The Incredible Busy Bee

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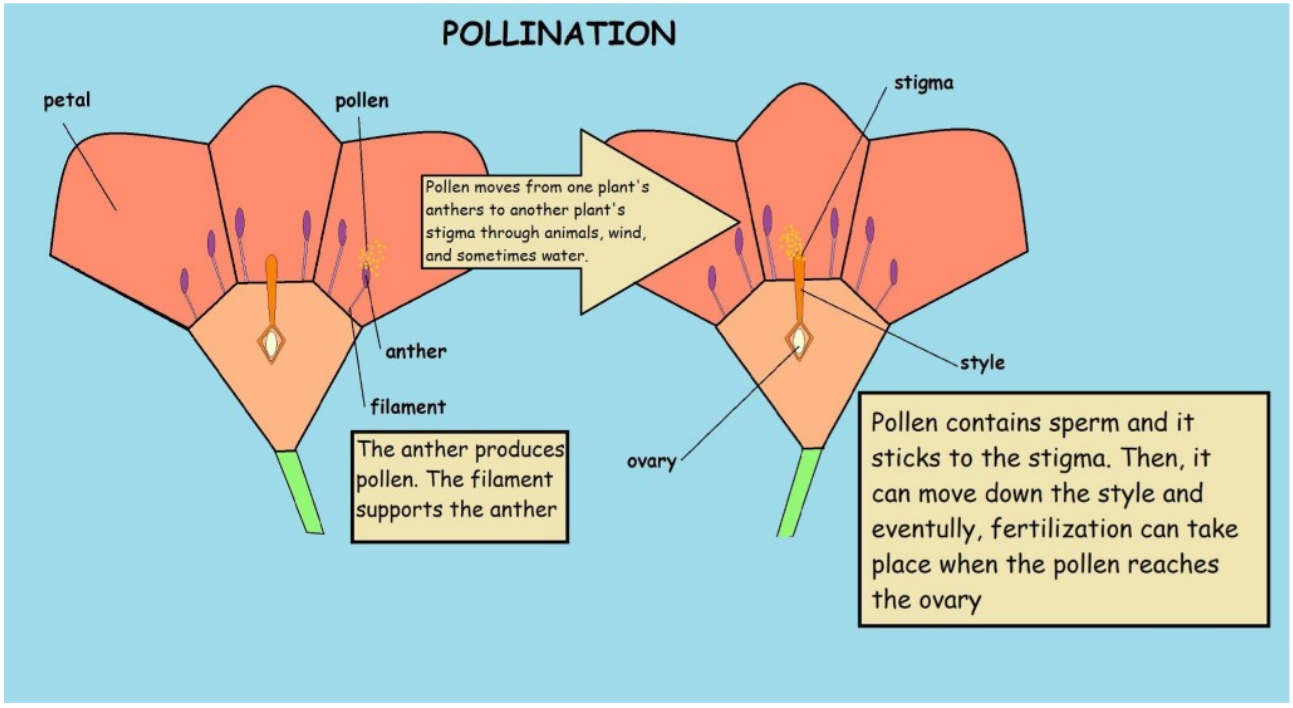
Bees are among the most unique insects in the animal kingdom. Their complicated yet ordered life styles are fascinating to study in themselves. In addition, they are an important *pollinator* of plants. Pollination of plants (see Box) allows plants to reproduce and also provides us with much of our fruits and vegetables. Without bees, many members of the plant kingdom would fade away. Of course, bees are an important source of two things used by humans and animals: **honey** and **wax**.

BOX1 Pollination

Plants reproduce in many ways. For fertilisation and seed production, the **pollen** from the *anther* (male part of the flower) has to be transferred to the *stigma* (female part of the flower). Seeds produced through fertilisation contain genetic material from both parents. This genetic diversity can help them survive over a long time. One common way for the transfer of pollen is by pollination.



Pollinating agents can be animals such as insects, birds, and bats. Even water and wind can disperse pollen.

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Bees have a special role in pollination. In this case, it is a kind of *mutualism*. This means that both the plant and the bees benefit from this interaction. The plants get fertilised so they can reproduce, and the bees get nectar from the plant, which they convert to honey.

Bees and flowers

Honeybees are well suited for pollination. Their special sets of eyes, their sense of smell and taste and their ability to locate the best food supply ensures this. In fact, today honeybees are responsible for pollinating 90 percent of the food supply and visit 50 to 100 flowers each foraging trip. They use their amazing sense of time to assess if the food supply is at a reasonable distance. This ensures that they don’t use more energy than they will be able to collect from the source.

In a special relationship with specific plants, honeybees prefer to visit only one flower species per trip. This means that the bee transfers the pollen from one plant to

another plant of the same species, and is therefore beneficial to plants. Of course, when they are in a garden with many plant types, they will visit more than one of them.
Pollen is collected when bees land on the flowers and is stored in *sacs* on their legs. But this is not the reason bees visit flowers. The flowers in turn attract bees by offering them *nectar*. Bees can smell the nectar from many kilometers away!

From nectar to honey

The bees have a specially adapted tongue called the **proboscis** that functions like a pump. Bees stick their proboscis in the flower and pull out nectar. The nectar is swallowed, but rather than entering the bee digestive tract, it is stored in a specially developed *sac* located at the bottom of the eosophagus (food pipe) above the stomach. As the bee flies back to the hive, she adds more saliva to the nectar. Bee saliva also contains a special adaptation: *invertase*. This enzyme, found no where else in nature, works to break down the complex sugars in nectar to simple sugars i.e., honey.
When the bee returns to the hive, this partially converted nectar is stored in the honeycomb, where the remaining conversion to honey takes place. The nectar is passed from bee to bee, each one adding more invertase until it's placed in a cell of the comb. When nectar flow is very high, partially converted nectar may be stored and additional invertase added when the nectar flow slows down. When the flow is slower, the bees fully convert the nectar to honey and store it in the comb, capped and stored to sustain them through the winter.

BOX2 Co-evolution

You may have heard about Darwin's theory of evolution: species change and adapt to their environment and the fittest survive. A fantastic relationship between the evolution of bees and flowering plants has been found: certain bee species (*Rediviva neliana*) have adapted with long legs in order to collect oil from the snapdragon plant (*Diascia capsularis*) which has two long tubular structures called **spurs** (see picture). The bees' front legs are coated in a dense pile of velvety hairs that soak up the oil, which is then mixed with pollen to form a super-nutritious bread for the larvae in their underground nests. The oil is also used to line the walls of these underground nests. Fascinatingly, the long spurs on the plant evolved so that the long legs of the bees would allow more pollen to be deposited on it! This made the bees with even longer legs more fit for selection, and this process has continued, driving the evolution of both bee and plant!

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Honeybee anatomy

Antennae: Honeybee antennae are used to communicate with their hive family via touch and assist in finding food sources.
Head: Although their brain is about the size of a sesame seed, it is capable of performing complex learning and communication tasks. Do you know that honey bees dance in such a way that they indicate to their family the direction where food can be found? The honeybee head contains a special gland (the *hypopharyngeal gland*). This secretes a protein that is used to feed larvae and is needed to produce royal jelly necessary to feed the queen bee. Each tiny honeybee head is has 170 **odour receptors**, giving them a sense of smell so precise they can tell the difference in hundreds of flower types and distinguish if a plant contains pollen or nectar from far away. For reference, fruit flies have only 62 odour receptors and mosquitoes only slightly more at 79.
Eyes: Bees have two sets of eyes, *compound* and *simple* (see picture). With their two huge **compound** eyes, bees are able to see in an omni-directional fashion. These eyes are located on each side of the head and provide a full surround view of their environment. Bees cannot see the color red, but they can see beyond purple into the ultraviolet (UV).
It has three **simple** eyes which are located on the top of the head and used to triangulate direction; this means, they are used for navigation. Both the two complex eyes and the three simple eyes are covered in hair which keeps foreign debris from getting in their eyes.

BOX Amazing fact:
Flowers typically have a negative electric charge. As bees fly through the air, they create a positive electric charge. When a positively charged bee lands on a negatively charged flower, pollen transfers via static electricity. Scientists have found that honeybees can also sense electric fields and distinguish their shapes and sizes.
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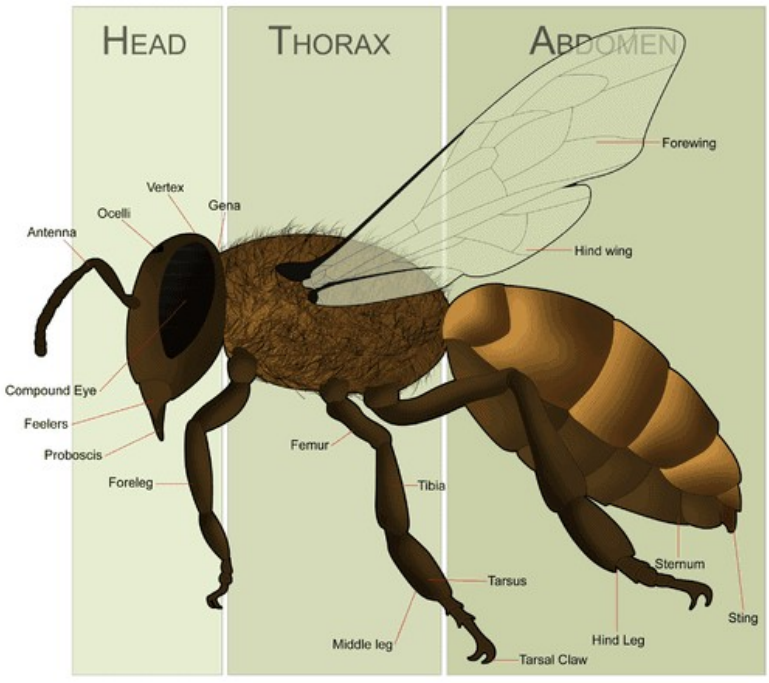
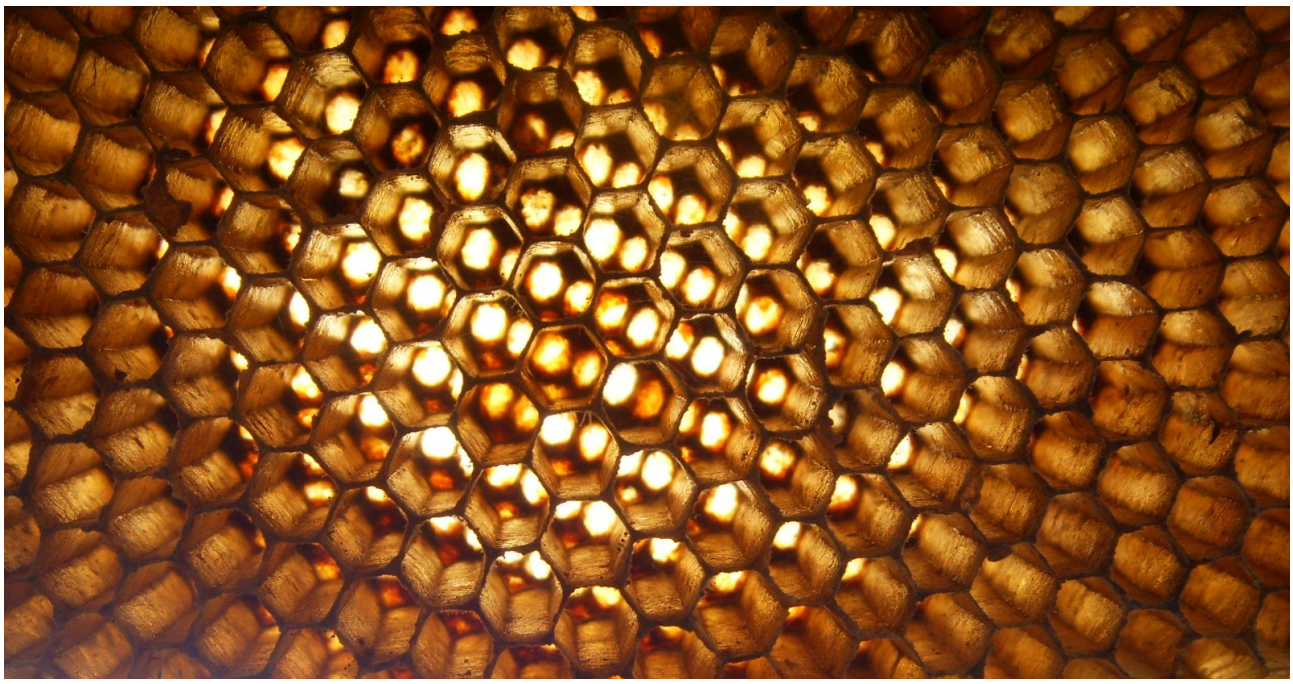


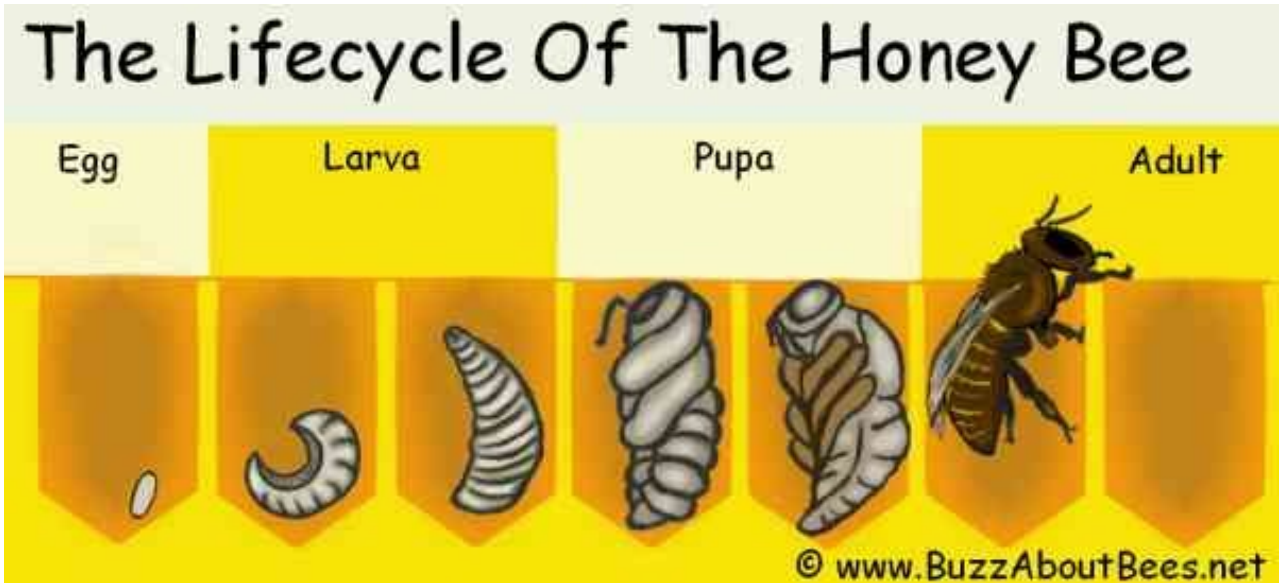
Legs: Unlike most insects, bees have feet! These feet are specially adapted to stand on a variety of surface types. The “toes” are claw-like to help them stand on rough surfaces such as a tree branch. The remaining soft padded areas provide greater surface area and friction so they can stand on smooth surfaces like flower petals (see picture).

Stinger: Honeybees use their stingers only in defense. When female bees feel their brood or food is endanger, they sting the perceived threat and die in the process. Male bees do not have stingers. When a female bee stings a threat, the barbed end of the stinger hooks in and causes the stinger to be pulled off as the honeybee tries to fly away. This kills her, but also releases a chemical substance called *pheromone*, which warns her sisters of potential danger. Thankfully, honeybees do not chase. When the threat moves away, they get back to work.

Bees and social life

Bees have a complex and extremely rigid social structure. The **queen** is the only bee in the hive to be fertilized by a male bee. She is the mother of all the bees in the hive and only eats a special food called *royal jelly*. The sex of a bee is determined by whether or not the egg is fertilised. Fertilised eggs produce female offspring called *worker bees*, and unfertilised eggs produce male *drones*.
Bees live in nests called *honeycombs* which are made of **beeswax**. The hexagonal grid (see picture) is made up of individual cells. The queen lays eggs in each. The cells for the male drones are made slightly bigger. The antennae are used to make the precision structure to yield this most beautiful and symmetric result. Also they are constructed to be strong and robust.
There are many more amazing facts about the bee life cycle: after the egg is laid, it turns into a legless larva and then a pupa. During this stage it undergoes a complete metamorphosis and emerges as an adult with wings!





Bees are among the most studied, yet least understood animals to share our world. They are critical to our survival, yet constantly at risk of extinction. Being so little understood, humans are still discovering ways to help them, and in doing so will hopefully save all of us.

Sources: Sarah Woodard, https://www.perfectbee.com, Wikipedia, phys.org