FIVE

Bees in the Hive

Question 1: How many bees are in a colony?

Answer: Honey bee colonies can contain from ten to fifty thousand bees and sometimes more. Bumblebee colonies are much smaller, containing from about two hundred to four hundred bees. The population of a honey bee colony varies with the yearly cycle within the hive, so that it has the highest densities of adults, pupae, and larvae when nectar-bearing flowers are most available (see this chapter, question 10: Is there a yearly cycle in the hive?). The queen lays eggs whenever there is a net gain of food resources for the colony, and her egg production rate drops substantially as temperatures grow cooler and the day length shortens in the fall and new supplies of nectar become increasingly scarce. During the deepest cold of the winter, there is no brood rearing at all; but the colony begins to produce brood again in the very early spring, although there are no flowers blooming. Stored pollen is the primary source of protein during this early period, and the population increases so that there is a well-developed forager force in place for the flood of nectar when the spring flowers finally begin to blossom.

Question 2: How do bees construct their nest?

Answer: In their natural state, European honey bees nest in cavities like holes in trees and crevices within cliffs. Beekeepers tend managed colonies in wooden boxes, called hives, that

Honey Bee in Different Languages

Arabic	هوني ب
Bulgarian	медоносна пчела
Catalan	*abella*
Chinese	蜂蜜蜂
Croatian	*pravo*
Czech	*včela medonosná*
Danish	*honing bi*
Dutch	*honings bij*
English	*honey bee*
Esperanto	*abelo*
Estonian	*mesilane*
Farsi	زنبور عسل (ج.ش)
Filipino	
Cebunao	*buyog, putyokan*
Hiligaynon	*ligob, putyokan, buyog*
Tagalog	*bubuyog, putakti*
Finnish	*mehiläinen*
French	*abeille de miel*
German	*Honigbiene*
Greek	*μέλισσα μελιού*
Hebrew	תרובך
Hindi	*Madhu makhi*
Hungarian	*méh, összejövetel*
Icelandic	*hunangsfluga*
Indonesian	*lebah madu*
Irish Gaelic	*beach*
Italian	*ape del miele*
Japanese	蜂蜜の蜂
Korean	꿀 꿀벌
Latvian	*bite*
Lithuanian	*bitė*
Malaysian	*lebah madu*
Norwegian	*bie*
Polish	*pszczoła*

(continued)

Honey Bee in Different Languages, *continued*

Portuguese	*abelha do mel*
Romanian	*albină*
Russian	пчела меда
Spanish	*abeja de la miel*
Slovak	*vcela*
Swahili	*nyuki*
Swedish	*honungbi*
Swiss German	*bienli, beili*
Turkish	*bal arısı*
Ukrainian	бджола
Vietnamese	*ong mật*
Welsh	*gwenynen*
Yiddish	*bin*

have removable frames of beeswax (see chapter 11, question 2: What does a beekeeper's hive look like?). When a swarm of bees moves into a new nesting space, their first task is to build out the sheets of wax combs that they use as a nesting substrate. As a part of the preparation for swarming, the bees will have consumed large quantities of nectar or honey, which primes their wax-producing glands (see chapter 6, question 9: How do bees make beeswax?). These bits of wax are called wax scales. They are chewed and sculpted into the familiar honeycomb pattern. As these workers continue to build, others begin to forage from the new nesting location in order to ensure that no bees, especially the wax-makers, go hungry while the new pantry is being built. Still other bees set up as guards to protect the new nest. The queen will generally walk around the comb, inspecting the cells for size and cleanliness before laying an individual egg in the bottom of each cell. Simultaneously, the workers will begin to fill nearby cells with pollen mixed with nectar (bee bread) in preparation for feeding the larvae that will soon emerge from the newly laid eggs. They deposit nectar around the periphery of the brood area, maintaining the brood in a central location close to the nest entrance as the colony grows, while the nectar is stored up and away from the entrance.

Question 3: What do bees do all day?

Answer: The saying "busy as a bee" undoubtedly arose from the impression one gets observing bees buzzing around a hive. Streams of bees zoom in and out, foraging and delivering nectar and pollen, and inside the hive they seem to be constantly in motion—eating, grooming, fanning, foraging, cleaning, building, and taking out the garbage. But researchers who have actually watched individual bees for days at a time, keeping careful track of their activities, tell a different story, and the results are a little disappointing: bees are really not all that busy.

In 1894, a scientist named C. F. Hodge watched a group of bees all day for several days. He reported that no bee worked more than three and a half hours a day. Typically, one bee might crawl into an empty cell and lay there for hours. In the 1950s, the behavioral physiologist Martin Lindauer followed up Hodge's work with a more comprehensive study, and he confirmed that a typical bee spent about two-thirds of her time doing no productive work at all.

European honey bees can't see well enough to forage at night, so this is when some honey bee foragers typically sleep. Barrett Klein working with Tom Seeley determined that honey bees shift their foraging schedules depending on when resources are available, and this dictates to some degree when they can sleep. Stefan Sauer and colleagues experimentally deprived foragers of sleep for a twelve-hour period in order to study their responses to the lack of sleep. Individual bees were placed into a glass cylinder with a light source equivalent to daylight and with free access to honey. The cylinder was secured to a motorized tilting device that produced one-second-long rolling movements, alternating with pauses of eleven seconds, effectively keeping the bees awake all night. The research team found that the exhausted bees compensated by sleeping more deeply the following night. Periods of time when their antennae were immobile were defined as sleep (also see chapter 3, question 10: Do bees sleep?).

Question 4: Do any bees forage at night?

Answer: Some tropical breeds of bees have adopted a nocturnal lifestyle, probably in response to the dangers and availability of resources of the tropical rainforests where they live. In contrast to European honey bees , Africanized honey bees can see under the light of a full moon and have been known to forage under these light conditions. Specialist in nocturnal vision Eric Warrant at Lund University in Sweden points out that "at light levels at which we are nearly blind, our cats are out stalking prey, and moths are flying agilely between flowers. . . . The same is true of an enormous variety of animals inhabiting the eternal darkness of the deep sea." Most of the animals in the world are primarily active in dim light, and research by Warrant and others has demonstrated that many of them see quite well. William Wcislo and his colleagues at the Smithsonian Tropical Research Institute in Panama observed that, although the light intensity at night may be as much as one hundred million times dimmer than daylight, the nocturnal sweat bees *Megalopta genalis* and *M. ecuadoria* have evolved a visual system that enables them to identify visual landmarks and navigate complex terrain in darkness. Their vision is only about thirty times more sensitive than that of diurnal bees, but specialized areas have been identified in the brains of these bees that seem to have the capacity to intensify the received images, and this may be what enables them to see well enough to forage at night (see color plate B).

Question 5: How does the queen control the hive?

Answer: The queen controls reproduction in the hive, and through that action she exerts a lot of pressure on what the workers decide to do, but she does not make the day-to-day decisions of the workers. Their behavior is influenced by the concurrent decisions of nest mates as well as by the impact of the environment outside the nest.

Queen substance is a pheromone, from the Greek *phero,* meaning "to bear," and *hormone.* Pheromones are chemical bouquets that trigger natural, behavioral responses in other individuals of the same species. Queen substance, also known as queen mandibular pheromone (QMP), is produced by the mandibular glands in the head of the queen honey bee once she has mated and is laying eggs. QMP is one of many compounds used for chemical communication within the colony (see chapter 3, question 6: How do bees communicate?). Workers smell the queen substance when they lick her body in the course of attending to her needs, and it gets passed around the colony as the bees touch each other. Because her pheromone is unique and distinct within the colony, it helps keep the colony integrated and centered around the queen as long as she is reproductively viable and the colony is healthy.

Among other effects, QMP suppresses the development of the workers' ovaries and inhibits them from rearing new queens. It signals to them, in combination with a chemical marker the queen deposits on her eggs and the presence of an adequate number of larvae, that the queen's egg laying and brood development is going well, and it influences the workers to exercise reproductive self-restraint. In the European honey bee colonies that they studied, Madeleine Beekman and Benjamin Oldroyd found that approximately 1 percent of the workers had active ovaries and were able to lay eggs. Somehow their ovaries had become activated despite all the cues to the contrary, but if they actually produced eggs, the eggs would most likely be removed, destroyed, or eaten by other workers because they lacked the queen's mark.

Christina Grozinger and her collaborators working on the Honey Bee Genome Project studied the role of QMP on gene expression, and they determined that exposure to QMP leads to direct changes in gene expression in the brains of honey bee workers. They reported that QMP consistently activates a group of genes that regulate nursing behavior and represses the activity of genes that regulate foraging activity, suggesting that QMP may delay behavioral maturation (from nurse to forager) by its effect on these groups of genes. In related research, Vanina Vergoz and colleagues identified a queen mandibular pheromone that prevents young bees from learning when to sting and has the effect of keeping them in close contact with their queen. When the bees are about three weeks old and have become mature enough to leave the hive and begin foraging, the pheromone wears off and they learn how to defend themselves. This pioneering area of research will undoubtedly lead to additional discoveries about pheromonal control of behavior in bees.

As the queen ages, her pheromone production starts to flag, her egg laying slows down, and she begins to lose reproductive control of the hive. If the queen dies or is removed from the colony, her absence is quickly noted and the behavior of the workers changes rapidly. When queen substance is scarce or is missing from a colony, the workers know that it is time to start constructing queen cells in order to rear another queen as a replacement.

There is one area where new research has established that the queen does not control the hive, as was previously thought. Andres Pierce and Lee Lewis, working with Stanley Schneider at the University of North Carolina at Charlotte, observed that colony reproduction, which involves the process of swarming and supercedure (replacing the queen), is regulated mainly by older workers rather than by the queen. In their words, the queen is relegated to the role of “passive egg layer whose own behavior is programmed, with changes dictated by signals delivered by older workers” in the form of piping and vibration signals (see chapter 3, question 6: How do bees communicate? and chapter 3, question 8: What is piping behavior?). During the two- to three-week period before swarming, older workers signal to the queen and the rest of the colony that it is time to swarm. With the queen in a passive role, they come to a group decision on a new place to locate the nest, and then they arouse the queen and the bees in the swarm and lead them all to their new home, where the queen resumes her reproductive responsibilities (see chapter 8, question 2 : What is swarming?).

Question 6: What is meant by "balling" the queen?

Answer: Bees may be hostile to a queen because she is a stranger to the hive that has been inserted by the beekeeper to replace an old queen, or she may be an old queen that is no longer laying enough eggs to meet the needs of the colony. In that situation, they will cluster around her in a ball that can be as large as three inches in diameter. Unless the queen is rescued by the beekeeper (either by using smoke or by dipping the ball in water) she will be smothered, overheated, or stung to death. To avoid this attack, beekeepers have developed various methods to safely introduce a new queen into an existing hive in order to make sure she is accepted (see chapter 11, question 9: Can the beekeeper put a new queen in the hive if the old one dies?).

Question 7: What is honeycomb?

Answer: Honeycomb is a hexagonal lattice of a single layer of relatively equal-sized cells in which nectar, honey, and pollen are stored and which contain the colony's eggs and developing brood. Made of beeswax, the walls of the comb are thin and translucent, but the wax can support thirty times its own weight. In 1999, Thomas Hales at the University of Michigan proved mathematically that this design is the most economical way to store the maximum amount of honey while using the least amount of beeswax for construction, although this idea was first hypothesized by Greek mathematician Pappus of Alexandria (A.D. 290–350). The sheet of wax that forms the base of the comb hangs vertically from the ceiling of the nest, and the cells fit together snugly and are arranged horizontally so their contents don't spill out, conserving space and maximizing storage capacity.

Stephen Pratt, now on the faculty at Arizona State University, explored the question of how a group of thousands of worker bees with limited information can proceed to build a pattern of comb that is best suited to the needs of the entire colony. What are the signals and cues that guide their collective decision making? After a swarm settles in a new nest site there is an initial surge of comb construction to provide cells for new brood and food storage (see chapter 8, question 2: What is swarming?). It might seem advantageous to build a lot of comb early in the season so that the colony can take advantage of surges in the flow of nectar due robust blooming conditions. Having empty cells can be an advantage, since if there is a shortage of storage space, foraging will have to slow down while storer bees search for places to deposit the high volume of nectar that is being collected. Construction uses up a great deal of the colony's energy resources as the builders must gorge on stored sugar supplies in order to produce wax with which to build the comb, so simply building lots of comb to be ready for a high volume of nectar is not necessarily an economical solution.

According to Pratt's observations, the winning strategy is for additional comb to be added in "pulses" throughout the nectar-gathering season, depending variably on several factors: adequate nutrition in young bees in order to promote normal wax gland development, the presence of a queen, the rate of the daily nectar flow into the colony, and the amount of empty comb that is available. How all of these factors are synthesized by the bees into a building plan and appropriate individual construction activity still remains to be discovered.

Question 8: What is propolis?

Answer: Propolis is a resinous plant substance that ranges in color from red to brownish yellow, depending on the location, season, and species of bee that collects it. Bees gather this resinous material from buds and from sap and gum on trees and use it in their hives. It is sticky when warm and brittle when it is cold.

Some breeds of honey bee are known to use large amounts of propolis, but other breeds that do not gather it are favored by beekeepers because it makes tending the beehives less cumbersome and sticky. Some stingless (*meliponid*) bees gather plant resins and mix them with the wax that they produce, creating a material called *cerumen* with the consistency of earwax. Propolis is also mixed with other substances like mud, plant matter, or even animal feces. This material is called *batumen* and it serves to strengthen and seal the nest cavity, providing extra protection that is especially important in the tropical areas where stingless bees live because of the multitude of ants and other predators that are ever ready to steal a meal of sugar or brood.

Traditional bee literature explains that bees use propolis to close gaps in the hive that let in cold air. These gaps are called *bee spaces;* if they are less than three-sixteenths of an inch, they will be filled in with propolis, and if they are wider than five-sixteenths of an inch, they will be filled in with comb. New research suggests that bees thrive with increased ventilation, and it seems that propolis may be more important in reinforcing the structure of the hive and making the hive more defensible. Bees have also been known to use propolis and wax to entomb the carcass of an intruder (like a mouse) that has died after breaking into the hive during the winter. Normally, bees carry waste out of the hive, but because a mouse is too large to remove from the hive, they effectively mummify it.

Propolis is marketed for human consumption in health food stores and by practitioners of Chinese traditional medicine, ayurveda, and homeopathy. Its chemical composition varies significantly depending on its source, and no consistent benefits have been clinically proven that are applicable to all propolis. Most of the traditional uses have not been clinically evaluated, but it may have some local antibiotic and antifungal properties. It is used to treat burns, and some feel it protects against dental caries, gingivitis, and canker sores. Beekeepers have been known to keep a piece in their mouth as a remedy for a sore throat.

Question 9: What is a brood comb?

Answer: The first three weeks of a bee's life are spent in the brood comb, give or take a few days. Usually in the lower part of the nest, this is the area where beeswax cells have been prepared to receive the eggs laid by the queen. This comb does not differ in its construction or initial appearance from the comb where the honey is made and stored. As the bees use the combs, the wax takes on the color of the nectar, pollen, and propolis that the bees collect and distribute, and it darkens after it is used repeatedly for brood rearing. While it remains clean, it can absorb the odors and chemicals present in the hive.

The temperature in the brood area needs to be kept within a very specific range in order for the brood to develop normally from egg to larvae to pupae to adult (see chapter 2, question 1: How does a honey bee develop from an egg to an adult?). During the warm weather when there is plenty of nectar, a healthy queen may lay as many as two thousand eggs each day, so there is a lot of activity in this area when so many bees a day emerge from their eggs and need to be fed. Conditions may become so crowded that the queen does not have room to lay sufficient eggs, and this may trigger swarming preparations (see chapter 8, question 2: What is swarming?).

Question 10: Is there a yearly cycle in the hive?

Answer: Honey bee colonies are perennial, so they normally live year round, attuned to the environment and totally dependent on the seasons. Their activities are limited by temperature because honey bees do not fly when the temperature is below about 45 degrees Fahrenheit (7 degrees Celsius). This physiological limitation corresponds to the growing season of the flowers that bees rely on for food, meaning that they are able to fly when food is available.

During the winter, bees stop foraging when nectar is no longer available. They depend on stored honey to sustain them through the cold weather, and they cluster together to stay warm. Most species have evolved responses that permit them to survive times of famine, and bees are no exception; they switch resources from reproduction to basic maintenance of the body. The queen stops laying eggs during the late fall and early winter so there are no larvae to attend. The bees' metabolism slows down, allowing them to minimize energy consumption when supplies are scarce. On nice days, bees emerge from the nest to get rid of wastes, but generally they stay relatively quiet until the spring arrives.

By some time in the very early spring, the queen begins laying eggs (brood production), as many as several hundred each day as long as there are ample supplies of honey and pollen remaining in the nest's storage cells and there are environmental signals that fresh supplies will soon become available as the flowers begin to come into bloom and there are enough workers to keep the eggs warm. If food is scarce, her egg-laying activity level is reduced, creating an ongoing seasonal balance between the food supply and the numbers of eggs, larvae, and pupae.

Assuming the queen is healthy as the warm weather sets in, the bees will become very active, filling the storage cells with nectar, attending to the brood, and carrying out all the normal activities of the colony. The colony population needs to be big enough to exploit the riotous blooms of spring flowers when the nectar flow reaches its maximum. The growth rate of the colony during the spring may be quite fast, and if the colony is tended by an attentive beekeeper, the colony can simply grow into the new spaces the beekeeper adds to the nest. An unattended nest may swarm if they have overgrown the available space. With a reduced population after the swarm departs and with a new queen at the reproductive helm, the colony begins to grow in number again (see chapter 8, question 2: What is swarming?). In the fall, brood production drops off and the foragers begin to prepare the nest to survive the upcoming winter, maximizing the honey stores needed to sustain the bees when the flowers are gone.

Question 11: What happens if the bees run out of honey?

Answer: It is not a satisfying answer, but "it depends" is the most accurate. If a colony is being tended by a watchful beekeeper, the colony should not run out of honey. If honey stores are low, the beekeeper can provide honey or sugar syrup to help the bees get through the period of dearth. Feeding bees is a necessary activity in the late winter and early spring in some parts of the country, especially if the beekeeper harvests honey too late in the season, depleting the honey stored for the winter. If the colony is in a natural cavity and it runs out of honey, the bees will not be able to withstand cold temperatures. Without that source of energy to generate metabolic heat to maintain a warm enough temperature in the nest, the bees will die.