SIX

Bees at Work

Question 1: Why do bees pollinate flowers?

Answer: Bees really don't intend to pollinate flowers, although pollination benefits them because it creates seeds that will make more flowers that will provide them with a continuing nectar flow in the future. Pollen transfer is passive; unless the bee is deliberately collecting pollen to take to the nest, the pollen a bee carries from one flower to another has been deposited by the plant on her back or in another place where she was unable to remove it when she instinctively groomed herself to eliminate dust and debris. As bees go from flower to flower collecting nectar, some of the collected pollen is inadvertently deposited on the stigma of a flower of the same species, resulting in cross-pollination.

At certain times when there is a large amount of brood in the colony, honey bees' primary goal is to actively collect pollen for larval food, storing the pollen on their hind legs on dense hairs referred to as a *pollen basket* (see this chapter, question 8: Do bees ever stop collecting nectar?). These hairs surround a groove, on the external hind tibia, that creates an elongated cup-like surface where the pollen sits. Bees are able to move some of the passively collected pollen into the pollen baskets, and once the pollen is packed into the transport structures, it is no longer available for pollination and is carried back to the nest.

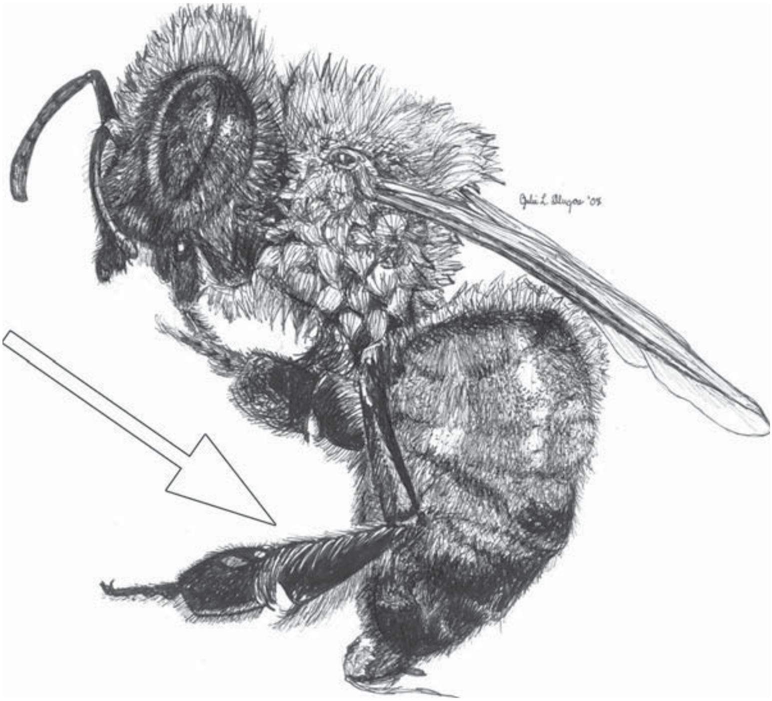

Fig. 19. A worker honey bee showing her specialized leg anatomy for carrying pollen. The arrow points to the corbiculum, or pollen basket. *(Drawing by Julie L. Dlugos.)*

Lawrence Harder and James Thomson describe flowers that have a dispensing schedule, requiring bees to visit more frequently because the flower's structure allows only a limited amount of pollen to be obtained in each visit. This increases the likelihood of passive transfer of at least some pollen instead of larger amounts being actively removed to provide larval food or lost to in-flight grooming.

Question 2: Which crops are pollinated by bees?

Answer: More than one hundred crop species in the United States rely to some degree on bee pollination, and these crops constitute approximately one-third of the American diet, in-

Pollination

Pollination is the process by which male and female chromosome-carrying cells (gametes) reach each other and fuse (fertilization), enabling a plant to bear fruit and reproduce. The vast majority of all plants are pollinated by living organisms, a process called *biotic* pollination. *Entomophily* is pollination by an insect. In addition to bees, moths, butterflies, wasps, ants, beetles, and flies are also insect pollinators. Pollination specifically by bees is called *melittophily,* although it is hardly a commonly used term. Honey bees and, to a lesser extent, other species of bees accomplish the majority of biotic pollination. Approximately three quarters of the over 250,000 species of flowering plants in the United States rely on mobile animal partners for pollination.

Because most bees carry an electrostatic charge that attracts lightweight particles, when they collect nectar from a flower their hairs rub against the plant's anthers and inadvertently collect the fine, dust-like grains of pollen containing the male gametes. When a foraging bee flies from flower to flower, some of the pollen grains that have been deposited on the bee will be brushed off and deposited onto the receptive female portion (the stigma) of a plant of the same species, usually resulting in fertilization. Sometimes, the goal of the bees is to collect pollen, and some species even moisten their pollen loads with nectar or oil to make it easier to transport (see this chapter, question 7: Do bees ever stop collecting nectar?). The fact that pollen transfer occurs is strictly inadvertent.

Some plants only offer nectar and pollen at specific times of the day, and many species of bees learn to adapt their foraging to the availability of their local flowers. Bees have a good sense of time, which makes it possible for them to synchronize their foraging with the plants' cycle. Because most bees tend to exhibit "floral constancy," which means that they show a preference for going from flower to flower of the same or similar species, the pollen carrying structures (usually hairs) in

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different bee species are modified according to the location of the pollen within their preferred flowers and the particular characteristics of the pollen they typically carry.

Some plants need to be vibrated in order to release pollen, and some bees oblige by grasping the anthers of the flower and shivering their flight muscles. This is called buzz pollination, and bumblebees pollinate many plants in this way, including tomatoes, raspberries, currants, oilseed rape (the source of canola oil), field beans, and many wildflowers. In addition to releasing the pollen, all that vibrating elevates the temperature of the bee, making flight easier on a cool morning. Some bees milk the anthers, grasping them near their base with the mandibles and pulling up. Biting the anthers is another way to release the pollen, and some flowers have trigger hairs that the bees need to trip before the pollen is released. There are even bees that collect pollen from the body of another bee, and there are bees with better-than-normal vision, due to enlarged ocelli, that are able to forage in low light.

Vertebrate pollination (zoophily) is primarily accomplished by hummingbirds and bats. There is also a bird called a honeyeater, belonging to a large family found mainly in Australia and New Guinea and in some Pacific islands, on which many plants in that area depend for pollination. The honey possum, found in parts of Western Australia, is a tiny nocturnal marsupial that weighs about half as much as a mouse, and its diet consists only of nectar and pollen. It has a very long tail that it uses like an extra hand when it climbs to reach nectar sources. Other vertebrates that are occasional or accidental pollinators include other birds, monkeys, marsupials, lemurs, bears, rabbits, deer, rodents, and lizards. Ninety-eight percent of the remaining plant species, especially grain crops, are pollinated by wind (anemophily), and a few aquatic plants release their gametes directly into the water, which transports them to a female plant (hydrophily). Flowers in the violet family are self-fertilizing, as are many other plants; some plants, like the dandelion, don’t require pollination because they produce a seed that already contains male and female gametes.

cluding the majority of high-value crops like fruits, vegetables, and nuts. Specifically, honey bees' pollination activities are important for almonds, apples, blackberries, blueberries, melons, cherries, peaches, pears, nectarines, cucumbers, cranberries, and soybeans. Honey bees pollinate the bulk of these crops, which are worth more than fifteen billion dollars to the U.S. economy, and they also contribute indirectly to the production of meat, milk, and cheese because they pollinate food crops used for livestock.

Bumble bees pollinate 10 to 15 percent of all the crops grown in the United States, particularly crops raised in greenhouses, including tomatoes, peppers, and strawberries. Fruits and seeds produced by insect pollination are important in the diet of about 25 percent of all birds and mammals, and bees also pollinate crops that provide shelter for birds and wild animals, and they pollinate plants that prevent erosion of the soil and keep creeks clean for aquatic life in wildlife habitats.

In Sichuan Province in China, pesticides have totally eliminated the bee population in an area that was famous for its production of pears. Rather than lose the crop, farmers in that area hand pollinate the pears. They collect pollen from the male parts of the flowers, dry it, and then climb into the pear trees and dust pollen on each flower with a feather, enabling fertilization and the production of the prized fruit.

Question 3: How do flowers attract bees?

Answer: Bees are primarily attracted to nectar-rich flowers by their color and, when they are closer, by their scent; and we know that bees and other pollinators are sensitive to the ultraviolet markings on flowers that guide them to the nectar-rich area of the flower, so they can collect the nectar in a minimum of time. Recent research has demonstrated that honey bees can learn to associate odors, colors, and patterns with food rewards, so we know that many elements go into choosing rewarding nectar sources. Bees will even locate nectar sources on a terrace in an urban high-rise; they have been seen as high as the

How Do Plants Attract Bees for Pollination?

Flowers offer a variety of cues to signal that they have tasty and energizing rewards for bees and other pollinators. Bright colors and ultraviolet patterns that can be seen from a distance, attractive chemical bouquets that can be perceived when the pollinator comes closer, and tactile cues that offer sensory stimulation when the flower is touched, all are part of a plant's repertoire to ensure that its pollen gets transported to another plant so that fertilization can occur. The size of the flower, the depth of its corolla tubes, and the viscosity and composition of its nectar are the more subtle qualities that focus some plants on particular pollinators.

When scientists experimentally modify plant characteristics, they often see a change in pollinator visitation. One such study involved the bee-pollinated monkeyflower *Mimulus lewisii,* a pink flower that is low in carotenoid pigments and has a wide corolla and a small volume of nectar, and the hummingbird-pollinated monkeyflower *Mimulus cardinali,* a red flower with a narrow corolla tube and a large nectar pool. When cross-breeding and genetic manipulation increased the concentration of carotenoid pigments in hybrids of the two species, bee visitation was reduced by a striking 80 percent. When they experimentally increased nectar production, hummingbird visitation doubled. These results focus on the adaptation of plants to the pollinators in their habitat and also nicely demonstrate that pollinators have strong preferences with regard to color and nectar reward. To some degree there is convergent evolution, a co-construction or mutual adaptation to each other's needs and attributes.

And then there are some plants that have more unusual strategies for attracting pollinators, even some plants that can't offer a nectar reward but still manage to be seductive. The primary alternative strategies used by these plants to attract bees are sex and heat.

When orchids in the genus *Ophrys* are in bloom, they appear to be covered with female bees and they give off a chemical bouquet that is similar to the female's sexual attractant (pheromone). The lip (labellum) of the flower is shaped and colored to resemble a particular species of female insect, and each different species of the orchid attracts males of a particular species of bee. A male bee lands on the orchid's labellum and tries to mate with it (pseudocopulation), and in the process he gets pollen stuck to his head, which he transfers to the next flower. Mission accomplished.

There are certain large *Oncocyclus* irises that grow in the Middle East, and these flowers have no nectar to offer, so they don't attract diurnal pollinators, but they do attract solitary male bees at dusk by offering a warm place to sleep within the flower. Pollen from the flowers was found on almost 40 percent of the males that had slept in the floral suntraps, supporting the conclusion that fertilization of these irises is dependent on their night sheltering of solitary male bees. In the laboratory, bumblebees *Bombus terrestris* were observed to prefer warmer artificial flowers to unheated artificial flowers containing the same nectar reward if they could tell the difference by color. When all the flowers were the same color and only some were heated, the bees were unsuccessful in reliably finding the warm flowers.

Plants develop a variety of qualities to entice pollinators, either by fair means or foul. Animals have their wiles, too, but when they pretend to offer food or sex, their goal is usually to kill the pollinator, rather then take advantage of its services (see chapter 3, question 14: Do bees ever get fooled by predators?). Seduction is not unique in the environment of the bee—it exists for everyone, many other insects as well as birds and other animals and, of course, humans. So when you smell something delicious or see something that looks irresistible, remember—it's a jungle out there.

thirty-fourth floor in Manhattan by co-author Carol Butler. Bees learn the location of rewarding food sites and will return to them regularly—terraces are no exception.

Question 4: Are there any flowers that bees prefer or avoid?

Answer: In his research, Cornell University scientist Thomas Seeley found that honey bees focus on flowers with higher concentrations of nectar when there is plenty of nectar available, but they forage among a wider range of flowers when nectar is in short supply. Nectar volume, composition, and concentration vary among different species of plants and can wax and wane at different times in the flowering season of the plant and at different times of the day. Seeley's research indicates that most nectars are somewhere in the range of 15 to 65 percent sugar, and honey bees tend to prefer nectar high in sucrose over glucose and fructose. Theodora Petanidou analyzed the nectars of seventy-three plant species in the Mediterranean area, and she found that summer-flowering plants had a higher percentage of sucrose in their nectar, which goes along with the general tendency of sugar concentrations to be highest in sunny areas. She also confirmed that bees (and wasps) prefer high-sucrose nectars, which facilitates sharing the resources in the habitat because flies, beetles, and butterflies prefer lower sucrose nectars.

Hannelle Human and Susan Nicholson studied these variations in *Aloe greatheadii* var. *davyana,* a preferred nectar source in South Africa, and they found that the volume and concentration of the nectar remained relatively the same during the day, despite wide shifts in temperature and humidity. Jacobus Biesmeijer and his colleagues found that stingless bees preferred nectar at a 60 percent concentration over less concentrated sources, and in their experiments *Melipona beecheii* completely ignored 20 percent solutions. The bees' own physical characteristics (morphology) apparently play a role in the choice of nec-

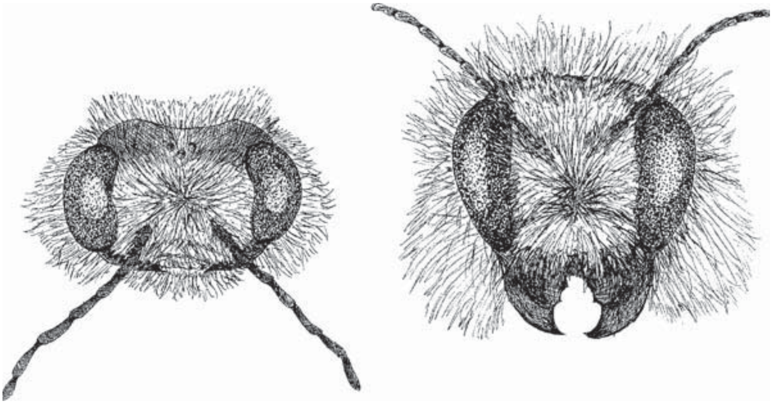

Fig. 20. The head of the red mason bee, *Osmia rufa,* introduced to North America from England, showing long body hairs and large jaws, or mandibles (*on right*). The illustration on the *left* shows an unusually shaped head that accommodates the muscles that work the large jaws. *(Drawing by John F. Cullum.)*

tar sources for the stingless bees studied. *Melipona beecheii* has a yellowish body and these bees were observed to prefer sunny patches, while *M. fasciata* with its dark brown body preferred shady locations. Mason bees, *Chalicodoma sicula,* studied by Pat Willmer in an arid area of Israel preferred more dilute nectar, and in that habitat collecting adequate amounts of water from flowers was more vital even than the energy reward of nectar.

There are certain flowers that bees learn to avoid. Gustavo Romero and Craig Nelson studied a certain female orchid, *Catasetum ochraceum,* which receives pollen from a bee and then swells and closes up, creating a very limited opportunity for fertilization. Male flowers of this species compete to be the one that fertilizes the female by rapidly heaping sticky sacs of pollen onto the back of any bee that visits. The large pollen sacks can weigh up to a quarter of the bee's bodyweight, and after one such experience, bees avoid male *Catasetum* and visit only females. Some related species exhibit similar learning behavior.

Some floral nectars contain toxins, secondary compounds such as alkaloids that are produced by plants to defend themselves against nectar thieves such as ants and other species that compete with pollinators for the resources of the flower. The toxins can produce erratic movement or loss of balance in the ants, and Andrew Stephenson reported that he twice observed skippers landing on innocent-looking and accessible *Catalpa speciosa* flowers, probing for nectar, and then dropping comatose from the flowers. David Rhoades and Jas Bergdahl have described some plant toxins that can incapacitate or even kill nectaring bees and will make any honey produced from the nectar toxic to humans. Some "mad" honey made from certain nectars can be toxic to humans but doesn't seem to affect the bees (see chapter 7, question 8: Can honey be toxic to humans?).

Question 5: How do farmers make sure there are enough bees to pollinate their crops?

Answer: In rural areas, local bees pollinate the flowers during the growing season, rotating from one species to another as each one comes into bloom and finding enough nectar to sustain the colony. Smaller farmers often arrange with local beekeepers to locate their hives on or near the farmer's property to improve their access to the pollinators. Farmers who want to encourage bee pollination try to provide continuous blooming by planting a variety of native species so the local bees can flourish, and they limit or stop the use of pesticides and lawn herbicides.

Huge commercial farms that grow only one crop (monoculture) cannot attract enough local bees to provide sufficient pollination when their crop is in bloom, and when the blooming season is over the farm has nothing growing to provide forage to sustain the bees. This has become an environmental issue as the number of commercial monoculture farms has increased, and the solution has taken the form of commercial beekeepers who migrate around the country with trucks full of hives, moving their bees to wherever there is a seasonal crop that needs pollinating. Commercial pollination has become a $14.6 billion business, according to figures obtained in 2008. Blue bottle flies and leaf cutter bees are also raised and sold for managed pollination.

When bees are rearing large quantities of brood, they temporarily focus on gathering pollen to provide protein for the larvae (see chapter 2, question 2: What do larvae eat?). Although the transfer of pollen is always unintentional, a honey bee that is deliberately gathering pollen is up to ten times more efficient as a pollinator than one that is primarily gathering nectar, so commercial beekeepers try to manage their hives so that the bees are in this pollen-gathering state when their "money" crops are in bloom.

Close to one million honey bee hives are needed in California in the spring when the almond orchards are in bloom. The apple trees in New York require about thirty thousand hives, and the blueberry crop in Maine requires about fifty thousand hives each year. Other crops that are raised on monoculture farms that import beehives are cucumbers, melons, squash, blueberries, and strawberries. Tomatoes and other crops raised primarily in greenhouses use bumble bees for buzz pollination (see this chapter, question 8: What is buzz pollination?).

Question 6: How much weight in pollen can a bee carry?

Answer: A worker honey bee has rows of hairs on the inner surface of her hind leg which serve as a pollen basket. She has a structure on her leg that serves as a comb, and she uses it to scrape pollen from the body hairs and to transport the pollen grains to the basket. In other bees, such as the Megachilid, or leaf cutters, the females have special pollen hairs (scopal) on the underside of the abdomen that are very effective at attracting pollen, which they transport to their nest. A load of pollen carried by a bee is not as heavy as the weight of an average nectar load.

Typical studies, such as one conducted by Athole Marshall, Terry Michaelson-Yeates, and Ingrid Williams, tend to measure how far bees carry the pollen, patterns of pollen deposition, and the rate of successful pollination, but we know of no contemporary studies weighing honey bee loads.

In Gustavo Romero and Craig Nelson's research on pollination of *Catasetum ochraceum* orchids, they reported that the flowers released their pollen sacs onto the backs of visiting "orchid" bees (also called euglossine bees) and that the pollen load could weigh as much as a quarter of the bee's known bodyweight (they determined this by weighing the pollen sacs). The bees reacted to this experience by becoming averse to visiting these orchids again, suggesting that the bees found carrying this amount of pollen to be uncomfortable or distasteful.

Manuela Giovanetti and Eloisa Lasso actually weighed bees to determine how much pollen they carried. Their subjects were 192 female communal bees, *Andrena agilissima,* in Tuscany, Italy, in the area of Isola d'Elba. The bees weighed from 67 to 127 mg, with an average weight of 95.75 mg (compared to a honey bee that weighs, on average, about 190 mg). Despite the range in bodyweight, there was no relationship between how much pollen the bee transported and her size. The pollen load carried by each bee varied from 6.3 percent to 37.5 percent of a bee's body weight.

The process by which Giovanetti and Lasso weighed the bees is fascinating. After each bee was captured, she was placed in a glass cup which was then put into a cooler with ice for about five minutes in order to temporarily immobilize her. Then each bee was transferred to an empty transparent pill capsule that prevented her from moving and losing pollen. After the bee plus its load was weighed on a precise digital scale, she was transferred to a shaded box for about half an hour's recovery time, during which she groomed herself and removed any pollen grains. Then an investigator gently pressed on the abdomen of the bee, causing her to regurgitate any nectar in her crop. The nectar's weight was estimated, and then the bee was re-weighed without any load.

Question 7: Do bees ever stop collecting nectar?

Answer: The amount of nectar that honey bees collect varies from season to season and on the time of day. When there is a large amount of brood in the colony, foragers concentrate on collecting pollen to feed the larvae (see chapter 2, question 2: What do larvae eat?); they collect just enough nectar to supply themselves with energy.

Bees don't collect nectar at a constant rate throughout the day. Manuela Giovanetti and Eloisa Lasso found that although pollen loads were fairly constant, the amount of nectar the bees transported increased in the afternoon, as did the sugar concentration stored in their crop. The number of bees carrying nectar increased as the day progressed; in the morning only 2 to 12 percent of the bees collected had nectar in their crop, while in the afternoon from 45 to 89 percent of the bees collected were carrying nectar.

Sometimes, when the nectar flow rate is high, the bees will collect more nectar than they can use, and the honeycomb cells become filled faster than the bees can build new comb. Beekeepers describe a colony in this state as being "honey bound," and when this occurs, the workers will slow down their nectar collection.

Question 8: What is buzz pollination?

Answer: The flowers of some plants, such as tomatoes and other plants in the Nightshade, or Solanaceae, family contain no nectar but do produce pollen. They need to be shaken to release the pollen, and at one time this was usually done by humans or, in the wild, by the wind. Farmers have realized that bumble bees and other sonicating bees (bees that produce resonant vibrations) are extremely efficient as "buzz" pollinators, and imported bumble bees are now widely used as the primary pollinators for greenhouse tomatoes and other self-fertilizing fruit such as kiwis (also known as Chinese gooseberries), rape, field beans, raspberries, and currants. To release the pollen in these flowers, bumble bees grasp the tubular anthers of the plant containing the pollen and rapidly vibrate the flight muscles of the thorax, causing the pollen to be dislodged. The pollen is carried on their hairs to the stigma of another plant, resulting in fertilization.

Bees and Honey in Judaism

"The true and righteous words and judgments of the Lord are said to be sweeter than honey" (Psalm 19:10; Psalm 119:103; Ezekiel 3:1–3; Revelation 10:9–11). Honey is consumed as a symbol of the New Year in the Jewish tradition. On the holiday Rosh Hashanah, bread and apple slices are dipped into honey and eaten to bring a sweet new year. In what is now the Republic of Georgia, formerly part of Russia, honey was part of a Jewish marriage custom. The doorposts of newly married couples were smeared with butter and honey to symbolize a sweet and prosperous match. Beeswax candles are important in the Jewish faith because the flames of beeswax are considered to be pure and worthy of their role in worship. In "Prophets," sugar is referred to as dry honey.

In Hebrew, the name for a bee is *dbure,* from the root *dbr,* meaning "speech." The woman's name Deborah comes from the Hebrew word *Devorah,* which means "honey bee" and derives from the Hebrew word *debesh.*

Question 9: How do bees make beeswax?

Answer: Wax is produced by young adult bees that are between twelve and seventeen days old. When wax is needed in the colony, they prepare themselves to secrete the wax by gorging either on nectar that has been stored in a cell in the colony or on sugar syrup that is provided by the beekeeper. They then rest for up to twenty-four hours while their bodies metabolize the wax, and then each bee approaches the comb and searches for a place that needs work. She has eight tiny slits on her abdomen, and tiny, moist scales of wax emerge from these openings, secreted by special glands that gradually atrophy when the bee gets older and begins foraging (see figure 6 in chapter 1).

Bees and Honey in the Bible

Honey is mentioned sixty-one times in the New King James version of the Bible, symbolizing sweetness, prosperity, purity, and eloquence. Milk and honey were considered rich and pure enough to be food for the gods, and the Promised Land is frequently described as a "land flowing with milk and honey." John the Baptist, the first-century Jewish preacher and ascetic, is described as eating only "locusts and wild honey," symbolically indicating that he is a man of God (Matthew 3:4; Mark 1:6).

Jesus proved to his frightened disciples that he was truly resurrected and human by eating a piece of broiled fish and some honeycomb (Luke 24:42). St. Ambrose taught that the church is a beehive and the bees are the faithful, diligently storing up treasure or honey in heaven, and St. Ambrose is represented in the Roman Catholic Church as the patron saint of beekeepers. According to the Golden Legend, St. Ambrose's father predicted his eventual eloquence when he discovered the sleeping infant's head covered with a swarm of bees. Beehives are also used in the Bible to represent peaceful, wisely ruled communities, nations, and monasteries which are governed by a single head. The Bible warns that Jesus' words may sting the sinner.

The pleasant words of humans are compared to the health-giving honeycomb (Proverbs 16:24). A sweet-talking person's lips "drip as the honeycomb," even if they are the deceitful words of a harlot (Song of Solomon 4:11; Proverbs 5:3). Proverbs warns against too much sweetness, saying, "Have you found honey? Eat only as much as you need, lest you be filled with it and vomit" (Proverbs 25:16).

Because the queen bee can be observed laying eggs continuously without any sign of mating, bees were once believed to be born from unfertilized eggs, and so became symbols of chastity, moral purity, and the Virgin Mary. The alleged

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Bees and Honey in the Bible, *continued*

sexual purity of bees made beeswax suitable for candles to burn in religious ceremonies.

On the negative or cautionary side, swarms of bees and the danger of their attacks are mentioned in Psalms 118:12 ("They surrounded me like bees"). In Isaiah 7:18 the "fly" and the "bee" are personifications, respectively, of the Egyptians and the Assyrians, inveterate enemies of Israel.

Samson found a "swarm of bees and honey" in the carcass of a lion he had slain (Judges 14:8), and it led him to pose this riddle: "Out of the eater came something to eat, and out of the strong came something sweet" (Judges 14:14).

Using a rear leg with spiky tongs, she takes each flake one at a time, chews it in her mouth for a few minutes to soften it, and places it on the honeycomb cell. Then each added bit of wax is smoothed and polished, and she moves along to another spot that needs her attention. Beeswax is composed of fatty acids, alcohol, hydrocarbons, and other substances; it is white when the bees first secrete it, but it gradually yellows and darkens. In the brood area it can look brown to black because it incorporates pollen, oil, and propolis residue from the larval food, plus cocoons from the bee brood.

Depending on a variety of factors, such as the breed of bee, the quantity and quality of honey, and the stressors in the colony, anywhere from four to twelve pounds of honey must be eaten in order to produce one pound of beeswax, and that pound can create as many as thirty-five thousand cells. Another way to conceptualize this is that ten thousand bees can produce about one pound of beeswax in three days.

Over eight million pounds of beeswax are produced each year, mostly to be used as an ingredient in industrial lubricants, salves, ointments, furniture polish, ski wax, crayons, adhesives,

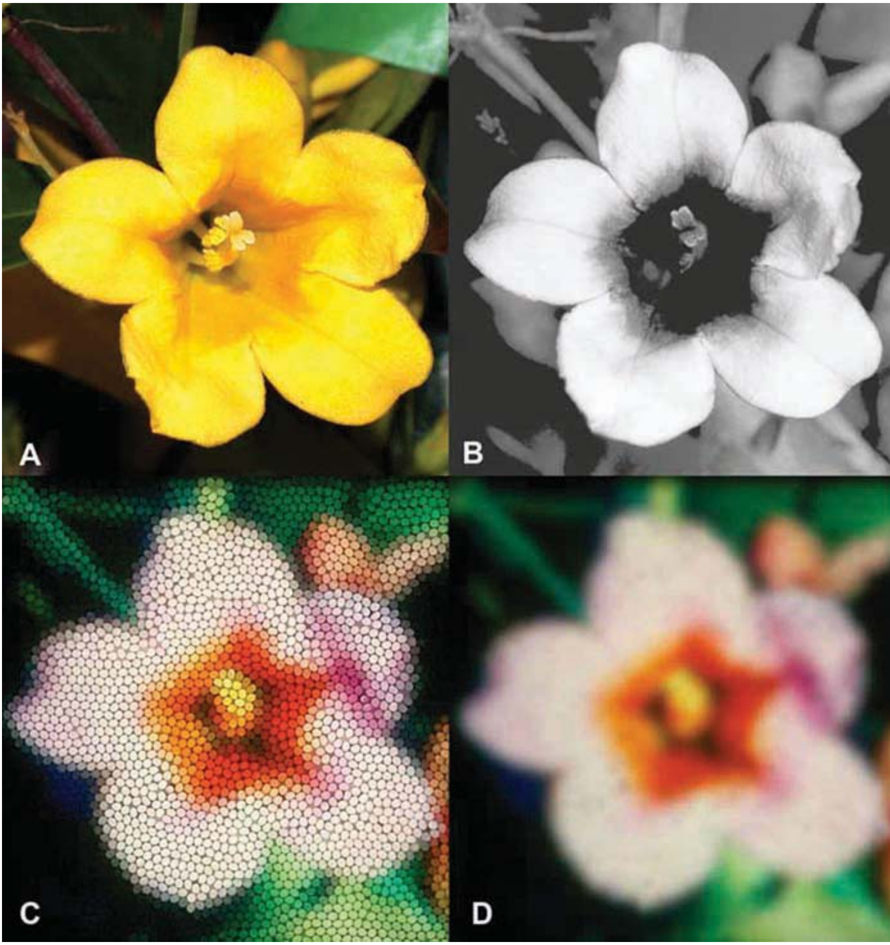
Each honey bee hive contains wooden frames filled with beeswax. The brood are in the center of the frame, while pollen and honey are stored in the peripheral areas, making a rainbow in the frame. *(Photograph by Debra Cook-Balducci.)*

Honey bees are very hairy insects. This bee even has hairs between the facets of her eyes. *(Photograph by Jeri Wright.)*

Megalopta genalis, a nocturnal sweat bee, has very large eyes and expanded ocelli, or simple eyes, on the top of its head. *(Photograph by Alexander T. Baugh.)*

Some seemingly plain flowers have hidden nectar guides that point to the location of their food rewards. Bees can see colors within the ultraviolet spectrum. We can, too, using special ultraviolet light photography that exposes the dark lines that appear on these black-eyed Susan daisies. *(Composite image created by Tom Biegalski/www.TTBphoto.com.)*

Orchid bees, like this male in the genus *Euglossa*, have very long tongues. They visit flowers for both food and floral oils, but scientists are uncertain what the males do with these scents. Orchid bees are largely restricted to the neotropics, but a small population of *Euglossa viridissima* has been identified in Dade County, Florida, USA. *(Photograph by Nicole Tharp.)*

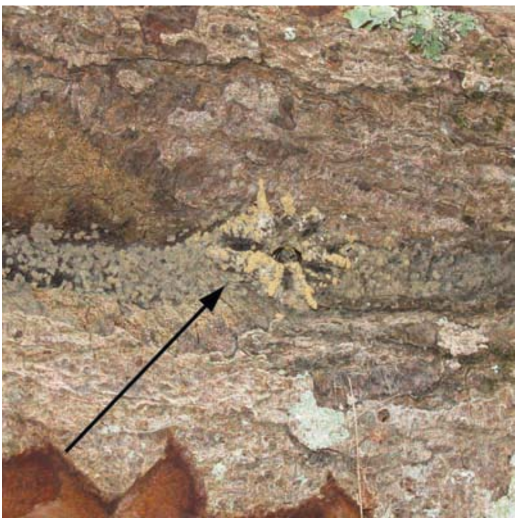


A: Color picture of a flower (*Gelsemium sempervirens*) for human vision.
B: Photograph of the flower taken through an ultraviolet transmitting lens.
C: False color image taken through an optical device simulating bee shape and color vision.
D: A filtered image that removes facets. This image is the most accurate simulation of bee color and spatial vision that has been developed and may hold lessons for technological advances using miniaturized optics.
(Image by Susan Williams and Adrian Dyer.)

Food sharing, or trophallaxis, is an important part of the many social exchanges within a honey bee colony. Here, the bee at the top is feeding the bee at the bottom. *(Photograph by Debra Cook-Balducci.)*

When honey bee workers emerge from the pupal state, they chew their way out of their natal cell. The bee on the right is almost free of the wax, while the bee in the middle is still pulling her way out. The bee on the left is a full emerged, fluffy adult. *(Photograph by Joe Spencer.)*

The nest of a stingless bee, *Melipona beechii,* is kept under the eaves of a house in rural Honduras. Honey is harvested once a year using a side entrance that is fitted with a wooden plug. *(Photo by Elizabeth C. Evans.)*



Many stingless bees close the waxy doors to their nests at night to keep marauding ants out. *Melipona beechii* is known in Honduras as *las abejas de estrella blanca,* or the "white star bees," because of the star-shaped nest entrance that is rebuilt each morning. *(Photograph by Elizabeth C. Evans.)*

Many stingless bees make their nests in the fallen branches of trees, including this species of *Melipona* from the forest around Santo Tomas, Honduras. *(Photograph by Jose Nuñez-Miño.)*

Wooden carvings with bee motifs found inside the Bee Hive House, Salt Lake City, Utah. *(Photographs by Elizabeth C. Evans.)*

Honey bee imagery is common in Salt Lake City, Utah, including on the top of the Joseph Smith Administration Building in Temple Square. *(Photograph by Elizabeth C. Evans.)*

Abandoned honey bee colonies are regularly infested with wax moths; here, pupal cases of these moths are visible on the tops of frames. *(Photograph by Elizabeth C. Evans.)*

Wax moth larvae feed on the wax remains of a former honey bee colony; they leave silken trails throughout the abandoned nest. *(Photograph by Elizabeth C. Evans.)*

inks, varnish, insulation, figurines, sculptures, and, of course, candles. When purified, beeswax has a high melting point (140 degrees Fahrenheit), which has an advantage over other waxes for applications in manufacturing.

Question 10: How is beeswax used in different cultures?

Answer: Multiple cultures used beeswax to produce light or fire in the form of candles, torches, or lamps. Because of its flammability, beeswax was also a component in incendiary weapons during the Crusades of the Middle Ages and in other battles as well. Before plastic was invented, beeswax was the best method available for food storage, and it was used to seal wine casks and jars of olive oil. Cheeses, meats, and eggs were sealed or dipped in beeswax to preserve them, and wax is still used in packaging some of these foods.

The Egyptians used beeswax to create figures to be put in tombs and to make molds. Beeswax figurines thought to have magical properties were also made by Aborigines in Australia, who, like other tribal peoples in Central and South America, made these objects from the waxes within stingless bee nests. Beeswax effigies were used in Roman times for various rituals, including funerals, and wax models were created for the study of human anatomy throughout European cultures.

The "lost wax" process of metal casting for sculpture was developed in ancient times, and according to Eva Crane, the process was widely used at one time throughout Europe, Asia, Africa, and the Americas. It is still used today by some sculptors and in commercial applications. In the lost wax method, layered wax is used to retain the impression of an image and then the wax serves as a mold and is finally melted away, yielding a sculpture cast in bronze or another material. Beeswax was also used in Egypt to embalm corpses, something bees do with propolis as well (see chapter 5, question 8: What is

Fig. 21. Early Egyptians used a complex pictographic writing system that included both logograms (where one sign represents a word, such as an owl representing an owl) and phonograms (where one sign represented one or more consonantal sounds, such as an owl representing the consonant *m*). The bee glyph, pictured here from the Temple of Horus at Edfu, Egypt, could function as a pictogram meaning "bee" or "honey" or as a phonogram for the sounds *bt;* early on, it also came to be a symbol for the kingdom of Lower Egypt, meaning "he of the bee," or ruler of Lower Egypt. *(Photo by Matthew B. Heintzelman.)*

propolis?). Roman historians of the fifth century B.C.E. described wrapping deceased royalty in cloths dipped in wax. Bodies preserved in this way were carried in processions around the kingdom of the deceased so that their followers could pay their last respects.

The Romans used beeswax as a writing surface. Messages were sent on wooden writing tablets coated with beeswax throughout the Middle Ages in Europe. The message was written in the wax with a stylus, and it could easily be erased and the tablet could be reused to write a reply. The Greeks used beeswax for decorative painting, and they mixed it with pigment to surface

Honey in Islam

The Qur'an refers to "rivers of honey pure and clear" in paradise (47:15), mentions honey as war booty (53:382), and cautions against it in the form of an intoxicating liquor "which the Yemenites used to drink" (59:631). A "gulp of honey" is valued for its healing properties (71:584), and it is specifically recommended by the Prophet Muhammed for abdominal troubles (71:588).

Aisha, one of Muhammed's wives, tells the following amusing story about how she stopped her husband from spending extra time with another of his wives (63:193). Muhammed was known to be fond of honey and sweet things to eat. After the last prayer of the day, he would customarily visit his wives and stay with one of them for the night. One evening he went to his wife Hafsa, the daughter of Umar, and stayed with her longer than usual, which made Aisha jealous. She found out that the reason Muhammed had stayed so long was that Hafsa had received a gift of a skin filled with honey, and she had made syrup from it and had given it to Muhammed to drink, which had delayed him. Aisha said, "By Allah we will play a trick on him," and she told Sada bint Zam'a, another of Muhammed's wives, that when he approached her, she should ask him if he had taken Maghafir (a bad-smelling gum). Assuming he would say "No," she was to reply, "Then what is this bad smell which I smell from you?" He hopefully would reply, "Hafsa made me drink honey syrup," in which case Sada was to respond, "Perhaps the bees of that honey had sucked the juice of the tree of Al-'Urfut, which is a foul-smelling flower." Aisha vowed that she herself would have the same conversation with him, and, indeed, they carried out their plan. And when Muhammed again went to Hafsa and she offered him more of the drink, he replied, "I am not in need of it." Upon hearing of this exchange, Sada said, "By Allah, we deprived him of it," and Aisha replied, "Keep quiet."

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Honey in Islam, *continued*

A man came to the Prophet and said, "I saw in a dream, a cloud having shade. Butter and honey were dropping from it and I saw the people gathering it in their hands, some gathering much and some a little." Abu Bakr said, "Allow me to interpret this dream." The Prophet said to him, "Interpret it." Abu Bakr said, "The cloud with shade symbolizes Islam, and the butter and honey dropping from it symbolizes the Qur'an, its sweetness dropping and some people learning much of the Qur'an and some a little (vol. 9, book 87, number 170).

walls. They also used it as a protective, water-resistant coating for boats, leather armor, and tents.

Beeswax is also an important component in the production of various dyed textiles and patterned metals or glass. Garments and decorative fabrics were marked with beeswax, which would then resist coloration by dyes or pigments. The wax-resist strategy is thought to have been initiated in India, and the techniques were passed along via the Silk Road traders.