's wing that they can be used to tell groups of bees apart. Depending on the bee, those membranous wings may carry the little creature (and its heavy pollen harvest) a great distance. Bumble bees have been known to travel up to 5 miles (but more typically travel a mile). Even medium sized bees may travel up to a mile from their nest in search of plants (and then back again).

LEGS

Bees have three pairs of legs (six total). In order from front to back, they are known as the foreleg, the midleg, and the hind leg. Each leg is made up of distinct parts, and the joints and the number of sections making up the leg are similar for each of the pairs, but each pair has distinctive added features. For example, most bees possess electrostatically charged pollen-collecting hairs known as scopa on their hind legs. In addition, bees that nest in the ground or in soft wood have spines or spurs on their tibiae that help them to maneuver when inside their tight burrows.

THORAX

The thorax is made of a series of plates fused together. Many of them serve no immediately obvious purpose. Some may be defensive, others may represent points of anchor for internal muscles, and the rest may be nothing more than carryovers from ancestors past. Regardless, many are very important for bee identification.

THE ABDOMEN

The abdomen is covered in a series of telescoping plates. On the top surface, the plates are known as tergal segments (one segment alone is called a tergum or tergite, and all together they are referred to as the terga). The terga furthest from the head are often difficult to see because the bee can collapse each segment into the one before it like nesting Russian dolls. On the bottom (ventral) surface of the abdomen are sternal segments. The sternal segments can have extra protrusions, flaps, or other projections, but these can be difficult to see. Males typically have more segments than females, and thus, the abdomen of males sometimes appears longer and may be curled under. At the tip of the abdomen there is a pygidial plate (not all bees have this, and its presence or absence can aid in identification), which is used in constructing and tamping down the earth in a ground-built nest.

STING

Finally, at the tip of the abdomen is the sting, a highly modified ovipositor (egg-laying tube). Over evolutionary time scales, the sting of a bee has become so modified for stinging that eggs are no longer laid through it, but from a separate opening near its base. Since the sting evolved as an apparatus for laying eggs, males don't have one, and therefore they cannot sting.

COMMON BEES OF ILLINOIS

The two most prevalent genera of bees found in Illinois are *Bombus* and *Apis*. The *Bombus* genus and the most common species from the *Apis* genus, *Apis mellifera*, will be covered in further detail below.

BOMBUS

This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 242-245). Princeton University Press. Kindle Edition.

DESCRIPTION

Bumble bees are medium to large hairy bees that all belong to the genus *Bombus*. Bumble bees are among the few bees native to North America that are truly social, with a queen and workers.

Credit: http://a-z-animals.com/animals/bumble-bee/pictures/1044/

DISTRIBUTION

Around the world over 250 bumble bee species are known, but fewer than 50 of them occur in North America. Bumble bees are found primarily in the Northern Hemisphere (North America, Europe, and Asia) but some native populations also exist in parts of South America. Also, a few species have been introduced to New Zealand and Tasmania. Although bumble bees can be found in most habitats in the Northern Hemisphere, ranging from the southwestern deserts to the tundra, these bees are most diverse in mountainous regions. Worldwide, the areas with highest bumble bee diversity are in Europe and Asia, particularly in the Himalayas and the Alps.

DIET AND POLLINATION SERVICES

Bumble bees are generalists and can be found foraging on a wide variety of plants. Some species have extraordinarily long tongues, enabling them to feed on nectar from plants with deep flower tubes like beardtongues (*Penstemon*), foxgloves (*Digitalis*), monkshoods (*Aconitum*), and columbines (*Aquilegia*).

Studies have shown that for many crops, pollination by bumble bees produces bigger fruit, faster fruit set, and larger yields than other pollination methods, most specifically honey bee pollination. First, bumble bees have a distinct advantage over European honey bees when it comes to retrieving pollen from some plants: they can buzz pollinate. They are therefore much more effective pollinators of some important crops, specifically those with flowers requiring buzz pollination. These plants include tomatoes, peppers, eggplants, potatoes, and even some berries like blueberries. Second, bumble bees have been shown to be faster workers than honey bees, often visiting twice as many flowers per minute. Finally, researchers have estimated that bumble bees will do at least eight times more work than a honey bee because bumble bees can remain active in colder temperatures, and they can carry more pollen.

OTHER BIOLOGICAL NOTES

Often, bumble bees are the first bees seen in spring and the last bees out in the fall. Bumble bees have special adaptations that allow them to be active in colder weather and colder climates than most other bees. In addition to their thick and insulating coat of hair, bumble bees often bask in the sun to warm themselves before they head out to forage.

When sun and fuzz aren't enough, bumble bees can actually generate heat internally by shivering their flight muscles. These bees can uncouple their wings from their flight muscles, allowing them to contract the muscles without flapping their wings. Those muscle contractions can raise the internal temperature of the bee, making them significantly warmer than their surrounding environment. In fact, bumble bees can't take off and fly until their flight muscles are above 80 ° F; by shivering their flight muscles to warm up, they can actively forage in temperatures much too cold for other bees.

Bumble bees are eusocial. Typically, in the spring a new queen bumble bee will emerge from her winter hibernation and begin searching for a nest site. Once a suitable site is established, the queen will collect pollen and nectar. When the nest is sufficiently stocked with pollen and nectar, the queen will lay eggs on the pollen mass and incubate

them by covering the eggs with her abdomen (like a bird on her brood). The queen stays in the nest from this point on, attending to her growing larvae, and leaving the nest only if more food is needed. About a month after they are laid, this first batch of eggs will have developed into adult workers. These workers then take over both the foraging duties and care of the next round of the queen's offspring. The nest continues to grow through the summer, with the queen laying more eggs, which develop into more workers. At the end of the season, the queen will produce a set of male offspring, followed closely by a set of new queens. These males and new queens leave the nest to find mates. After mating, the males die and the new queens find a place to hibernate through the winter. The old queen and all remaining workers die at the end of the year, and the cycle begins again the next spring.

Most bumble bee species make their nests in the ground, often in preexisting cavities like abandoned rodent burrows, in piles of wood, or in leaf litter. Occasionally, some bumble bees will nest in building foundations.

Bumble bees are one of the only bees native to the United States and Canada that are truly social, meaning they live in a hive with a single reproductive queen and multiple sterile workers. Unlike honey bee queens, a bumble bee queen lives for only a single year. This annual cycle generally keeps bumble bee hives much smaller than the hives of honey bees. Most mature bumble bee colonies consist of fewer than 200 bees, although some can have as many as 1,000 individuals. For comparison, honey bees may have around 60,000 bees in a single colony. All bumble bee workers are female. They perform a variety of duties including foraging for nectar and pollen, feeding the growing young, feeding the queen, cleaning the nest, and defending the hive when needed. Worker bumble bees generally do not lay eggs, either because they have underdeveloped ovaries due to the suppression of a hormone needed for ovary development, or because of physical aggression from the queen. Either way, the queen is the primary reproducer and the workers simply maintain a healthy colony. Male or drone bumble bees do not participate in the activities of the workers.

APIS MELLIFERA

This section was adapted from: Wilson, Joseph S.; Messinger Carril, Olivia J. (2015-11-24). The Bees in Your Backyard: A Guide to North America's Bees (Page 246-250). Princeton University Press. Kindle Edition.

Apis mellifera are not native to North America, but were brought here by European colonists in the 1600s. Honey bees differ from most other bees in North America in two key ways: (1) they are social (with a queen and workers living in a hive) and, (2) related to their sociality, they produce large amounts of honey.

DESCRIPTION

Credit:

Often, when people think of a bee they picture a honey bee. Honey bees are common, medium-sized bees in the genus *Apis*. In North America, all honey bees are members of the same species, *Apis mellifera*, also known as the European honey bee.

DISTRIBUTION

Apis mellifera is found worldwide with the exception of Antarctica, the Arctic Circle, and the Sahara desert (although a wild colony was discovered at an isolated oasis in Libya). While the European honey bee, because of its domestication by humans, is extremely widespread, six other *Apis* species also exist. They are native to Asia and the Middle East and are not as far ranging.

DIET AND POLLINATION SERVICES

Honey bees are true generalists and will collect pollen or nectar from nearly every type of flower. They have even been seen gathering pollen from plants that are typically wind pollinated like corn, pine trees, or sagebrush. In addition to collecting pollen to feed developing larvae, honey bees spend a fair amount of time collecting nectar, which is stored as honey. Honey bees collect nectar from flowers and transport it back to the hive. Here, it is partially digested, then regurgitated into honeycomb, and finally thickened into honey when the bees buzz their wings over the honeycombs and excess water is evaporated. In wild colonies, the honey is used as a food source during colder months, when floral resources are scarce. In domestic colonies, the honey is harvested and bees are often fed a diet of sugar water during cold months.

Honey bees have become the most widely used pollinator in agricultural systems, largely because of their easily manageable, transportable, and extremely large colonies. In fact, honey bees account for nearly 80% of all crop pollination in the United States. Most beekeepers use modern box-like hives to house their colonies, which can be easily transported from one crop to another. This allows beekeepers to rent out their colonies for crop pollination across the country. Some are shipped from Michigan to California to Florida in the span of a few months in order to provide pollinators for the crops grown in each of these states at different times of year.

OTHER BIOLOGICAL NOTES

One aspect of honey bee biology that makes them particularly valuable for agriculture is that they are active primarily on the basis of temperature rather than seasonality the way other bees are. Honey bees are most active between 60 and 105 ° F, though they can forage at temperatures as low as 55 ° F. This characteristic makes them valuable pollinators of crops that bloom before many native bees are active. For example, almond trees in California will flower in February, earlier than most native bees typically emerge, but honey bees will effectively pollinate the almond trees as long as the temperature is warm enough. The ability of honey bees to forage at such a large range of temperatures means that they are active somewhere in North America during every month of the year.

Despite the common depiction of honey bee hives as oval-shaped structures, covered in a paper-like substance and hanging from a tree branch as a tempting snack for a cartoon bear (think of Yogi Bear and Winnie the Pooh), honey bees actually nest in cavities like hollow trees or rock cavities. The paper nests we see hanging from tree branches belong to wasps.

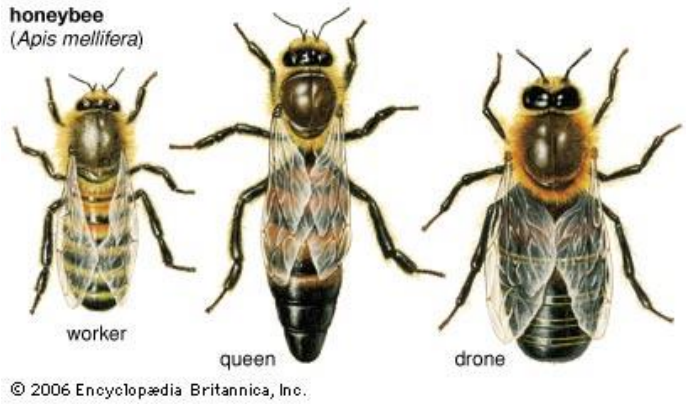
Predators seem to inordinately target honey bees and their colonies (to feed on the honey and the larval bees). As a result these bees have evolved some unique defenses. First, inherent to their social structure, they are able to defend their hive as a coordinated group, with several hundred or thousand bees attacking a predator. Second, honey bee workers have a unique sting with barbs on it, like a harpoon. When a honey bee stings a predator, the barbs on the sting cause it and the attached venom sack to lodge in the skin of the attacker. The venom sack continues to pump venom through the sting into the skin of the predator, potentially inflicting more damage than barbless stings inflicted by other bees.

One result of the honey bee's sting and venom sack becoming lodged in the attacker is that when the bee pulls away from her victim, she suffers a mortal wound; her sting and venom sack are ripped out of her abdomen. A honey bee worker can thus sting only once, dying soon after stinging something. Despite this deadly defensive strategy, a colony consisting of tens of thousands of worker bees will be better off losing a few hundred members in defense of the hive than having the entire hive destroyed.

Dozens of books have been written about honey bees, specifically about their social structure. Thus, the following is just a brief overview. As mentioned previously, honey bees are known to be eusocial, meaning they live in a colony that participates in cooperative care of the young and there is a division of labor with reproductive and non-reproductive groups. A honey bee colony typically consists of a single reproductive queen, several thousand drones (fertile male bees), and tens of thousands of sterile workers, which are all female.

QUEENS

Queen honey bees are adult females that have mated. Typically a queen will mate with 12–15 drones. She then stores the sperm from these drones in a special organ called a spermatheca. In this organ she will keep the sperm alive for the remainder of her life, which can be from two to seven years. A queen bee can choose whether she wants to lay an unfertilized egg, which will develop into a male bee, or to use some sperm from her spermatheca to fertilize an egg, which will develop into a worker or new queen. At the peak of egg laying, a queen can lay up to 2,000 eggs a day—more than her own body weight. This feat is made possible by the hoard of worker bees meticulously attending to the queen's every need, including feeding and cleaning her.



WORKERS

Worker honey bees are females that lack full reproductive capabilities. Worker bees have a much shorter life span than the queens, typically living only a few months, even fewer during the summer season. Over the entirety of their lives, worker bees' duties include cleaning brood cells, feeding larvae, feeding drones, feeding the queen, producing

wax, building brood cells and honeycomb, sealing full honeycombs, attending the queen, storing pollen, removing dead larvae and workers, fanning the hive to maintain a constant temperature, carrying water, foraging for pollen and nectar, and defending the colony. These tasks are taken on sequentially, with worker bees playing different roles as they mature. A young worker bee is responsible for cleaning the brood cells, the areas of the hive where larvae grow and develop. Older worker bees function as nurse bees, responsible for feeding the colony's larvae. These larvae will develop into either more workers or future queens, depending on the diet they are fed by the nurse bees. After being a nurse bee, a worker honey bee focuses on wax production, then on repairing the wax cells used to house larvae and honey. Wax is produced by the worker through special glands on the abdomen. These roles: cleaning, nurse bee, and wax production, last about half a worker's life; the remainder is spent foraging.

Honey bee workers exchange information about good foraging resources by dancing inside the hive. This process, known as the waggle dance, can portray information about the distance and direction of a particular resource from the hive, so that other workers will be more efficient in their foraging.

DRONES

Drones are fertile male bees. Drones do not perform tasks around the colony the way workers do; their main role is to mate with a receptive queen (from a colony other than their own). The life expectancy of a drone is typically about three months.

DISAPPEARING HONEY BEES

An important topic seen frequently in the news is the "disappearance" of honey bees. The cause of honey bee declines is currently a focus of numerous scientific studies, but the reason remains elusive. Bees have always suffered from a number of issues related to nesting close together (mites, viruses, fungi, etc.). The current epidemic, wherein all the workers in a hive disappear (leaving the queen behind), is called Colony Collapse Disorder (CCD). CCD is concerning because our agriculture system relies heavily on honey bees for pollination, and the shortage of healthy hives to transport to flowering crops means much-reduced fruit set. It is important to realize that this phenomenon is not one in which all the bees die (with dead workers filling the hive), but rather a case where something causes all the worker bees to leave the hive and not return. Similar things have happened in the past;

for example, symptoms similar to those of CCD were documented as far back as 1869. In the early 1900s, a similar phenomenon was called disappearing disease. While an explanation for CCD remains uncertain, scientists think that other factors may be exacerbating the problem (pesticides, parasitic mites, viruses, and climate change).

THE VALUE OF BEES

This section was adapted from: http://usda.mannlib.cornell.edu/usda/current/Hone/Hone-03-20-2015.pdf; https://beespotter.org/topics/economics/; http://govinfo.library.unt.edu/npr/library/reports/ag02.html

It is estimated that in North America around 30% of the food humans consume is produced from bee pollinated plant life. The value of pollination by bees is estimated around $20 billion in the US alone. We would be unable to enjoy most of our favorite fruits, vegetables, or nuts without these pollinators. Foods and beverages produced with the help of pollinators include blueberries, chocolate, coffee, melons, peaches, pumpkins, vanilla, and almonds. Plants that depend on a single pollinator species, and likewise, pollinators that depend on a single type of plant for food are interdependent. If one disappears, so will the other. Bees also pollinate crops such as clover and alfalfa that cattle feed on, making bees important to our production and consumption of meat and dairy.

Whereas crop pollination is, by far, the most important and profitable of bee services, honey is the most well known and most profitable of the direct products resulting from the efforts of honey bees. Natural honey is sweet, pleasant smelling, and delicious to many. It can also be artificially and naturally flavored with nuts and spices. Honey production from around 212 thousand American beekeepers caring for approximately 2.74 million colonies totaled almost 178 million pounds in 2014. This production sold at a record per pound cost of 216.1 cents. Although honey is often the first product to come to mind, bees also make or are indirectly involved in making other goods. These include honey based products (such as candy), beeswax, pollen (as a supplement), candles, propolis (or bee glue, used in cosmetics), as well as additional bees for sale to other parties.