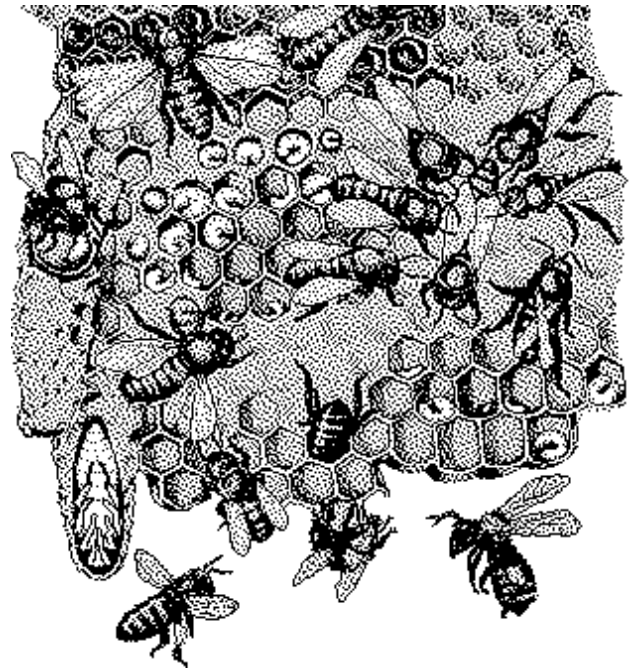


# The Biology of the Honeybee, *Apis Mellifera*



**NOTE:** The images found in this document have been redrawn from Mark L. Winston. 1987. *The Biology of the Honey Bee*. Harvard University Press. Cambridge, MA. These redrawn figures appear here with permission of Harvard University Press [Ref: 973029]. Winston's comprehensive book (ISBN: 0-674-07409-2) is excellent and is recommended here as additional reading for those interested in understanding the details of honeybee biology. Please note: because the figures here are redrawn with permission, they are NOT my figures, so I cannot give permission to use them to anyone else. If you seek to use the pictures in this file, you really need to ask the permission of Harvard University Press and take your images from Mark Winston's original text.

## Classification and Origin of Honeybees

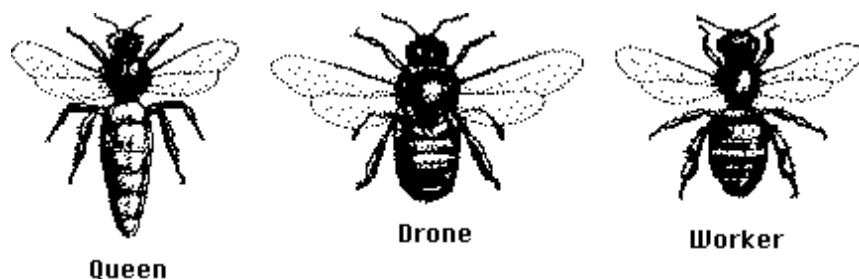
Honeybees have been classified as follows:

Kingdom **Animalia**  
Phylum **Arthropoda**  
Class **Insecta**  
Order **Hymenoptera**  
Family **Apiidae**  
Genus **Apis**  
Species ***Apis mellifera***

Honeybees probably originated in Tropical Africa and spread from South Africa to Northern Europe and East into India and China. They were brought to the Americas with the first colonists and are now distributed world-wide. The first bees appear in the fossil record in deposits dating about 40 million years ago in the Eocene. At about 30 million years before present they appear to have developed social behavior and structurally are virtually identical with modern bees.

## Who's Who in the Hive

A typical small hive contains perhaps 20,000 bees and these are divided into three types: Queen, Drone, and Worker. The chart below compares these types:



	<b>Queen</b>	<b>Drone</b>	<b>Worker</b>
<b>relative size</b>	large	medium	small
<b>#/hive</b>	1	~200 or 0	20K-200K
<b>lifespan</b>	2 years depending on #sperm	21-32 days spring 90 days summer or until mating 0 winter	20-40 days summer (worked to death) 140 days winter
<b>sex</b>	female/bisexual	male	sterile female
<b>functions</b>	-kill sisters and mother -mate with males -lay 1500 eggs/day = 200K eggs/year -secrete pheromone = 9-hydroxydecenoic acid HOOC=C-C-C-C-C-C-CO <sub>2</sub> H	-mate with young queen	-make comb -tend larvae -tend young drones -tend queen -clean hive -gather nectar -gather pollen -gather propolis -evaporate nectar -cap cells -defend hive -starve drones -lay drone eggs -move larvae for making new queen

## The Not-So-Queenly Queen Bee

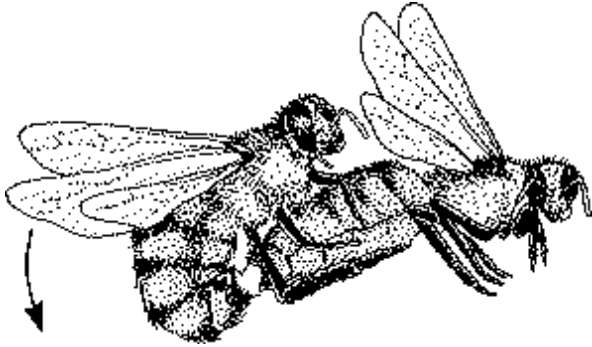
Careful observation of the table above, shows how the hive functions. The queen basically keeps the workers uninterested in reproduction on their own by secreting a pheromone. This chemical is spread from body to body among the workers starting with those tending the queen.

The other job of the queen is to lay eggs and this task consumes all her conscious effort. You might wish to calculate this rate down to the minute and you will see that she has no time to eat or fly around. A group of five to ten workers feed her a small bit after she lays about 20 eggs. In fact, if she stops making pheromone or laying eggs, one of her most recent eggs will be moved to a specially prepared queen cell to produce a replacement queen.

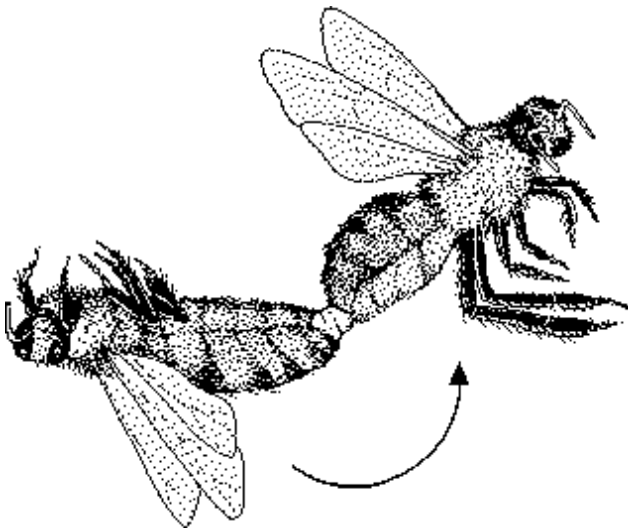
The newly hatched queen destroys any other unhatched queens, fights to the death any hatched queens,

may destroy her mother, and then takes her mating flights.

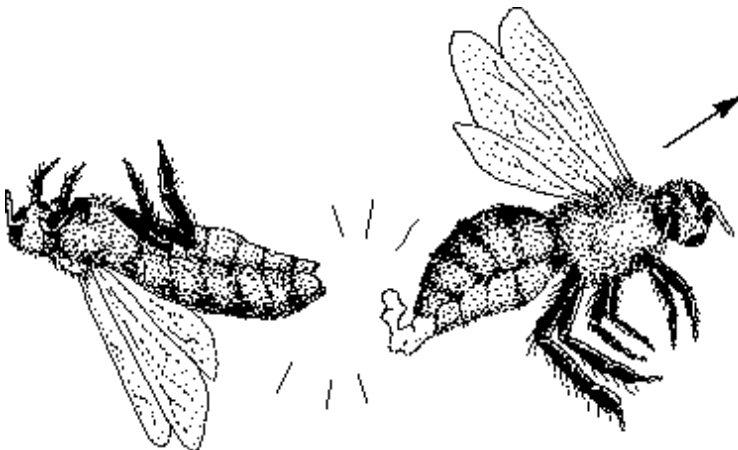
The mating flight follows a pattern. The virgin queen flies to a congregation area where hundreds or thousands of unrelated drones await. The drones pursue the queen and several mate with her in flight.



The drone mounts the queen, inserts his endophallus, and ejaculates his semen.

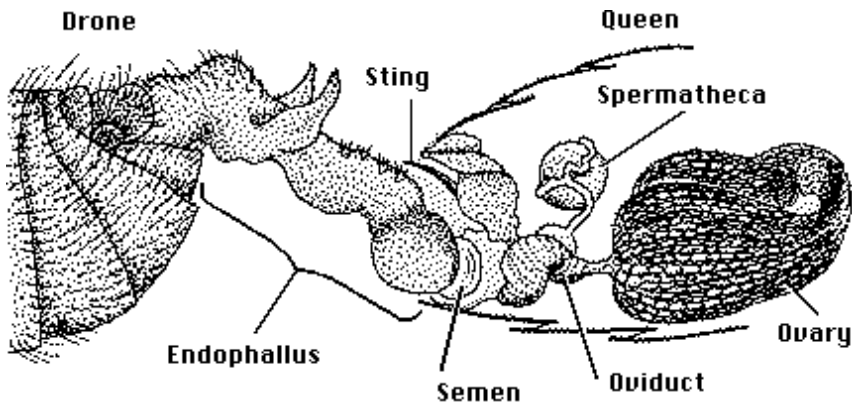


During ejaculation, the male falls back and his endophallus is ripped out of his body and remains attached to the queen.



Drones mounting later remove the previous drone's endophallus and lose their own through similar matings. The emasculated drones die very quickly with their abdomens burst in this fashion.

Of the 90 million sperm deposited by several males in the queen's oviducts, a mixture of about 7 million are stored in a special pouch in her body called the spermatheca.

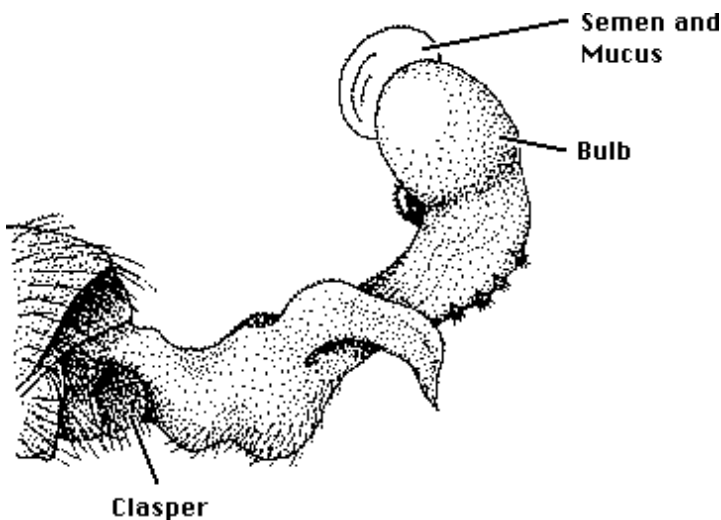


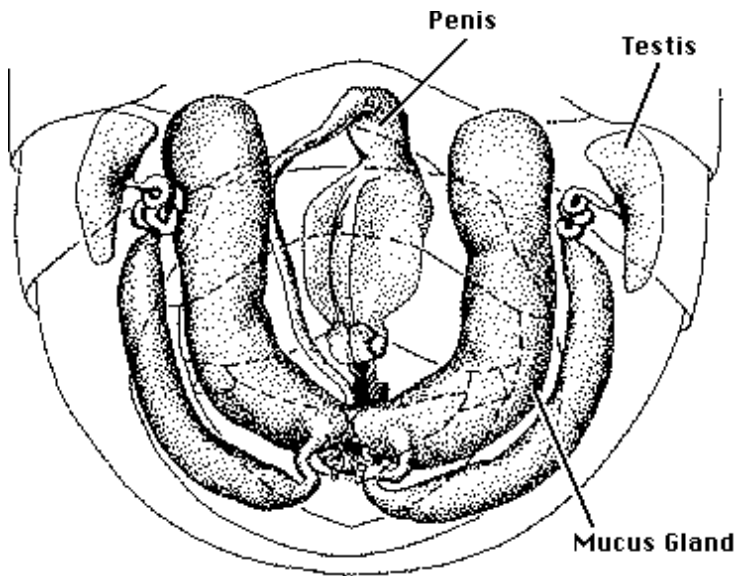
These sperm will be used, a few at a time, during the queen's life to fertilize her eggs. The one (or few) mating flight(s) in her first few days of life are her last. Should the old queen run out of sperm, a new queen will be produced through the intervention of the workers.

## The Specialized Drone Bee

Drones are tolerated in the hive only when there is a possibility that they may mate with a queen. Thus a few are tolerated in spring and fall, more in the summer, but none in the winter. The workers keep the drones out of the hive to starve to death in the autumn.

Drones, like queens, lack the body parts to effectively harvest nectar or pollen to feed themselves. Drones also lack a stinger of any kind. They are designed for mating only.



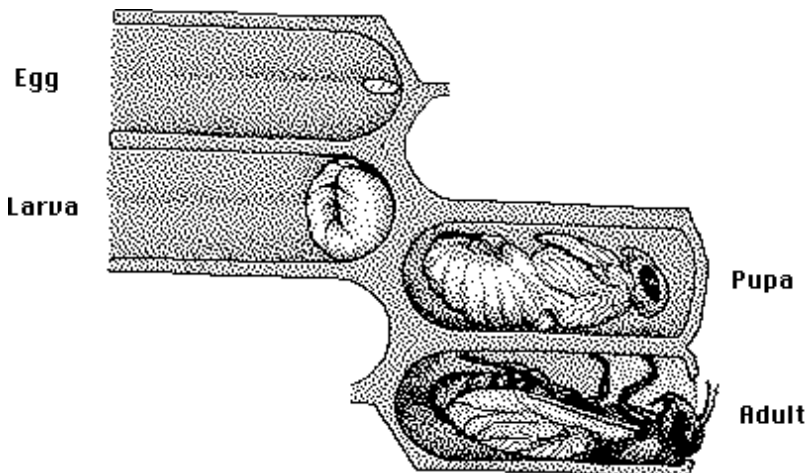


Drone's eyes and antennae are specialized for seeing, following, and mating with a queen and most of the drones' internal organs are designed for flying fast enough to catch the queen or for delivering sperm cells into her oviduct. If the drone succeeds in this, it dies. Thus all surviving drones are virgin.

## The Important Worker Bee

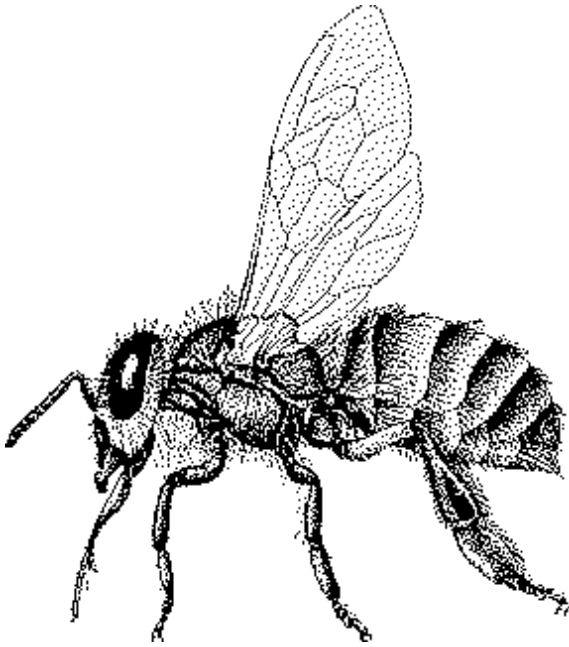
Workers, as their name implies, do most of the "work" around the hive. They secrete wax from glands on the abdomen and fashion the honeycomb and broodcomb from it. This comb contains hexagonal cells large enough to hold a developing worker or drone, a small quantity of honey, or pollen. When the cells are filled with honey, pollen, or a pupa, a worker caps the cell thereby sealing the contents inside.

The workers tend the queen and young drones as well as the young brood. All bees develop through a complete metamorphosis: after three days, the egg hatches into a worm-like larva which feeds voraciously and grows and molts each day for about four days. It then goes into a resting stage, the pupa, which lasts for another few days in a capped cell until the bee emerges as an adult. This process takes 16-24 days depending on season and class of bee. As mentioned previously, workers feed the young larvae and seal the pupa into the cell. They also feed the emerged young adults until they are old enough to fend for themselves.



The young worker tends larvae and uses its wings to help ventilate the hive. As it gathers strength, it will start cleaning out old used cells for reuse, may tend the queen or young drones, or work on capping cells.

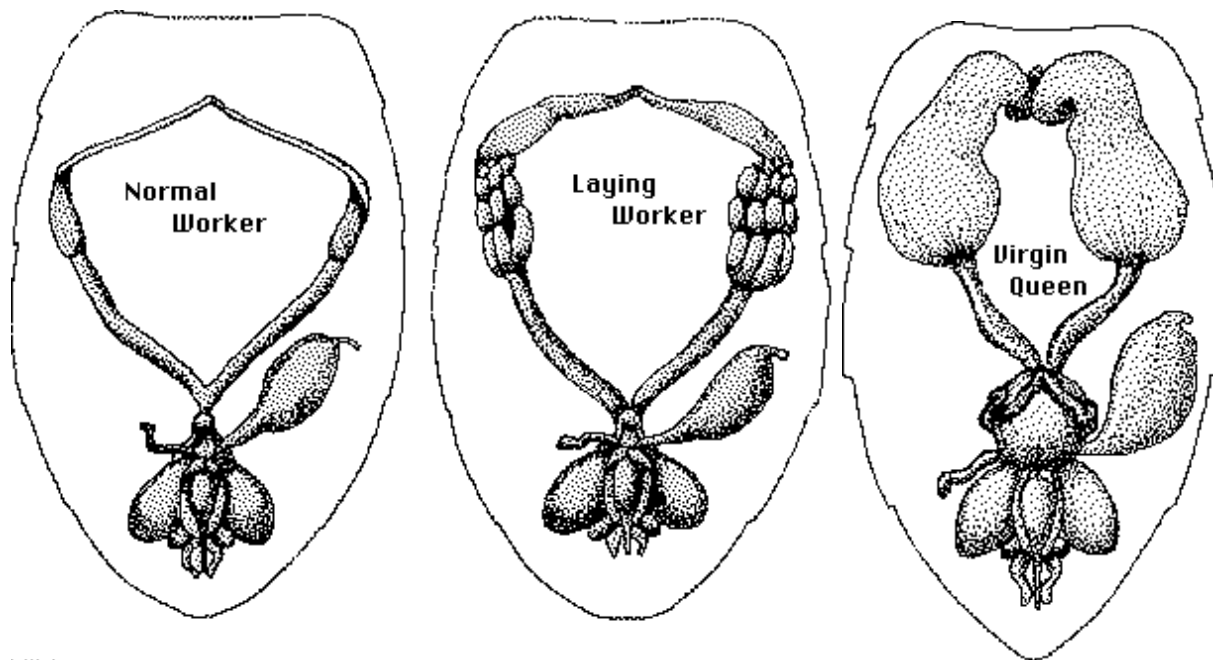
Depending on the season, and after a few days have passed, the worker works at gathering operations. The bee will fly out of the hive and visit flowers in search of nectar and pollen, or will visit trees for harvesting resin to make propolis. The propolis is used as glue and caulk to seal cracks in the hive. The nectar and pollen are collected and returned to the hive for use and/or storage.



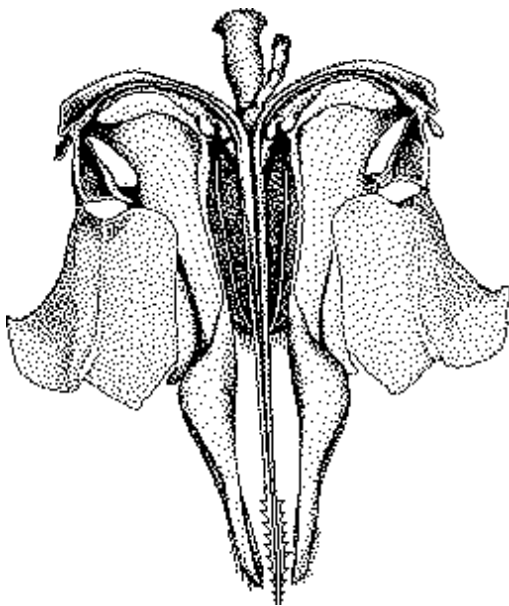
Pollen is stored in broodcomb cells and is the main supply of protein and vitamins for the hive. Pollen is 6 to 28% protein by weight and usually contains the 10 amino acids essential for bees.

Nectar is from 5 to 80% sugar but is less than 0.2% in protein, so nectar is the carbohydrate supply for the hive. Nectar is placed in honeycomb cells and the bees tending the honeycomb evaporate the water from the nectar by rapid wing movement to create ventilation. When the amount of water remaining in the nectar is less than 18%, the mixture is called honey and the bees cap off the cells.

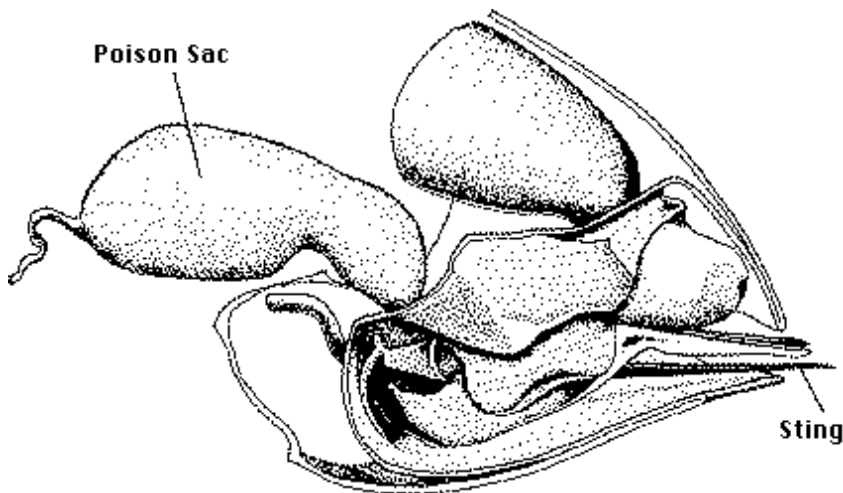
A mixture of honey and pollen is called "bee bread" and is the food for most larvae and bees. When a worker egg has been selected to become a queen, it is moved to a much larger queen cell and is fed large quantities of "royal jelly" which is similar to bee bread but contains more mandibular gland secretions and more honey (34% vs 12%). The larger cell for growth, larger food supply, additional carbohydrate, and more worker secretions results in the development of a queen.



The workers defend the hive with their sting. Rather than developing extensive ovaries, the worker bee develops a barbed stinger and a muscular venom pouch. When it is necessary to kill an intruder, a worker pushes the tip of the stinger into the surface of the intruder. The muscular barbed stings quickly saw their way into the skin of the invader and the venom pouch begins to contract rhythmically to pump venom into the intruder.



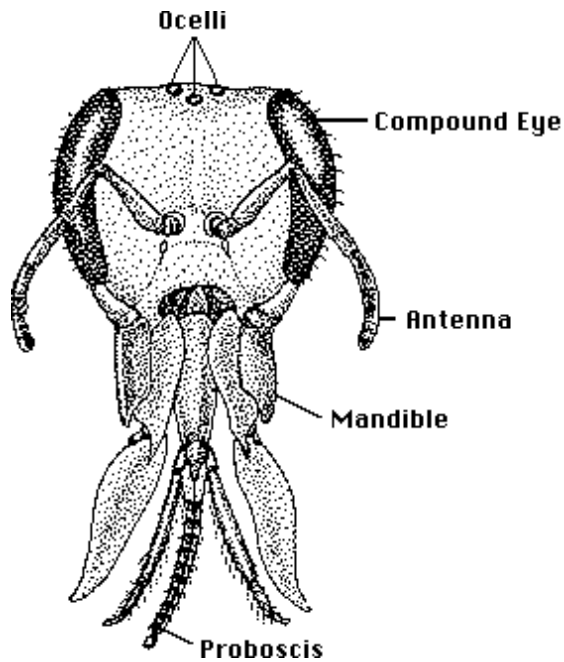
Generally the bee pulls herself away, leaving the venom pouch and sting in the invader; the worker soon dies because of the abdominal rupture. Thus stinging for honeybees is an act of self-sacrifice. Unlike many other hymenopterans, honeybees are not likely to sting unless provoked.



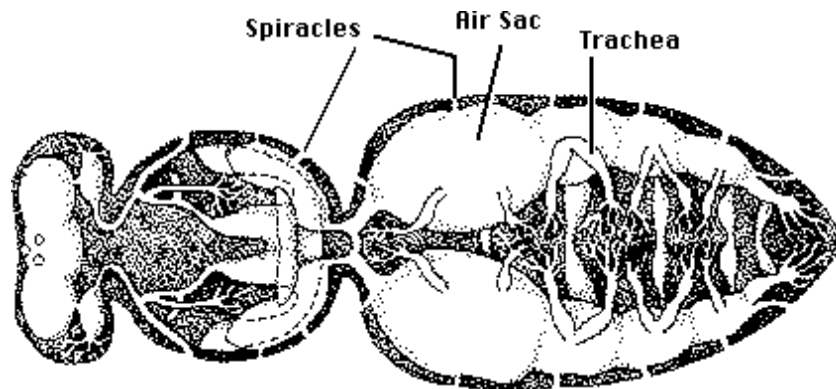
Compound	% of Venom	Effects
Melittin	50 %	Lysis of blood cells Release histamine Depress blood pressure
Phospholipase A	12 %	Cell lysis Pain Toxicity
Hyaluronidase	<3 %	Spreading factor Hydrolyzes connective tissue
Acid phosphatase	<1 %	Induces allergic reactions
Histamine	<1 %	Itching Pain

The diagrams included here show the various parts of a honeybee. The importance of the figures should be obvious with a little thought.

The bee has eyes for seeing flowers, antennae for detecting fragrances, wing muscles for flight, legs for walking and pollen gathering, a crop for transporting nectar, and a sting for defense of the hive. In your project today you will learn which colors are attractive to bees; their vision is not sensitive to the same range of colors as ours. Theirs is insensitive to red but detects ultraviolet light which is invisible to us.



For today's project, it is also important to note that bees are cold-blooded animals and lack automatic control of their body temperature. They have only behavioral control of temperature, but nevertheless maintain the hive at  $32 \pm 0.6$  C regardless of the outside temperature! When too cold, bees contract their flight muscles repeatedly without moving their wings; this behavior generates heat.



When too warm, bees pump their abdominal system to move more air through their spiracles and trabeculae; this evaporates more water and cools the bee. It might not be surprising then to see some connection between the quality of the nectar and the ambient temperature.

## The Relationship Between Flowers and Bees

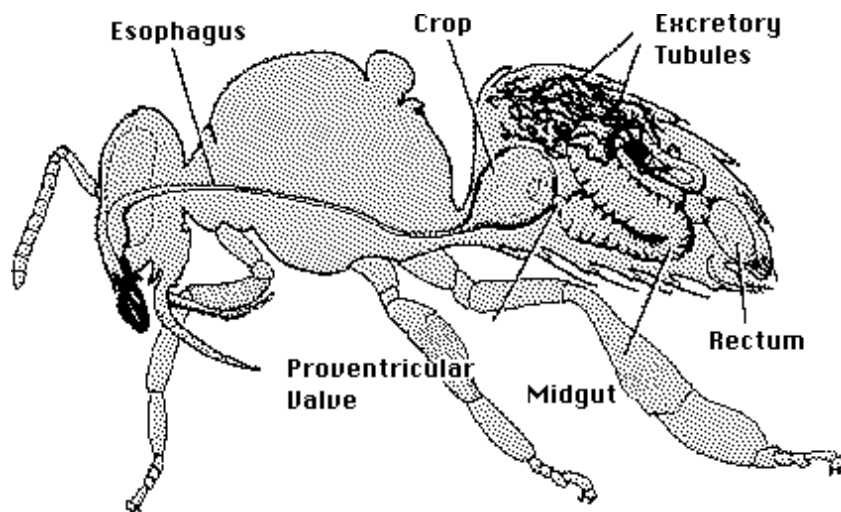
Flowers which have evolved to attract honeybees have optimized their flowers to increase the chance of a bee visit. The bees unwittingly carry pollen from flower to flower, thus pollinating the plants and permitting them to reproduce. Plants most successful in attracting bees and getting them to make repeat visits will out-reproduce those which are less successful. Thus flowers must both attract and reward an insect visitor.

### Attraction.

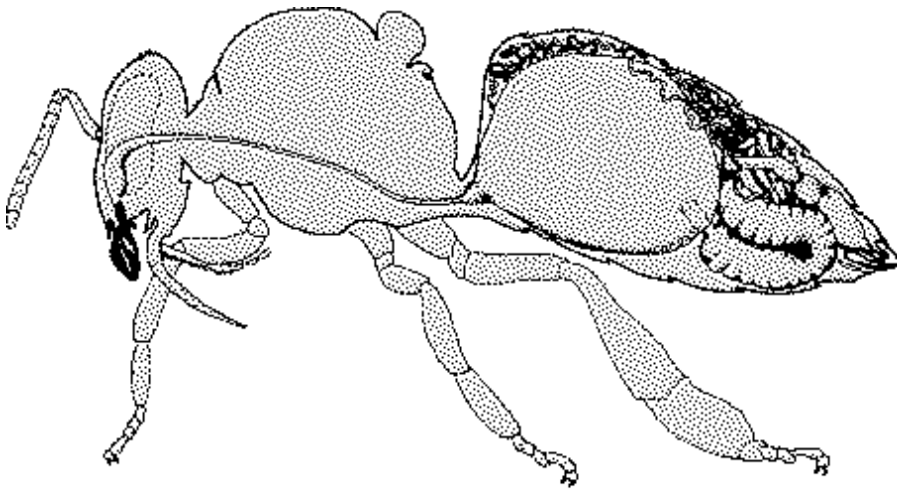
The design of bee-pollinated flowers includes mechanism(s) to attract a bee to visit the flower. The flower is shaped differently from the display of the leaves. The flower is usually a different color than leaves so that the flower is visible on the background of leaves. In general the coloration is designed so that the bee learns to distinguish it and associate a visit to that pattern with the reward. Flowers have evolved bull's-eye and nectar guide patterns in their floral displays to attract a passing bee into landing. Some flowers also attract insect visitors with fragrances. Bees have an excellent sense of smell with chemoreceptors in their antennae and are attracted to particular fragrances. The combination of visual and olfactory attractants gets the bee to land most frequently. In the absence of attractants, a bee is unlikely to observe the flower and make a landing even if there is a reward waiting for her!

## Reward.

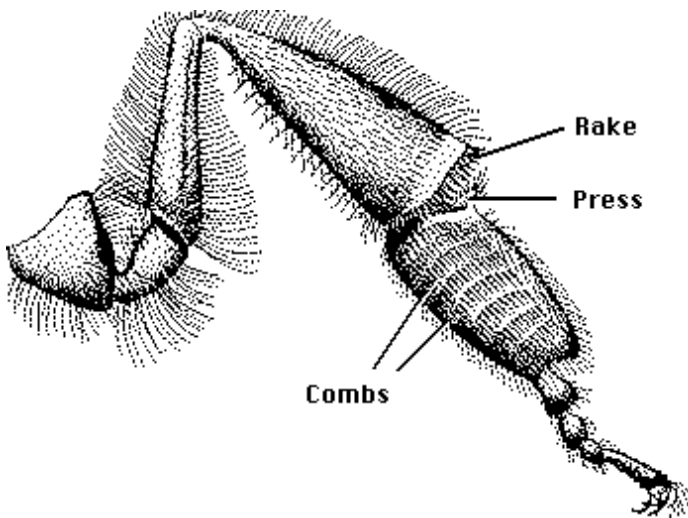
The reward plants provide bees include nectar and pollen. The nectar is a sweet liquid composed of mostly sucrose. The bees collect this liquid in their crop.



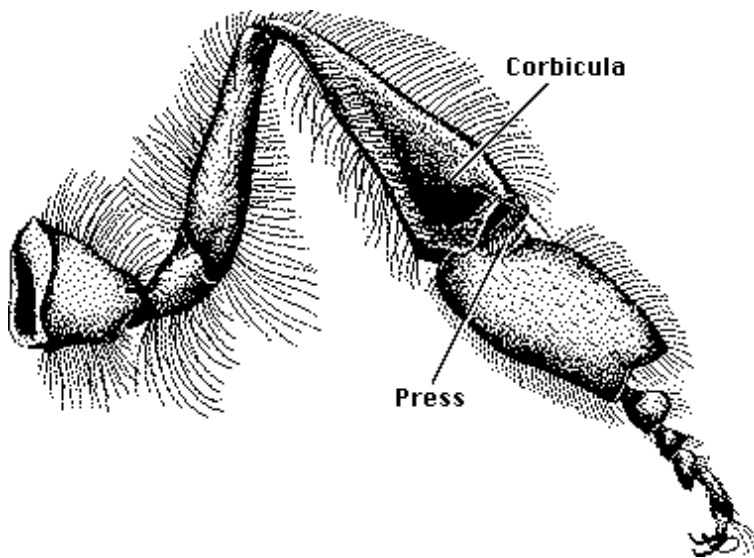
Digestive enzymes, most importantly invertase, are added. By the time the bee returns to the hive, much of the sucrose is converted to glucose and fructose. In the hive the bee empties its crop into a cell or the nectar is transferred to another worker who takes it to the honeycomb for evaporation to make honey. The bee below has a full crop!



Pollen is dusted all over the bee as she visits a flower. The bee's legs are designed to comb this pollen from her body...



and catch it in a tuft of bristles on her third pair of legs:



Fortunately for plants, the bee does not clean herself completely or often enough to prevent pollen from being transferred from flower to flower; so the flowers are usually sufficiently pollinated.

**If a plant provides little in the way of reward,  
a bee is unlikely to make many repeat visits.**

## **Bee Learning and Communication**

Bees are quite adept at association learning. A single bee will visit different flowers in the morning and, if there is sufficient attraction and reward in a particular kind of flower, she will make visits to that type of flower for most of the day, unless the plants stop producing reward or weather conditions change.

The mutualistic relationship between flowers and bees has been going on for millions of years and, not too surprisingly, has developed many interesting specialized relationships.

Bees have also apparently learned to communicate their floral findings. A bee which returns from an area with many flowers producing much nectar performs a dance on the comb. The orientation of her movements and the frequency of her vibrations indicate the direction and distance of the flowers from the hive. Thus other bees, observing her dance, will know where to find this wonderful source of food.

This amazing level of learning and communication benefit both bee and plant.

## **Human Concerns**

Understanding the relationship between bee and plant also help humans. All fruit and seed crops must be pollinated for our food and oil. Indeed, for tree fruits, bee hives are transported from orchard to orchard with trees in flower to improve the pollination of the fruit trees, but also to increase honey production. We also need bees to pollinate clover (animal forage), cotton (oil and fiber) and sunflowers (oil). Most of our "vegetables" are really fruits (tomatoes, peppers, beans, peas, corn, squash, cucumbers, etc.) and most of these need pollination by bees. Thus our study of pollination is critical to plant and bee but also to our own survival.

**One final note:** this page is written by a plant physiologist, so I am not an expert on all things insect,

hymenopteran, bee, or honeybee. So if you have "bees" that you would like to have identified, please contact your local county extension agent in the government listings of your local phonebook. If you have honeybees that are in your walls, under your porch, in your landscape, please contact your local beekeeper in the yellow pages. If a beekeeper cannot be found, try an orchard. Failing that, try an exterminator. While I am happy to have provided this page for you, I am really not the person you need to assist you with local problems. The sting of honeybees can be dangerous to those who are allergic to the venom, so I urge you to get professional help rather than relying upon this page or email to me for homespun assistance. Also, honeybees have many relatives that people casually think are honeybees. Nothing could be farther from the truth. For a nice page on the biology of the bumblebee, for example, please visit: [www.mearns.org.uk/mrsmith/bees/bees.htm](http://www.mearns.org.uk/mrsmith/bees/bees.htm). For additional reading on the honeybee I would refer you to an excellent book: Gould, J. L. and C. G. Gould. 1995. *The Honey Bee*. Scientific American Library: W. H. Freeman & Co. New York.

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