Bee Observer Cards

Complete Set of 36 Cards

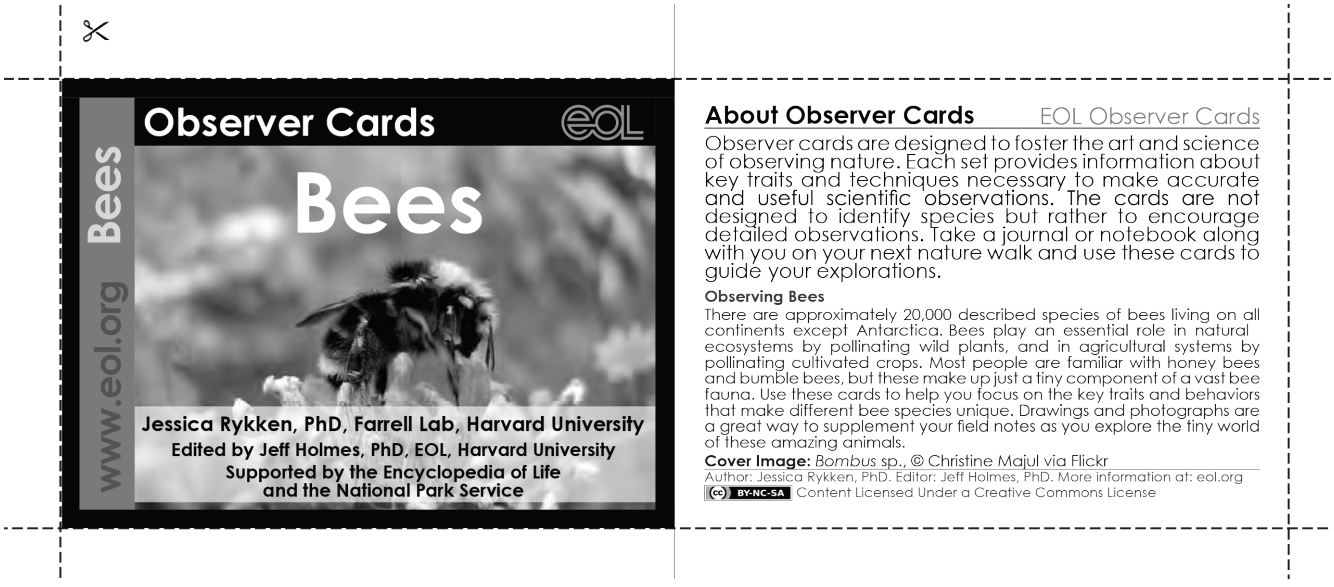
There are approximately 20,000 described species of bees living on all continents except Antarctica. Bees play an essential role in natural ecosystems by pollinating wild plants, and in agricultural systems by pollinating cultivated crops. Most people are familiar with honey bees and bumble bees, but these make up just a tiny component of a vast bee fauna. Use these cards to help you focus on the key traits and behaviors that make different bee species unique. Drawings and photographs are a great way to supplement your field notes as you explore the tiny world of these amazing animals.

About Observer Cards

Observer cards are designed to develop the art and science of observing nature. Each set of cards provides key traits and techniques neccessary to make accurate and useful scientific observations. Observer cards are not designed to identify species, but rather to encourage detailed observations. Although, if you carefully observe many or all of the traits shown in the cards, it's likely an identification could be made. Take a journal or notebook along with you on your next nature walk and use these cards to guide your explorations.

Print Instructions

- Print pages 2-13 of this PDF document
- Fold each page in half lengthwise
- Cut along the dotted lines
- Fold the cards and join together with tape or glue
- You should have a set of 36 cards



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Bees

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Observer Cards

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Edited by Jeff Holmes, PhD, EOL, Harvard University
Supported by the Encyclopedia of Life
and the National Park Service

About Observer Cards

EOL Observer Cards

Observer cards are designed to foster the art and science of observing nature. Each set provides information about key traits and techniques necessary to make accurate and useful scientific observations. The cards are not designed to identify species but rather to encourage detailed observations. Take a journal or notebook along with you on your next nature walk and use these cards to guide your explorations.

Observing Bees

There are approximately 20,000 described species of bees living on all continents except Antarctica. Bees play an essential role in natural ecosystems by pollinating wild plants, and in agricultural systems by pollinating cultivated crops. Most people are familiar with honey bees and bumble bees, but these make up just a tiny component of a vast bee fauna. Use these cards to help you focus on the key traits and behaviors that make different bee species unique. Drawings and photographs are a great way to supplement your field notes as you explore the tiny world of these amazing animals.

Cover Image: *Bombus* sp., © Christine Majul via Flickr

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Bees

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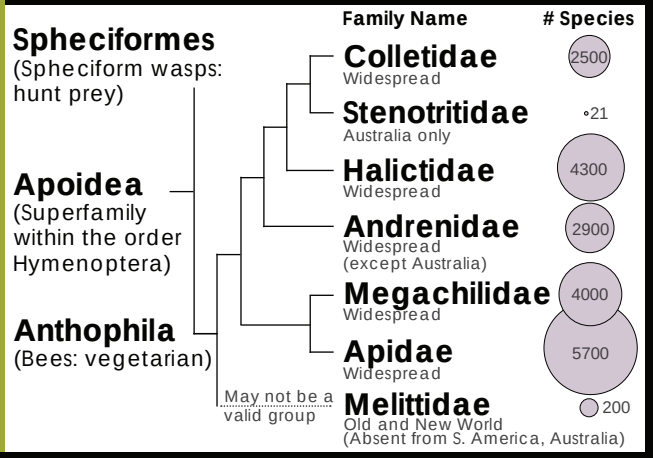
Bee Families



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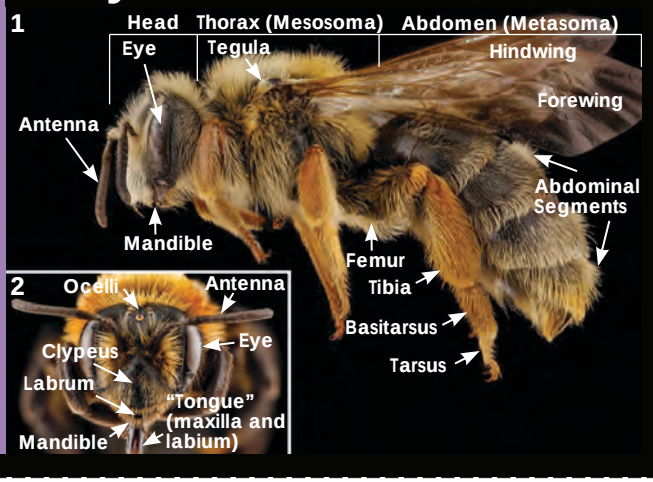
Bee families graph based on: Danforth, B.N., S. Cardinal, C. Praz, E.A.B Almeida, and D. Michez. 2013. The impact of molecular data on our understanding of bee phyologeny and evolution. Ann. Rev. Entomol 58:57-78.

Bees

Anatomy

Body Plan



Body Plan

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Like other insects, bees have three basic body parts: head, thorax, and abdomen. The head has a large pair of eyes with a row of three small ocelli above, one pair of antennae, and a mouth with both chewing and lapping structures. Attached to the thorax are two pairs of wings and three pairs of legs. The slender waist between the thorax and abdomen allows flexibility. The abdomen is segmented, and females have a stinger projecting from the last segment.

Supplemental Notes

The slender waist common to all bees (and wasps) is actually a constriction between the first and second abdominal segments. The first abdominal segment, known as the "propodeum" is fused to the thorax, together they are termed the "mesosoma." What we see as the abdomen (segment 2 onwards) is termed the "metasoma."

Images: 1. Lateral view of *Andrena commoda* female, © USGS BIML via Flickr; 2. Head of *Andrena lupinorum* female, © USGS BIML via Flickr.

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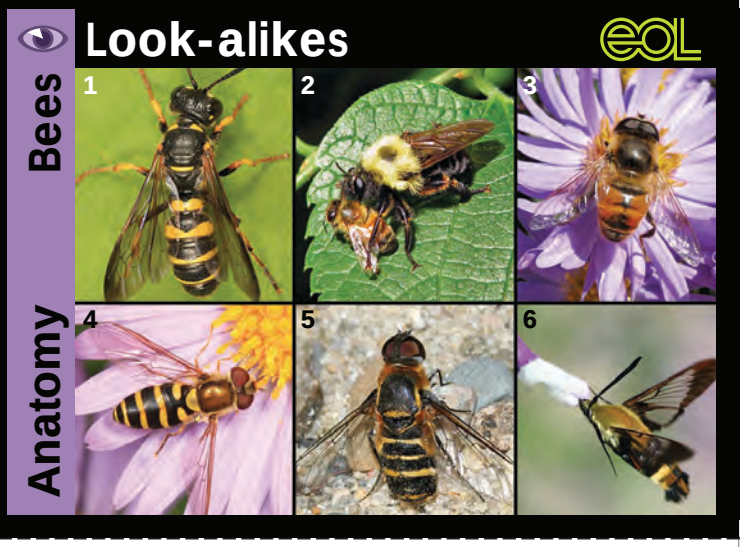

Look-alikes

EOL Observer Cards

Observing a few key characters will help you distinguish a bee from a closely related wasp or a bee-mimicking fly. Wasps are less hairy than most bees, often have more obvious "waists," and generally have brighter color patterns. Some flies look like bees, but they have only two wings (versus four for bees and wasps). Most flies have larger eyes that meet nearly on top of their head, and shorter, thinner antennae.

Supplemental Notes

Although most wasps and flies do not gather pollen as a protein source, many visit flowers for nectar. Bee-mimicking flies include flower flies which hover like helicopters, bee flies, and robber flies. Cuckoo bees (true bees) can be difficult to tell from wasps because they do not transport pollen and so tend to have little hair. They are also often brightly-colored.

Images: 1. A crabronid wasp (*Cerceris* sp.), © Tom Murray; 2. A robber fly (*Laphria* sp.) preying on a honey bee, © Lisa Brown via Flickr; 3. *Eristalis tenax*, a hover fly often mistaken for a honey bee, © Gilles Gonthier via Flickr; 4. A hover fly (*Syrphus torvus*), © Tom Murray; 5. A bee fly (*Villa* sp.), © Tom Murray; 6. Moths can mimic bees too! Hummingbird clearwing moth (*Hemaris thysbe*), © Ken Slade via Flickr.

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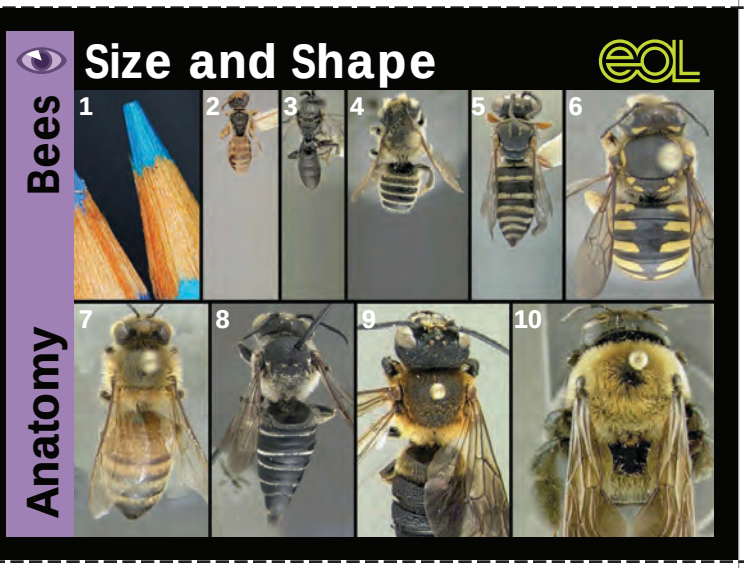

Size and Shape

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Observing the size and shape of a bee can help you identify it, as these dimensions are quite variable across species. North American bees range from 2mm to more than 25 mm in length. As you compare body shapes, note that some bees have a slender thorax and/or abdomen, while others are much stouter. Also examine the tip of the abdomen - is it rounded or pointed?

Supplemental Notes

Body size can influence the types of flowers a bee visits. For instance, very large bees, like carpenter bees, are limited to visiting flowers large and strong enough to provide a supportive landing pad. Body shape can provide information about the habits of bees. Leafcutter and mason bees have relatively broad abdomens, and this is where they carry their pollen loads. They also often have broad heads because their jaws are large for gathering leaves and other nesting materials.

Images: 1. Pencil tips to show scale, © Mark James, via Flickr; 2. *Perdita gerhardi* (♂) 4.5 mm, © Smithsonian Institution, Entomology Dept.; 3-9 © The President and Fellows of Harvard College. 3. *Lasioglossum foxii* (♀) 6-7 mm; 4. *Megachile brevis* (♂) 7-9 mm; 5. *Epeolus pusillus* (♂) 9 mm; 6. *Anthidium manicatum* (♀) 11-13 mm; 7. *Apis mellifera* (worker ♀) 12-15 mm; 8. *Coelioxys rufitarsis* (♀) 12-18 mm; 9. *Megachile sculpturalis* (♂) 19-22 mm; 10. *Xylocopa virginica* (♀) 19-23 mm.

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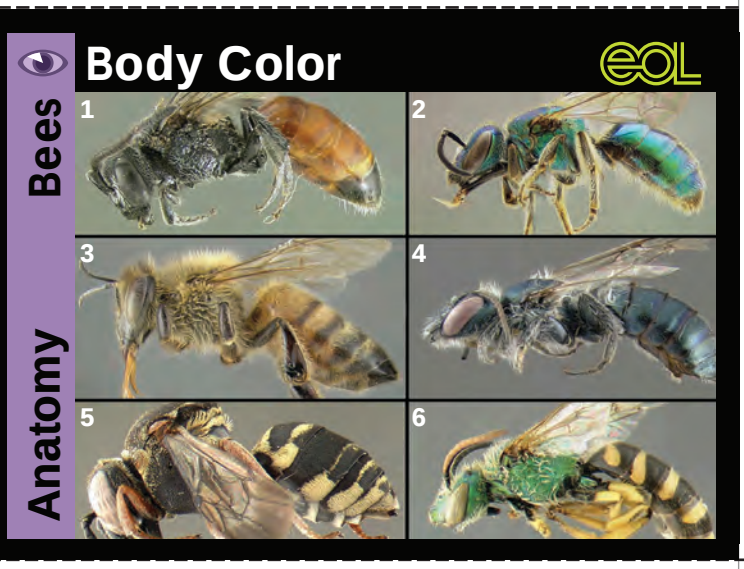

Body Color

EOL Observer Cards

Observing the color of bees can sometimes provide a good hint to their identity. Many bees are brown or black, but others come in metallic colors such as green and blue, as well as orange, red, and yellow. Bees may be all one color (like green sweat bees) or they may be patterned with colorful bands or patches (like honey bees). Take note that males and females of some species can have quite different colors and patterns.

Supplemental Notes

Color in a bee can come from two sources. The integument (or exoskeleton) can be various colors, and the hair of the bee can be different shades of black, brown, yellow, and white. In some cases, if the hair is thick and/or flattened, it can be difficult to tell if the color you see is hair or integument.

Images: All images © The President and Fellows of Harvard College 1. *Sphecodes heraclei* (♀), a cuckoo sweat bee; 2. *Augochlorella aurata* (♀), a sweat bee; 3. *Apis mellifera*, a honey bee worker (♀ sterile); 4. *Osmia atriventris* (♂), a mason bee; 5. *Epeolus autumnalis* (♀), a cuckoo bee with light stripes of flattened hairs; 6. *Agapostemon virescens* (♂), a sweat bee.

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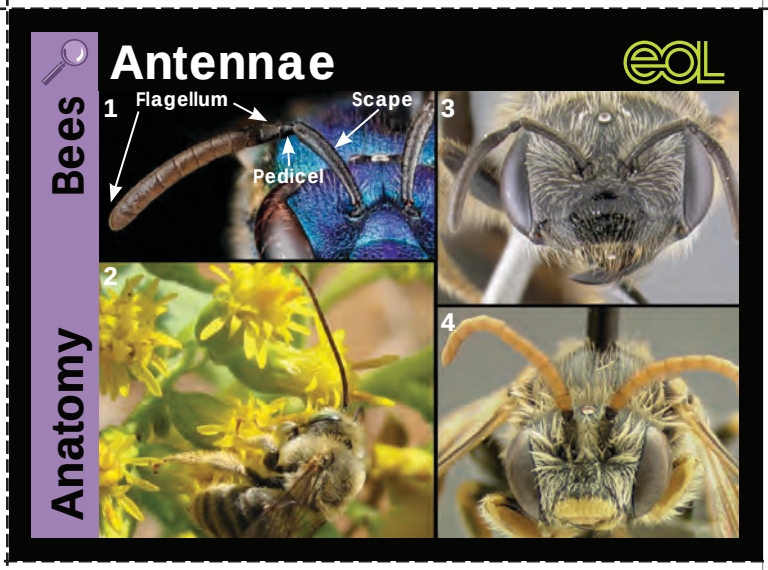

Antennae

EOL Observer Cards

The length and/or color of a bee's antenna can tell you its sex, and also help in species identification. The antennae of male bees are generally long and arched, while female antennae are shorter and often "elbowed." Males of the aptly named "long-horned" bees have extremely long antennae. Antennae are most commonly brown or black, but some bees have lighter colors at the base or on the ventral side.

Supplemental Notes

The long basal segment of the antenna is named the scape, the second small, cup-like segment is the pedicel, and the rest of the segments make up the flagellum. Males have one more flagellar segment than females (11 vs. 10), and the segments themselves are longer. Longer antennae carry more chemoreceptors, which help male bees locate females for mating.

Images: 1. Bee antenna (female), © USGS BIML via Flickr; 2. A male long-horned bee (*Melissodes druriella*) with extremely long antennae, © Edward Trammel; 3. A female sweat bee (*Halictus ligatus*) with shorter, elbowed, brown antennae. © The President and Fellows of Harvard College; 4. A male bee (*Halictus ligatus*), with long, arched, yellow antennae. © The President and Fellows of Harvard College.

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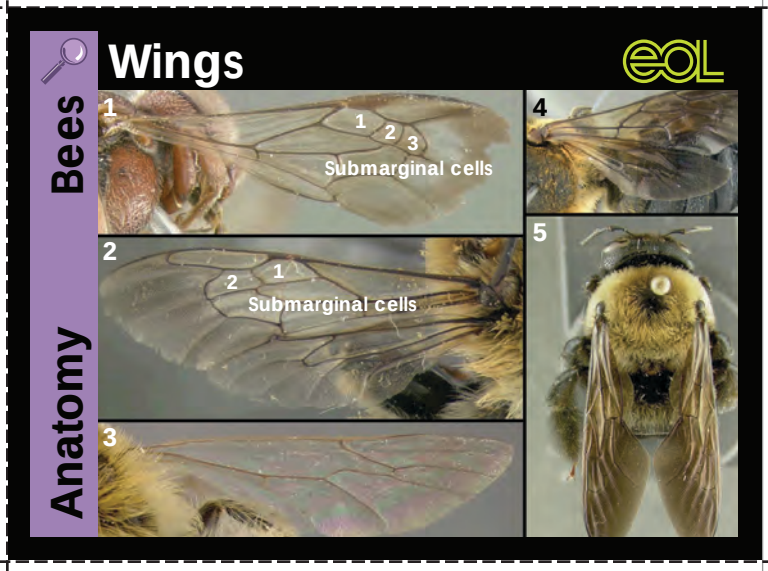

Wings

EOL Observer Cards

The color of bee wings, as well as the pattern of their veins, are used to identify bees. Wings of many bees are clear, but others have smoky brown or yellowish wings. The arrangement of veins and cells on the forewing can be seen with magnification, and is helpful for separating groups of bees. One important forewing identifying character is whether there are 2 or 3 submarginal cells.

Supplemental Notes

All bees have two pairs of wings. As with other winged members of the order Hymenoptera, bees have tiny hooks which connect the forewing to the hindwing while in flight. This makes it look like the bee has only one set of wings when flying. At rest, the wings often lay over each other, making it difficult to count how many there are. Wings are amazingly strong, but wear with time.

Images: All images © The President and Fellows of Harvard College 1. A *Nomada* bee with three submarginal cells on its worn forewing; 2. *Megachile latimanus* with two submarginal cells, showing the fore- and hindwings hooked together; 3. Hindwing of *Andrena perplexus* with few veins or closed cells; 4. *Megachile sculpturalis* with darkened wings; 5. A carpenter bee, *Xylocopa virginica*, showing the typical overlapping position for wings at rest.

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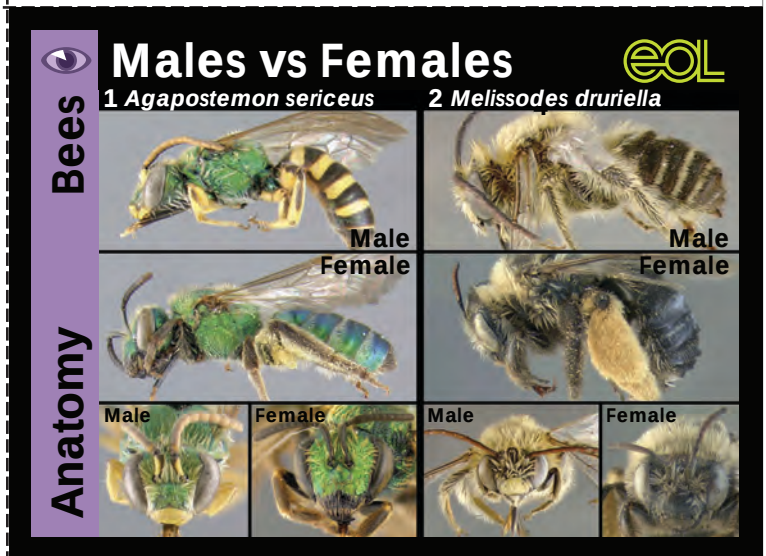

Males vs Females

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Male and female bees of the same species can look very different. In general, females are larger, and have pollen-carrying structures on their legs or abdomen (except for cuckoo bees and species that carry pollen internally). Only females have a stinger at the end of their abdomen. Males have longer antennae, and an additional abdominal segment. Some males have abdominal spines for defense. Color and hair patterns can also differ between the sexes.

Supplemental Notes

Behavioral traits can also be useful for differentiating the sexes. Males usually emerge a few days earlier than females, allowing them to become familiar with the landscape before mating begins. Groups of males may congregate at flowers where females forage, or at nest sites. Males of some species travel circuits or paths to find mates, using their long antennae to pick up female scents. Females spend most of their time foraging at flowers and tending their nests.

Images: All images © The President and Fellows of Harvard College. 1. *Agapostemon sericeus* showing both male and female specimens; 2. *Melissodes druriella* showing both male and female specimens.

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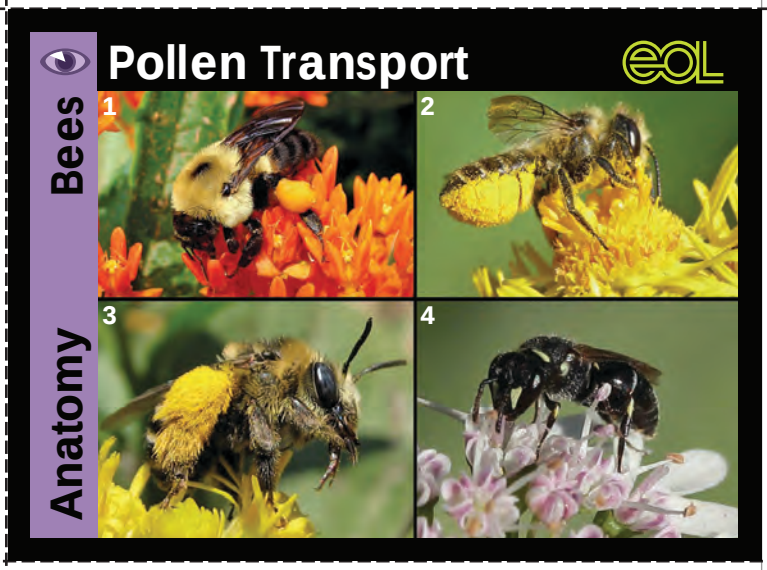

Pollen Transport

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Observe where bees carry pollen on their bodies. Honey and bumble bees carry a mixture of pollen and nectar in a "corbicula" or concave basket surrounded by stiff hairs on the hind leg. Other bees carry pollen on a stiff brush of hairs called a "scopa" on the underside of the abdomen or on the hind legs. You will not see pollen carried on cuckoo bees, nor on bees in the genus *Hylaeus* who carry pollen internally in their "crops" and then regurgitate it later.

Supplemental Notes

Both males and females forage at flowers to feed on nectar for energy, but only females collect pollen to take back to the nest. Females of most bee species accumulate pollen on feathery hairs all over their body, then use their front and middle legs to rake the pollen and transfer it to scopae or corbiculae. Males unintentionally pick up some pollen while foraging.

Images: 1. Bumble bee with pollen and nectar packed into her corbicula, © Martin LaBar via Flickr; 2. *Megachile* bees carry pollen on abdominal scopae, © Ian Boyd via Flickr; 3. *Melissodes* bees have scopae on their hind legs, © Edward Trammel; 4. *Hylaeus* bees have sparse hair and carry pollen internally, © el chip via Flickr.

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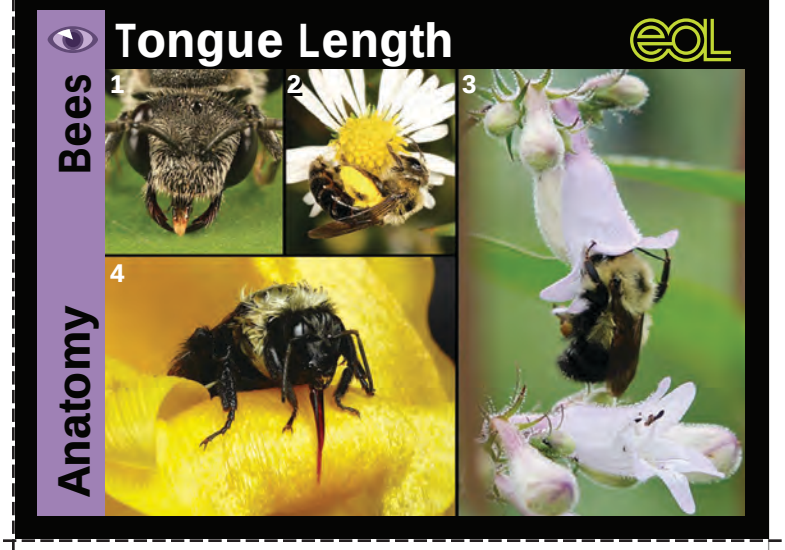

Tongue Length

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The length of a bee's proboscis or "tongue" determines what types of flowers it can access for nectar. Short-tongued bees are limited to gathering nectar from flowers that are open or have short-tubed corollas, such as sunflowers and goldenrods. Long-tongued bees (including honey, bumble, leafcutter, and mason bees) are also able to access long-tubed or complex flowers such as monkshood or *Penstemon*.

Supplemental Notes

The nectar reward from a flower that can only be visited by long-tongued bees is generally higher than from an "easy access" flower that can be visited by many more generalist pollinators. Some small bees with short tongues can also get into deep, wide corollas. Bee tongues are constructed from modified mouthparts (labia and maxillae) that are shared by most insects. Their complex and variable structure is used to identify bee families and species.

Images: 1. *Sphecodes davisii*, a cuckoo sweat bee with a short tongue, © Tom Murray; 2. *Andrena asteris*, a short-tongued mining bee, on an open flower, © Tom Murray; 3. A bumble bee accessing nectar from a long-tubed corolla © John Baker via Flickr; 4. *Bombus impatiens* showing its long tongue, © sankax via Flickr.

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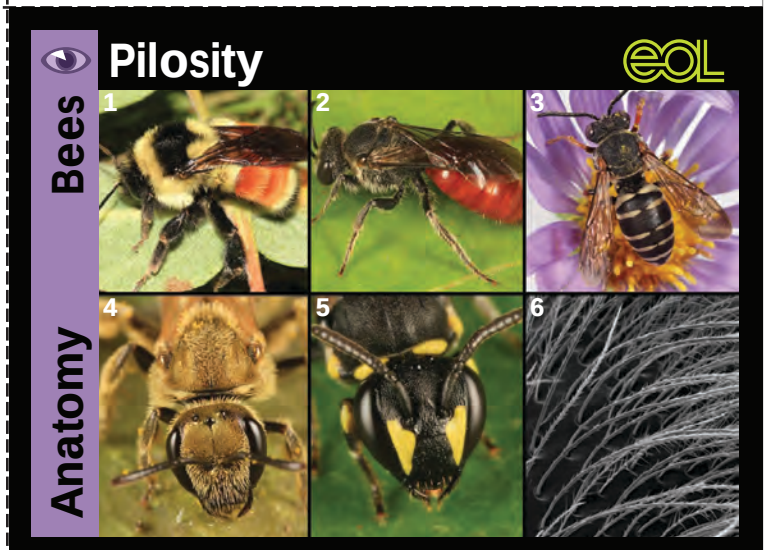

Pilosity

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Bees vary greatly in the density and pattern of hair (pilosity) on their bodies. For example, bumblebees have long, dense insulating hair, while most of the cuckoo bees have very little hair and resemble smooth, shiny wasps. Hair may stick straight out or lay flat against the body. It can be arranged in patches or bands, and can be colored various shades of white, yellow, orange, brown, and black.

Supplemental Notes

Bees have microscopically branched hairs that are very effective for trapping pollen grains. As they're flying, bees also build up an electrostatic charge that helps attract and hold the pollen. Hair can have good insulative value, and this is one of the adaptations that allows fuzzy bumblebees to thrive in cold climates.

Images: 1. *Bombus ternarius*, a very fuzzy bumblebee, © Tom Murray; 2. *Sphecodes davisii*, a cuckoo sweat bee with sparse hair, © Tom Murray; 3. *Epeolus autumnalis*, a cuckoo bee with bands of short, flattened hairs on its abdomen © Tom Murray; 4. *Lasioglossum pilosum*, a sweat bee with short, dense hair, © Tom Murray; 5. Masked bees (*Hylaeus* sp.) have little need for hair because they transport pollen in their crops, © Tom Murray; 6. Close up view of branched hairs from a bumblebee, © Fred Nijhout, Duke Univ.

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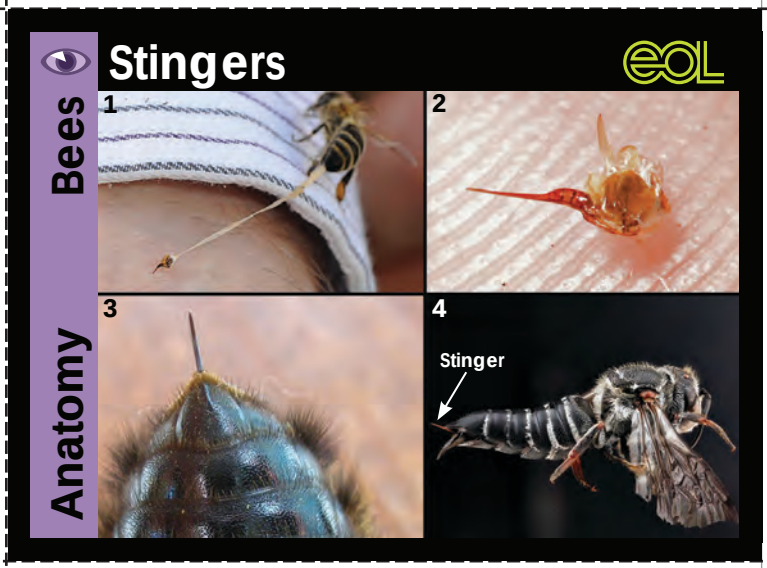

Stingers

EOL Observer Cards

The risk of being stung is minimal with most solitary bees. A bee's stinger is a modified egg-laying apparatus (ovipositor), so only female bees have stingers. Social bees, such as honey bees and bumble bees, are apt to sting while defending their nest, but are much less likely to be provoked while foraging at flowers. Female solitary bees do not defend their nests, and many are incapable of penetrating human skin with their stinger.

Supplemental Notes

A bee sting is most likely to come from a honey bee worker - the only bees who leave their barbed stinger (along with a venom sac) in human skin. Remove the stinger as quickly as possible to avoid the continued release of venom! All other bees have smooth stingers which stay attached to their body after they sting.

Images: 1. Once a honey bee stings a human it will die because the end of its abdomen is torn off as it flies away, © Kathy Keatley Garvey; 2. Barbed stinger, venom sac, and part of the abdomen of a honey bee, © e_monk via Flickr; 3. The stingers of all other bees are smooth (not barbed) like this bumble bee stinger, © Candace Best; 4. Cuckoo bees often have stronger stingers than those of other solitary bees in order to protect themselves from host bees when invading a nest (*Coelioxys sayi*), © USGS BIML via Flickr.

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Food Sources

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Observe bees foraging for nectar and pollen. Nectar is a sugar-rich liquid that provides energy to both males and females; bees use their tongues to lap it up from various parts of a flower. Pollen granules from a flower's anthers are the source of protein. Females transport both nectar and pollen back to the nest to provision their developing young. Nectar is carried internally in the bee's sac-like crop, while pollen (either dry or mixed with nectar) is typically carried on specialized external structures.

Supplemental Notes

Bees usually visit a wider variety of flowers for nectaring than for gathering pollen. A few bees collect floral oils to feed their young. Oil-producing flowers do not provide nectar, so adults must forage at different flowers for their own energy source.

Images: 1. Bumble bee sipping nectar and loaded with pollen to take back to the nest © Martin LaBar via Flickr; 2. Bee food: anthers of a tulip loaded with pollen, © Martin LeBar via Flickr; 3. The sealed brood cell of a red mason bee (*Osmia rufa*) is provisioned with all the pollen and nectar the developing bee will require, © tpjunier via Flickr; 4. Bees feed at "nectaries" located on various parts of a flower, © Tess Watson via Flickr.

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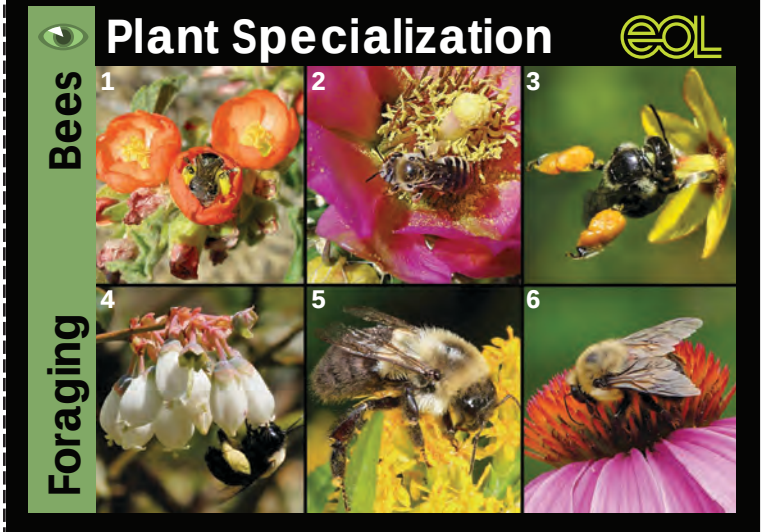

Plant Specialization

EOL Observer Cards

Note the flower species on which a bee is foraging. Many bees gather nectar and pollen from a wide range of host plants, especially bees that are active for much of the growing season, such as bumble bees. Other bees (such as *Peponapis* squash bees) are more selective, and forage only on a group of related plants. A few species consume pollen from just a single plant species, for example the southeastern blueberry bee specializes on rabbiteye blueberry.

Supplemental Notes

Sometimes all bee species within a genus specialize in collecting pollen from closely-related plants, such as *Macropis* bees, which collect oil and pollen from loosestrife (*Lysimachia*) plants. Alternatively, closely-related bee specialists (e.g. *Diadasia*) may forage on plants that are unrelated.

Images: 1. *Diadasia diminuta*, a globe mallow specialist, © Vince Tepedino, USDA ARS; 2. *Diadasia rinconis*, a cactus specialist, on *Opuntia imbricata*, © Cynthia McAlister; 3. *Macropis ciliata*, sponging oil from a *Lysimachia* flower with her foreleg, © Micahel Veit; 4. The southeastern blueberry bee, *Habropoda laboriosa*, © Darrel Martin; 5. A generalist, *Bombus impatiens*, on goldenrod (*Solidago*), © Tom Murray; 6. *B. impatiens* on purple coneflower (*Echinacea*), © Dendroica cerulea via Flickr.

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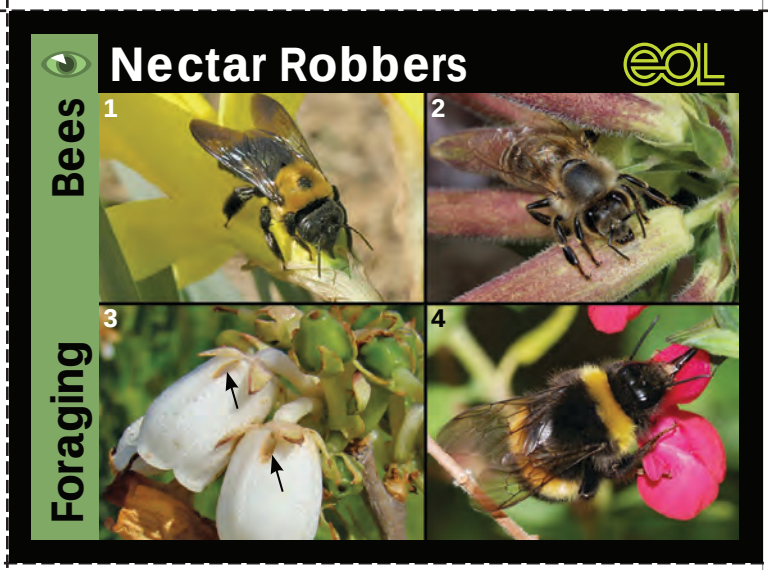

Nectar Robbers

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Observe on what part of a flower a bee is foraging. If it is feeding while on the **outside** of the petals, it is probably robbing nectar. Some bumblebees and carpenter bees chew or poke holes at the base of petals and extract nectar without ever entering the inside of the flower. Alternatively, look for the small holes at the base of flower petals as evidence of nectar robbing.

Supplemental Notes

Nectar robbers typically do not get near the plant's reproductive parts while feeding and thus have long been considered "cheaters" in the plant-pollinator relationship. However, it is now thought that nectar robbers may have a beneficial or neutral effect on pollination by reducing the amount of nectar available, causing other bees to visit more flowers and transport pollen to plants at greater distances.

Images: 1. A carpenter bee (*Xylocopa virginica*) robbing nectar from a daffodil, © Marvin Smith via Flickr; 2. Honey bees are "seconday robbers", using holes made by other bees to steal nectar, © Bernhard Jacobi; 3. Highbush blueberry flowers with slits made by a nectar robber, © Anita Gould via Flickr; 4. A bumble bee (*Bombus terrestris*) robbing nectar, © Joaquim Alves Gaspar via Wikipedia.

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Social Bees

EOL Observer Cards

Social bees live in colonies and divide labor among females of different generations. Honey bees live in large hives that persist for many years, with thousands of workers providing for one egg-laying queen. Bumble bees have small, annual nests. Fertilized queens overwinter alone, and emerge early in the season to forage and find a nest site. Here they produce sterile female workers and later in the season, males and new, fertile queens.

Supplemental Notes

The degree of sociality among bees varies greatly. Honey bees are highly social with perennial nests and the most pronounced division of labor. Bumble bees and many sweat bees have annual colonies with founding queens who assume all roles to get the colony growing in the spring. Other bees are considered "semi-social," with division of labor occurring among females of the same generation.

Images: 1. Exposed combs of a wild honey bee (*Apis mellifera*) nest, © Max Westby via Flickr; 2. Honey bees "swarm" to find a new hive site, © Forest and Kim Starr via Flickr; 3. Bumble bees (*Bombus* sp.) often nest in abandoned small mammal burrows, © Doug Waylett; 4. Immature bee cells and nectar pots in a large bumble bee nest, © Photo Munki via Flickr.

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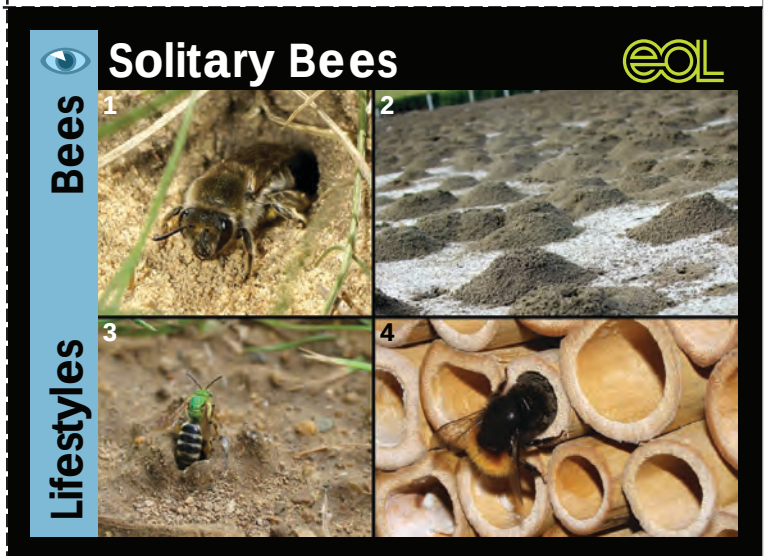

Solitary bees

EOL Observer Cards

For the vast majority of bees, each female builds and provisions her own nest. Most nests are dug underground (by miners), but others may be constructed in pre-existing cavities and crevices (by masons and leafcutters), or actively excavated in soft wood or pithy plant stems (by carpenters). Look for female bees entering or leaving their nests as they forage for food and building materials, or find completed nests whose entrance holes may be plugged with leaves or mud.

Supplemental Notes

Ground-nesting solitary bees sometimes construct their individual burrows in dense aggregations, with each female tending her own nest. Other bees are considered "communal" in that two or more female share a nest entrance, even though they construct and tend their own brood cells.

Images: 1. A cellophane bee, *Colletes inaequalis*, emerging from her burrow, © Rob Cruickshank via Flickr; 2. Aggregation of alkali bee (*Nomia melanderi*) nests, © Jim Cane; 3. Some metallic green bees in the genus *Agapostemon* are communal nesters, © Drew Marold via Flickr; 4. A mason bee in the genus *Osmia* seals the end of her tubular nest with mud, © Max Westby via Flickr.

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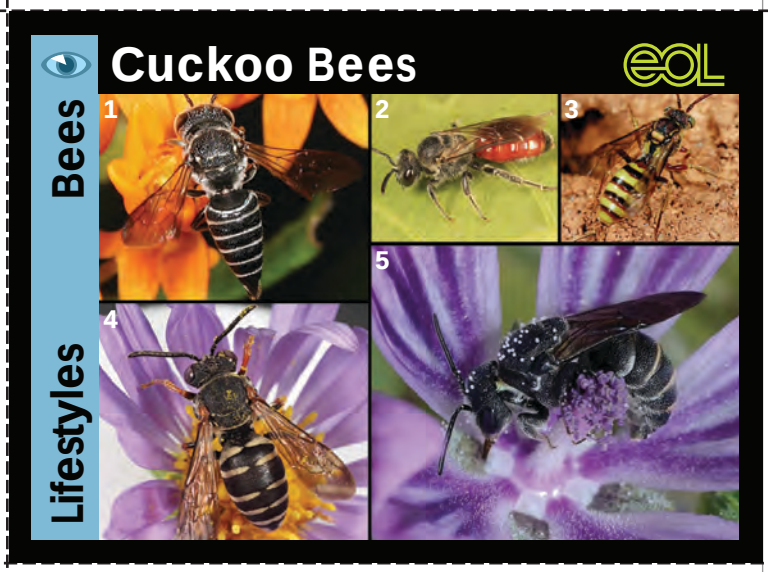

Cuckoo Bees

EOL Observer Cards

Observe bees entering and exiting nest holes. Their behavior and appearance can help you determine whether they are residents or intruders! Cuckoo bees sneak into unguarded nests to lay their eggs while the host female is off foraging. Because their offspring feed on the host's pollen stores, cuckoo bees don't need to transport pollen, and thus have very little hair. Many cuckoo bees resemble shiny, brightly-colored wasps.

Supplemental Notes

After hatching, each cuckoo larva kills the resident egg or larva in the brood cell and, as it develops, consumes the pollen and nectar provisioned by the host female. The relationship between the host and the cuckoo bee is also referred to as "cleptoparasitism." Cuckoo bees are common, about one fifth of all North American bee species share this lifestyle.

Images: 1,2,4 © Tom Murray; 1. *Coelioxys modesta*; hosts for this genus are leafcutter bees (*Megachile*); 2. *Sphecodes confertus*; hosts are other sweat bees (*Halictinae*); 3. *Nomada imbricata* at the entrance to a host mining bee (*Andrena*) nest, © Patrick Coin; 4. *Epeolus autumnalis*; hosts are cellophane bees (*Colletes*); 5. *Stelis punctulatissima*; hosts are mason and leafcutter bees, © bleu.geo via Flickr.

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Miners

EOL Observer Cards

Look for small holes, often surrounded by mounds of excavated soil, on lawns or sparsely vegetated open areas as evidence of mining bees. Other mining bees nest in vertical soil banks and some construct tube-like turrets by sticking together small soil pellets with a gluey secretion. Sandy or loamy soil is often preferred.

Supplemental Notes

Mining bees make up about 70% of our native bee fauna, and nest architecture below ground varies widely among different species. Nests may extend 60 cm or more in depth, with one or more tunnels leading to the brood cells where eggs are laid and the young develop. Most species line the cells with a secretion to make them waterproof and resistant to mold. Although mining bees are typically solitary nesters, some species nest in dense aggregations of thousands of bees, each bee in its own nest.

Images: 1. The nests of *Anthophora bomboides* can be found near the sea shore. © Sean McCann; 2. Turrets at the nest entrances of *Anthophora abrupta*. © John Hartgerink; 3. The hind end of an *Andrena bradleyi* as she enters her nest. © Zach Portman; 4. *Colletes inaequalis* lines its nest with a waterproof "cellophane." © Michael Battenberg.

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Masons

EOL Observer Cards

Most mason bees make nests in pre-existing cavities. They gather materials such as mud, resin, plant hairs, pebbles, or chewed leaves to line the nest, and to mold into brood cell walls and a plug at the nest opening. Look for these solitary bee nests in crevices in bark and rock, old insect holes in dead wood, abandoned wasp nests, pithy plant stems, and empty snail shells.

Supplemental Notes

Some tunnel-nesting mason bees, such as orchard mason bees, can be enticed to nest in aggregations in artificial nest sites such as wood blocks drilled with holes, or bundles of hollow stems or tubes. The bees can then be managed for pollination in orchards and farms.

Images: 1. A wool carder bee (*Anthidium manicatum*) carding "wool" from lamb's ears (*Stachys byzantina*) to line its nest, © Alan Phillips; 2. A male mason bee (*Hoplitis spoliata*) emerging from a nest, © Rob Cruickshank via Flickr; 3. Mason bees (*Osmia* sp.) plug the ends of their bamboo nests with mud, © poppetwithacamera via Flickr; 4. Snail shell containing brood cells of the mason bee, *Osmia spinulosa*, © Andreas Müller; 5. Artificial nesting blocks for mason bees, © Margriet Dogterom.

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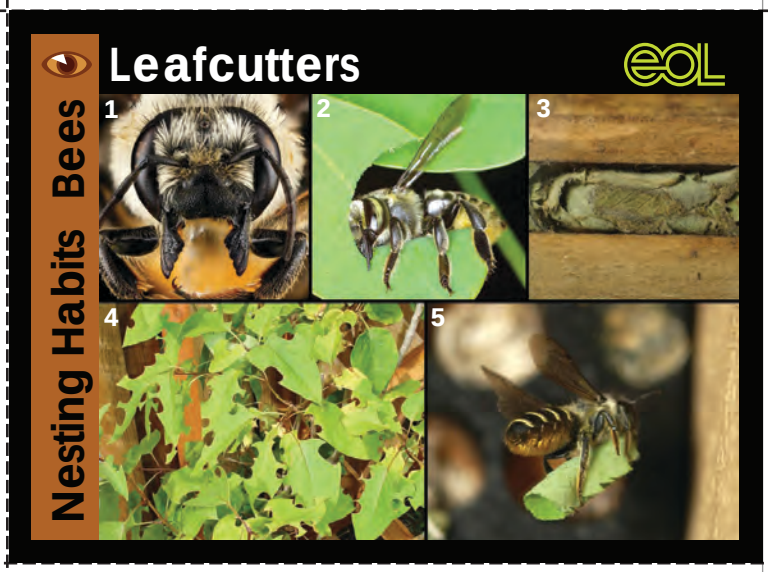

Leafcutters

EOL Observer Cards

In summer, look for bees cutting small discs of leaves or petals with their scissor-like jaws, or flying with the cuttings to a nearby nest. Leafcutter bees typically nest in existing cavities like insect holes in wood, hollow plant stems, even garden hoses, and use leaf fragments to line the nest and make cell walls. A bee will usually gather all the leaf material for her nest from one place, and will leave behind many tell-tale leaves with holes in their margins.

Supplemental Notes

The leaf fragments used in nest-building are shaped differently according to their purpose. Those used to line the sides of brood cells are oval, while the dozen or more leaf pieces sealing each cell are perfectly round. One cell can take an entire day to provision and construct. The female sits at the nest entrance each night to deter predators.

Images: 1. The large mandibles of *Megachile latimanus* have beveled edges like scissors, © USGS BIML via Flickr; 2. *Megachile albitarsis* cutting a piece of leaf with her large mandibles, © Tim Lethbridge; 3. Cross-section of a leafcutter nest, showing the leafy brood cell walls, © Rob Cruickshank via Flickr ; 4. A lilac bush with the tell-tale signs of a leafcutter bee, © Strata Chalup via Flickr; 5. A bee carrying a leaf disc to her nest, © Rob Cruickshank via Flickr.

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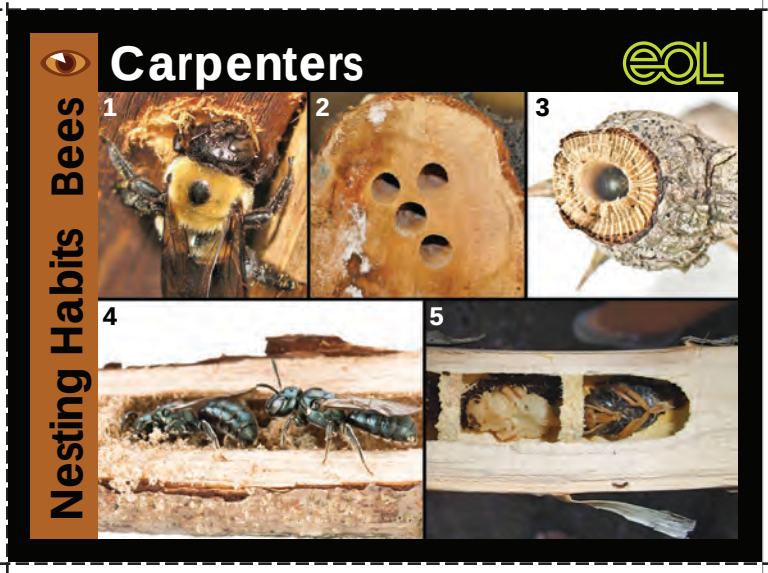

Carpenters

EOL Observer Cards

Look for large holes in soft wood (including tree snags, branches, lawn furniture, house eaves) and plant stems as evidence of large carpenter bees who use powerful jaws to excavate their nests. Smaller holes in the pithy stems of shrubs may indicate nests of small carpenter bees. Small carpenter bees can often be seen at their nest entrances, where they remain, and die, while their offspring develop and overwinter inside the stem.

Supplemental Notes

Since carpenter bees excavate their own nests, you may see piles of sawdust below the nest entrance of large carpenter bees, especially while they are excavating. Carpenter bees do not eat the excavated wood or pith, but they use both for partitioning their brood cells, which are typically arranged in a long row.

Images: 1. A large carpenter bee (*Xylocopa virginica*) begins excavating a new nest, © Scott Nacko; 2. Holes excavated in plum wood by a female large carpenter bee (*Xylocopa varipuncta*), © Kathy Keatley Garvey; 3. An adult small carpenter bee (*Ceratina* sp.) at the nest entrance, © Alex Surcică; 4. Cross-section of a small carpenter bee (*Ceratina calcarata*) nest, within the pithy stem of a shrub, © Alex Surcică; 5. Cross-section of a *Xylocopa* nest, showing pupae in brood cells separated by sawdust, © Elizabeth Sellers via Flickr.

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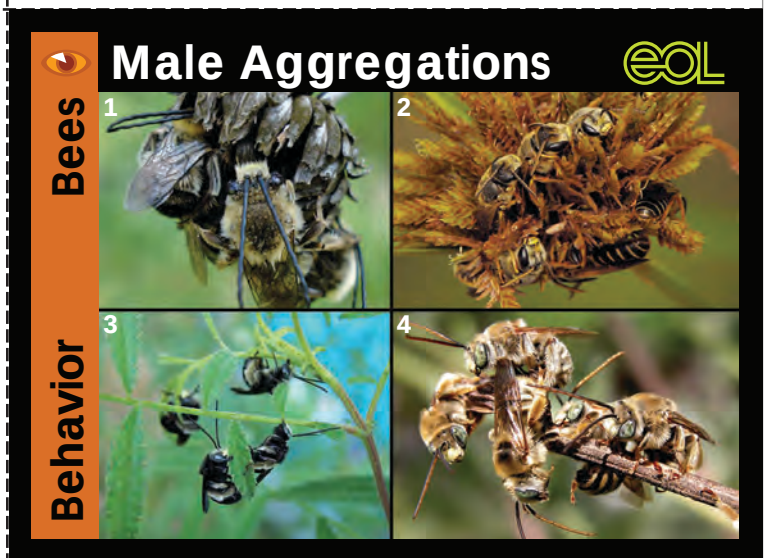

Male Aggregations

EOL Observer Cards

Look carefully for groups of bees crowded together in the evening or early morning. They may be hanging by their jaws from various plant parts, hidden inside flowers that are closed up for the night (e.g., squash flowers), or even dug into a temporary shelter in the sand. These are male solitary bees, and although they may be very territorial by day, they become much more cooperative at night!

Supplemental Notes

Because male solitary bees don't have a nest to return to at the end of the day, they often aggregate in the late afternoon to spend the night together. This is thought to be a defensive strategy. Males will often return to the same "roost" each night. Aggregations may consist of males from a single species, or there may be several species in the group.

Images: 1. Male long-horned bees (*Eucera* sp.) hanging on an old flower pod, © Beth Sands; 2. *Halictus parallelus* males. © Sean McCann; 3. *Melissodes bimaculata* males hanging by their mandibles. © Hannah Nendick-Mason; 4. *Melissodes communis* males. © Hartmut Wisch.

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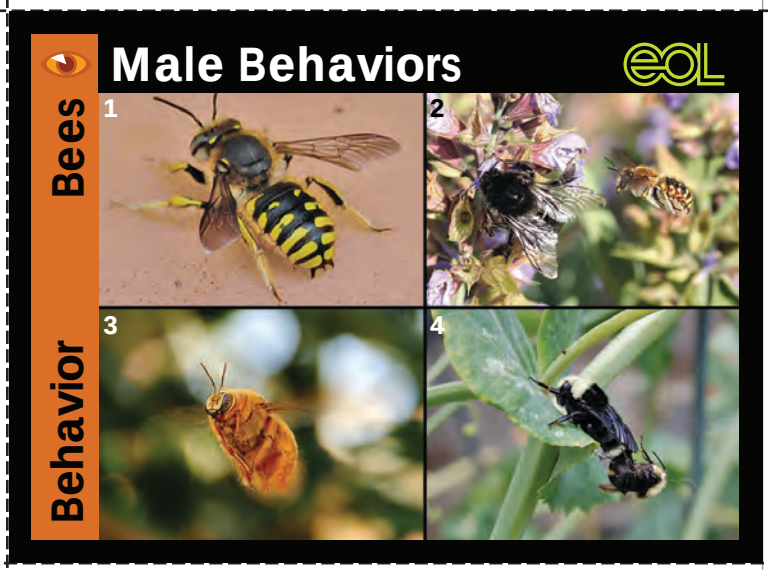

Male Behaviors

EOL Observer Cards

Observe bees in flight. Male bees of many species are territorial and patrol areas near foraging and/or nesting sites where they hope to encounter females. Their flight patterns are often erratic, interspersed with periods of hovering, as they dart out to investigate intruders or capture females within their territory. Some species are quite aggressive and will attack competing males and other insects to protect their resources.

Supplemental Notes

Not all males are territorial. Rather than defend territories, bumble bees patrol trails or circuits which they mark with scents to attract females. These males fly regular routes that may be 100-300 m in length, chasing down any females that are lured into their flight path. Males of other species rely on targeted searches at flowers or nest sites to find females, often in the company of other males.

Images: 1. Male wool carder bees (*Anthidium*), are very aggressive and use sharp abdominal spines to combat intruders in their territory (*A. manicatum*), © Sheryl Pollock/www.discoverlife.org; 2. A male wool carder bee (*A. florentinum*) attacks a large black bumble bee in its territory, © el chip via Flickr; 3. This male carpenter bee (*Xylocopa varipuncta*) is patrolling, © tdlucas5000 via Flickr; 4. Bumble bees typically mate near scent-marked sites on their patrol circuit, © Kevin Krejci via Flickr.

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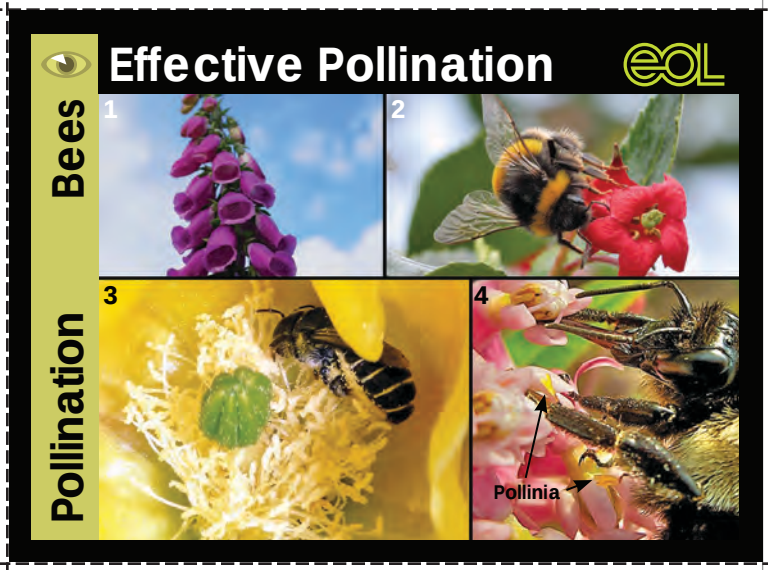

Effective Pollination

EOL Observer Cards

Seeing a bee on a flower does not guarantee that it is pollinating the plant. As bees move between blooms foraging for food or looking for mates, they may "accidentally" transfer pollen between male anthers and female stigmas of flowers. Observe closely: if there is pollen on the bee's body, where is it located? As the bee moves within and between flowers, is pollen being transferred from anther to bee to stigma?

Supplemental Notes

Most plants require cross-pollination to produce viable seeds, so the pollen from one plant must be transferred to the stigma of another. Plants have evolved ways to ensure cross-pollination, including asynchronous timing of pollen production and stigma receptivity, or the spatial arrangement of floral structures.

Images: 1. A bee visiting foxglove nectars at lower flowers first, brushing pollen onto receptive stigmas, then collects pollen in the newer flowers above, to transport away, © Randi Hausken via Flickr; 2. A nectar-robber is not an effective pollinator if it does not touch anthers or stigmas, © Richard Carter via Flickr; 3. Collecting pollen from anthers on an *Opuntia* cactus, note the green stigma above, © cobalt123 via Flickr; 4. Bees foraging on milkweed nectar receive sticky packets of pollen (pollinia) that will later brush off on the stigmas of other milkweeds, © Martha B. Moss.

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Floral Lures

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Take note of the scent, color patterns, time of bloom, and shape of flowers on which you observe bees foraging. Plants need to advertise themselves to pollinators, and bees respond to a variety of floral lures in their search for nectar and pollen. Some lures are invisible to humans, such as ultraviolet patterns and slight electric charges. The recurring combination of floral traits that attracts a particular group of pollinators is referred to as a "pollination syndrome."

Supplemental Notes

Bees visit a wide range of flowers, but generally prefer yellow, blue, purple, and ultra violet colors. Some flowers have distinct color patterns that serve as "nectar guides" for bees. Tubular, bell-shaped, and bilaterally symmetrical flowers are most often visited by bees.

Images: 1. A dandelion flower as it appears to humans (left) and bees, as ultra violet light (right), © Kevin Collins via Flickr; 2. A bumble bee following the trail of spots leading to nectar in foxglove (*Digitalis*), © Eleanor Martin via Flickr; 3. Purple lines guide bees to the nectar in the throat of this prairie violet (*Viola pedatifida*), © Frank Mayfield via Flickr; 4. A bumble bee making its way from the landing pad of an iris flower to a nectary, © Shaun Dunphy via Flickr.

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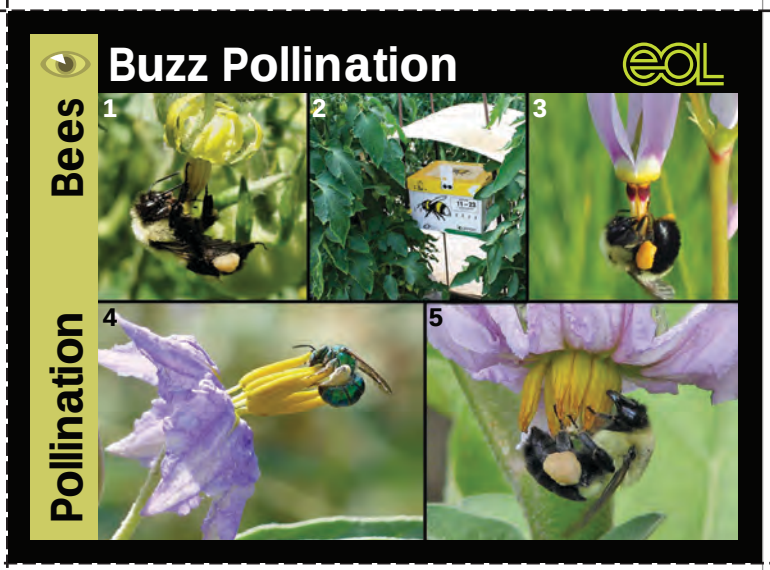

Buzz Pollination

EOL Observer Cards

Observe foraging bees to see how they access nectar and pollen. Bumble bees, carpenter bees, and some other native bees pollinate certain plants by vibrating their flight muscles while holding onto the flower's anthers. This buzzing vibration releases dry pollen from the anther in a visible cloud that coats the legs and underside of the bee. Honey bees are not able to buzz pollinate.

Supplemental Notes

About 8% of the world's flowering plants rely on vibration to release pollen through tiny pores at the ends of their tubular anthers. These plants include blueberries, cranberries, tomatoes, potatoes, and eggplants. While their flowers typically offer no nectar for buzz pollinating bees, their pollen is an especially protein-rich reward.

Images: 1. Bumble bee buzzing the anthers of a tomato flower, © Damon Taylor; 2. Bumble bees are so effective at pollinating tomatoes that they are often reared with this crop in greenhouses, © Mark Carter via Flickr; 3. Shooting stars (*Dodecatheon* sp.) also require buzz pollination, © Lisa Culp; 4. A green metallic bee (*Agapostemon splendens*) vibrates the anthers of a nightshade flower (*Solanum elaeagnifolium*), © Jeff Trei; 5. Bumble bee on an eggplant flower, another member of the nightshade family, © Kevin Matteson.

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Crop Pollination

EOL Observer Cards

Note the kinds of bees you see pollinating crops such as alfalfa, apples, blueberries, tomatoes, sunflowers, and squash. While introduced honey bees are the superstars of crop pollination because of their sheer numbers, generalist food habits, and hive portability, native bumble bees and solitary bees are far more efficient pollinators for many crops, such as those listed above.

Supplemental Notes

The cultivation of non-native bees for pollination services can have mixed results. Introduced bees, such as super-abundant social honey bees, can displace native bees by competing for forage, and may introduce new diseases. Some North American bumble bees have been transported out of their native ranges to pollinate greenhouse crops such as tomatoes. This practice has resulted in new diseases being spread to wild local bumble bees.

Images: 1. Reared bumble bees at work on tomatoes in a greenhouse, © Jeff Couturier via Flickr; 2. Loose nest cells of the alfalfa leafcutting bee (*Megachile rotundata*) are stored over winter, incubated, and adults are released in the spring, USDA ARS Ins. Pol. Res. Unit; 3. Dormant orchard mason bees (*Osmia lignaria*) can be ordered by mail for pollinating fruit trees, www.knoxcellars.com; 4. Squash bees (*Peponapis pruinosa*) specialize on pumpkins and other cucurbits, © Ron Hemberger.

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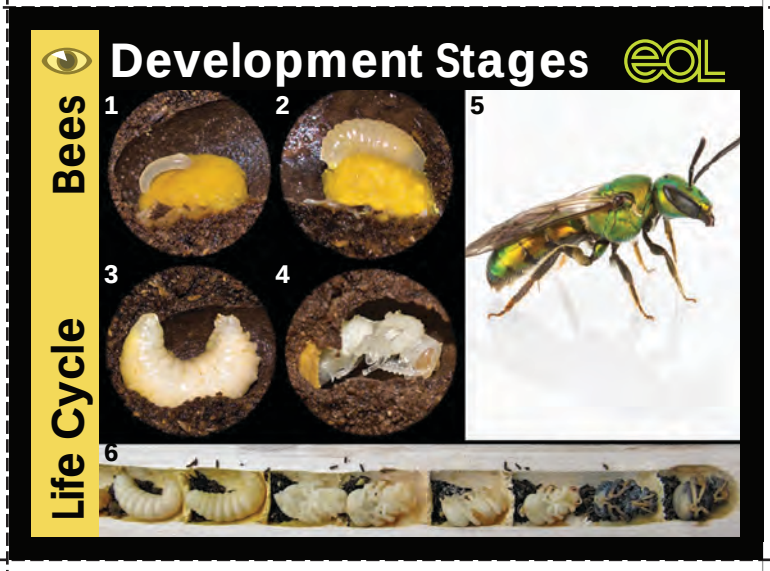

Development Stages

EOL Observer Cards

Inside a bee nest, you might see any of the four developmental stages that bees undergo to complete metamorphosis: egg, larva, pupa, and adult. Eggs vary in size and number per nest. In solitary bee nests there is one egg per brood cell, provisioned with all the food it will need for development. Larvae are legless white grubs that go through several molts as they eat and grow before pupation. Pupae look more like adults, but are soft, white, and immobile.

Supplemental Notes

After mating, female bees carry a lifetime supply of sperm, this allows them to control the sex of each egg as it is laid. Fertilized eggs become females, and unfertilized eggs become males.

Images: 1-5, © Alex Surcică Stages of development in the sweat bee, *Augochlora pura*: (1) Oblong egg (note orange "loaf" of pollen and nectar); 2. Early-stage larva; 3. Pre-pupal larva (note the loaf is mostly eaten); 4. Pupa; 5. Adult; 6. Cross-section of a large carpenter bee (*Xylocopa* sp.) nest. Each brood cell contains one immature bee, increasing in age from left to right. Note the accumulated dark frass (waste) in each cell, © Joel Gardner.

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Collecting

EOL Observer Cards

Observing bees in their natural habitats is informative, but collecting and examining bees under high magnification is often necessary for species-level identification. Collecting methods and tools include nets, vials, soapy-water-filled bowls, and Malaise traps. Passive traps kill bees by design, but active netting or hand-collecting give you the option to "catch and release." Take notes to record where, when, and how you collect.

Supplemental Notes

The types of collecting techniques you use will depend on your objectives. Active methods allow you to associate bees with flowers or nest sites, but they take time and require some skill. Passive methods, such as bowl traps, provide a simple, standardized way to sample bees in an area, and can collect many more bees if they are left out for several hours or days. However, host plant or nest site data are lost, and preparation of wet specimens is far more time-consuming.

Images: 1. Collecting with an insect net, © Dave Wrobel; 2. "Bee bowls" are small, painted, water-filled cups deployed in transects of 10-30 bowls, © Jessica Rykken; 3. Straining the contents from a blue bee bowl, © Jessica Rykken; 4. A Malaise trap intercepts flying insects, © Jessica Rykken; 5. Note where, when, and how you collect your specimens in a field notebook,© Dave Wrobel.

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Hitchhikers

EOL Observer Cards

Watch for tiny arthropods hitchhiking on their bee hosts. A keen observer may see mites, beetle larvae, or twisted-winged parasites attached to various parts of a bee. A variety of mites are associated with bees, some are parasitic on adults, but others are catching a ride to the bee nest where they'll disembark and feed on bee eggs and nectar/pollen provisions or other small arthropods.

Supplemental Notes

Tiny triungulin larvae of blister beetles congregate on flowers or stems, also in the hopes of hitchhiking to a bee nest to feast on their host's eggs and food. Strepsiptera, or twisted-winged parasites, are strange-looking insects that develop inside their bee host. The adult female stays wedged between the bee's abdominal segments, while the winged male leaves the host and flies just long enough to find a mate on another bee.

Images: 1. These mating red mason bees (*Osmia rufa*) have heavy mite loads; © Matt Cole; 2. Blister beetle triungulin larvae (*Meloe violaceus*) congregate on a flower and wait for a free ride to a bee nest, © Bernhard Jacobi; 3. A mining bee (*Andrena carantonica*) hosts a flightless female twisted-winged parasite (*Stylops* sp.) © Ed Phillips; 4. Adult male twisted-winged parasite (*Stylops melittae*) on an *Andrena* mining bee, © Aiwok via Wikipedia.

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Seasonality

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Note the date when you observe a bee; many bees are active as adults only at certain times of year. For instance, specialists on willows or blueberries are out early in the spring, while specialists on sunflowers or goldenrods are active from late summer through fall. Generalist foragers, such as bumble bees, are often active throughout the growing season, visiting different flowers as they come into bloom.

Supplemental Notes

Keep a running annual log of the earliest date when you see a bee foraging on a particular plant, such as willow or sunflower. Consistent monitoring of recurring life cycle stages, also known as "phenology," can help us keep track of the impacts of global climate change on plants and animals. To get involved with a national phenology monitoring effort see: www.usanpn.org.

Images: 1. An early-season species, *Andrena mandibularis*, foraging on willow, © Michael Veit; 2. The southeastern blueberry bee, *Habropoda laboriosa*, is also active in spring, © Darrel Martin; 3. The goldenrod specialist, *Andrena hirticincta*, is seen in the late summer and fall, © Tom Murray; 4. The cuckoo bee, *Nomada vicina*, follows the seasonal patterns of its bee host, *Andrena hirticincta*, © Tom Murray.

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Conservation

EOL Observer Cards

Learning about native bee diversity through careful observation is the first step in bee conservation. You will see more bees in your back yard if you plant a variety of native, bee-friendly flowers and provide nesting habitat, including bare soil. Also, consider the needs of pollinators in landscape management plans that involve burning, mowing, grazing, or pesticide use.

Supplemental Notes

A combination of factors such as pathogens, pesticides, and habitat loss have been implicated in the recent decline of honey bees and bumble bees. For most solitary bees, we know too little about their natural populations to assess their resilience to these and other threats, such as climate change. Inventory and monitoring of native bees can provide insights into bee health, diversity, and the functioning of ecosystems. Learn more at: www.pollinator.org or www.xerces.org

Images: 1. Bee-friendly garden with nest blocks for mason bees and a variety of flowers for foraging, © Fiona Sinclair; 2. Education is the key to conservation, a bee garden in Gilbert, AZ, © Darren Williams via Flickr; 3. A home-made bumble bee nest box, © Rob Cruickshank via Flickr; 4. A manicured lawn in Plano, TX, with no pollinators in sight (inset). The same front yard several years later, now a certified Texas Bee Garden, © 2012 Michael McDowell.

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