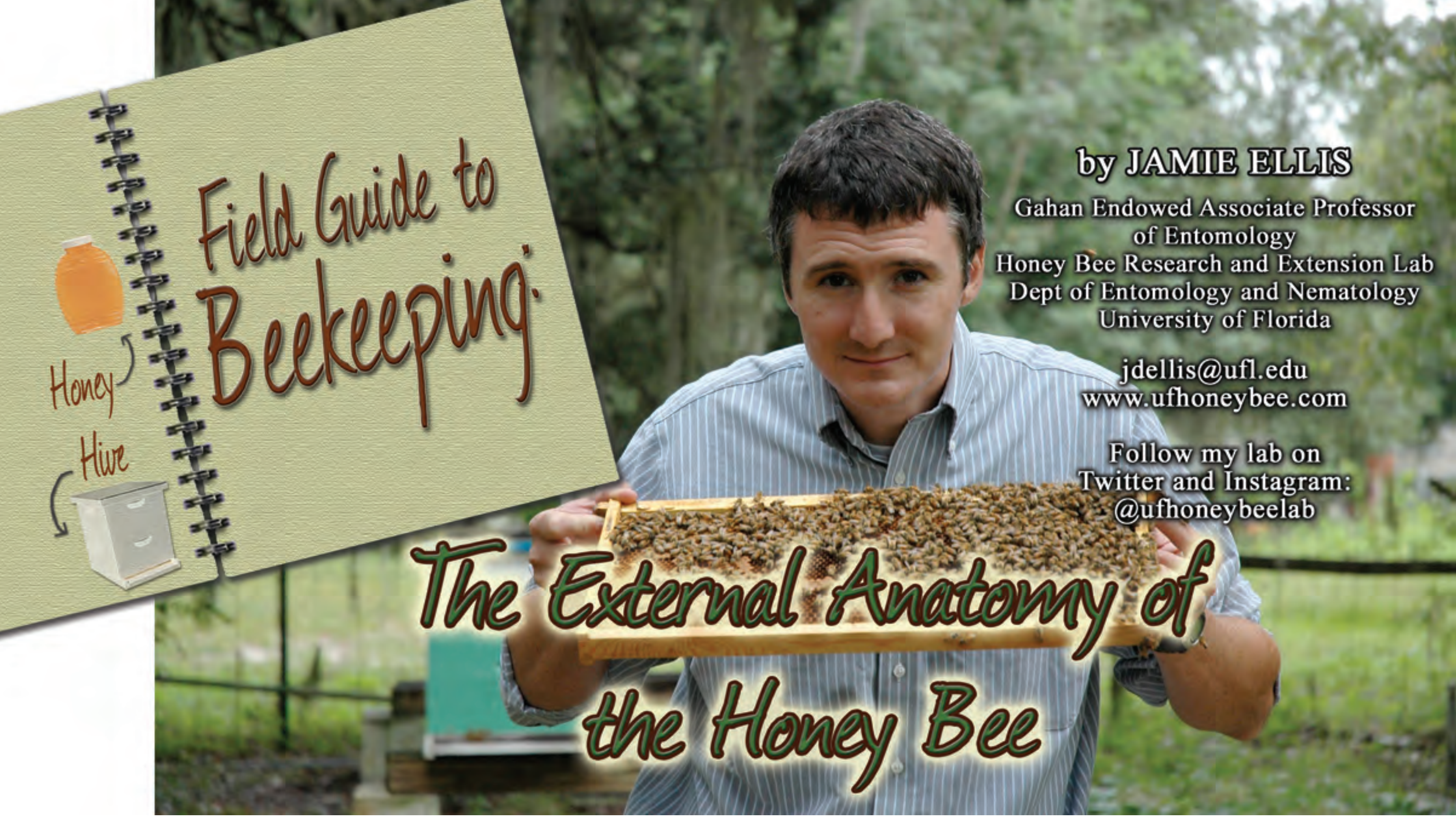


The External Anatomy of the Honey Bee

by JAMIE ELLIS
Gahan Endowed Associate Professor of Entomology
Honey Bee Research and Extension Lab
Dept of Entomology and Nematology
University of Florida

jdellis@ufl.edu
www.ufhoneybee.com

Follow my lab on Twitter and Instagram: @ufhoneybeelab

The honey bee is a wonderful creature. Its behavior, physiology, and ecology are marvels to behold. The range of behaviors expressed by honey bees is diverse and sophisticated. Its internal workings keep the bee alive and healthy, ultimately producing an ecology that is profound, perhaps the most impressive of all the social insects. All of these wonders are made possible by the bee's physical structure. Honey bees have an external anatomy that perfectly complements its function. It is this external anatomy to which I want to introduce you in this article, with the key words printed in **bold font**.

General anatomy

Honey bees are insects and there are certain physical characteristics that all insects share. Most notably, insects have three body regions and six legs (Figure 1). The body regions are called the **head**, **thorax**, and **abdomen**. Each body regions has its own important role to play in the overall function of the honey bee. Correspondingly, the external structure of each body region is developed to support the given region's function.

As for other insects, a honey bee's body is covered in a thick layer of cuticle that entomologists call **exoskeleton**, or external skeleton. The exoskeleton is made of a few different layers itself. However, it is sufficient to say that it forms the hard structure that protects the bee's vital internal organs. It also serves as a point of attachment of muscle and other tissues of the body. The exoskeleton of the bee can be pigmented or lack pigmentation. Generally speaking though, the exoskeleton is what gives the bee its dark color since it usually is pigmented black or variations thereof, especially in the head and thoracic regions. That said, there is a special condition where bees produce brown pigmentation in areas that otherwise normally would be black. This produces a bee that is reddish-brown in color. This trait is called **cordovan**, hence the origination of

Figure 1. A lateral (side) view of the adult worker honey bee. The three body regions of this insect, from right to left, are the head, thorax, and abdomen. Notice that the honey bee is covered in hair. *Photograph by Mike Bentley*.

Figure 2. A front view (face) of the head of a worker honey bee. The two large and black compound eyes can be seen on either side of the head and the two antennae are in the center of the face, extending toward the viewer. One of three ocelli (dark circle at the top center of the face, surrounded by tall hair) is at the top of the face while the biting/chewing mouthparts (the mandibles) are at the bottom. *Photograph by Mike Bentley*.

Figure 3. A closer view of a worker honey bee's compound eye. You can see the individual facets of the eye in the two areas of the eye that are reflecting light. Notice that the eyes also contain lots of hair. *Photograph by Mike Bentley*.

Figure 4. A closer view of a worker honey bee's antenna. *Photograph by Mike Bentley*.

the cordovan bee. Incidentally, the bee in Figure 5 is cordovan while the one in Figure 1 is not. You can see the clear difference in the coloration pattern of the two bees.

Bees' bodies also are covered in **hair**. A bee's hair differs from ours in one notable way. Our hairs are single shafts while a bee's hair is branched. This is part of what distinguishes the bees from the wasps. The branched hairs help pollen stick to the bee's body easier. Furthermore, these hairs build up an electrostatic charge as bees fly. This charge makes the pollen jump onto a bee's body when she visits a flower. Clearly, these hairs are important to the survival of the bee colony.

Head

The honey bee **head** is the center of sensory perception for the bee. Almost everything that a bee uses to sense the outside world is part of or connected to the head. The most notable external features of a bee's head occur on the front or **face** of the bee (Figure 2). These include two large compound eyes, three small ocelli, two antennae, a tongue, and mandibles.

Bees have five eyes, two large compound eyes and three ocelli. The **compound eyes** are situated on either side of the bee's head (Figure 3). The compound eyes are composed of thousands of little lenses or **facets**. Together, the facets help bees see color, movement, and patterns. The images from all of the lenses in a single compound eye are believed to be joined into a single image in the bee's brain. The bees do not see images the way we see them. It is possible that

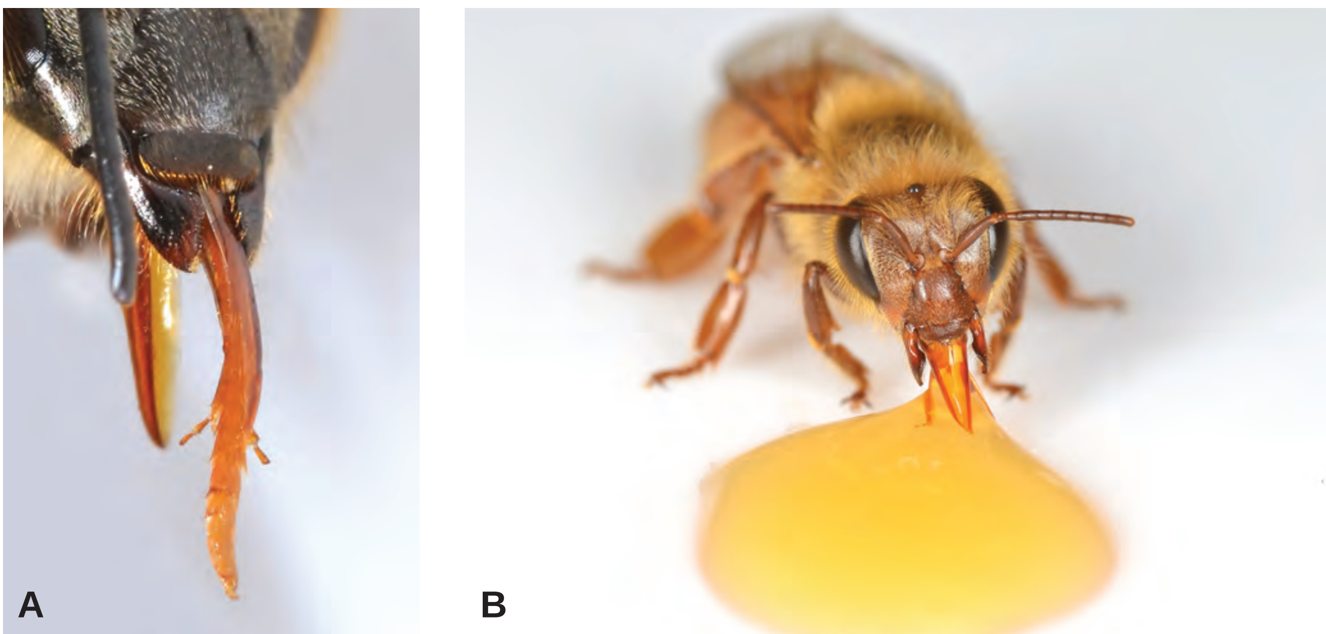
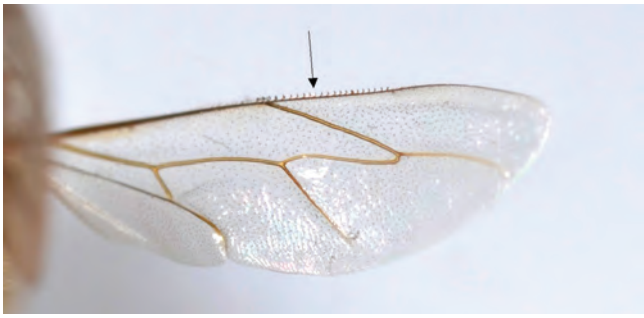


Figure 5. The proboscis or tongue of a worker honey bee (A). The bee is able to use its tongue to lap and suck up fluids (B). The worker bee in Figure 5B is cordovan. In Figure 5B, notice how the bee's mandibles have opened wide to allow the tongue to extend from the center of the face. The front, center ocellus can be seen at the top center of the head. *Photographs by Mike Bentley*.



(l) Figure 6. The forewing of a worker honey bee. The forewing is the larger of the two wings that a worker bee has on both sides of her body. It has a fold at the back edge (in this photo, at the bottom of the left side of the wing, arrowed) that accommodates the hamuli on the leading edge of hindwing. This allows the wings to be joined and beat in unison. (r) Figure 7. The hindwing of a worker honey bee. Notice the hamuli, or little hooks, on the leading edge (top, arrowed) of the wing. These hook on the fold at the back of the forewing. The hindwing has a significantly reduced wing venation pattern. *Photographs by Mike Bentley*.

they perceive images more like a mosaic, because they are less able to see definition and outlines. Interestingly enough, bees see further into the ultraviolet (UV) spectrum that do humans. Many flowers of bee-pollinated plants have petals containing patterns that only can be seen by organisms possessing the ability to see into the UV spectrum. Of final note, bees can detect polarized light, but do not see as far into the red spectrum as do humans. Red appears black to a bee.

The function of the three **ocelli** at the top of a bee's head is less understood. These eyes are arranged in a triangular pattern and each contains only one lens. Ocelli, sometimes called simple eyes, aid in the detection of sunlight, or light intensity in general. Thus, the ocelli help bees navigate during flight.

Honey bees have two **antennae** that come out of the face between the compound eyes (Figures 2 and 4). The antennae are major sensory organs. They are covered in small hairs and recessed pits. The hairs on the bee's antennae detect tactile sensation (i.e. touch) while the pits detect chemical scents. With these functions, antennae are used much the same way we use our fingers to touch items, our nose to smell them, and our tongues to taste them.

The honey bee's **mouth** is located at the bottom of the bee's head (Figure 2). The mouth is composed of many external parts, too many to discuss in great detail here. However, it is sufficient to say that a worker bee's mouthparts are used for two primary purposes: (1) biting/chewing and (2) lapping/sucking.

Bees have special mouth parts that they use to bite and chew items. These mouthparts are paired, hard, contain ridges, and are called **mandibles** (Figure 2). The mandibles are used to manipulate wax, bite small nest intruders, pick up small items, etc. In some ways, they are much like our teeth and hands. Given that bees do not have hands, they use their mandibles to move and carry items.

Bees have **tongues**, called **proboscises** (plural of **proboscis**), that fold behind the mandibles. The tongues can be extended (Figure 5A) and are used to lick surfaces, suck fluids (Figure 5B), exchange food between bees, remove water from nectar, etc. Bee tongues are composed of multiple parts that, when properly in place, form a hollow tube through which bees can suck fluids.

Thorax

If the head is the bee's main body segment used for sensory perception, then the **thorax** is the bee's main body segment used for locomotion. Quite frankly, the thorax is the point of attachment for everything that moves a bee. In fact, a dissection of the thorax will show that it is full of the muscle necessary to power the bee's wings and legs.

Adult honey bees have four **wings**, two on either side of the body. The wings make it possible for the bees to fly. The larger of the two wings on either side of the thorax is called the forewing (Figure 6) while the smaller is called the hindwing (Figure 7). A detailed look at either wing, especially the forewing, will show that the wings have an intricate venation pattern. The **veins** in a bee's wing, and more importantly so the places where the veins intersect and the patterns they create, can be used to help distinguish between the subspecies of honey bees.

The back edge of a bee's forewing contains a fold to which small hooks on the leading edge of a bee's hindwing can fasten. These hooks, called **hamuli** (see Figure 7), allow the wings to be joined (Figure 8) and move in unison as the bee flies. This is a useful thing to know because certain conditions that bees get cause the wings to unhinge. This condition is called **K wing** because the bee's body and unhinged wings look like the letter K.

The three pairs of legs a bee has also are attached to the bee's thorax. The three pairs are called the forelegs, middle legs, and

Figure 8. The joined fore- and hind-wings of a worker honey bee. *Photograph by Mike Bentley*.

Figure 9. The foreleg (front leg) of a worker honey bee. The most notable characteristic of this leg is the notch in the middle of the leg that accommodates the bee's antennae. In this picture, the circular notch is about halfway up the left side of the leg and is arrowed. The notch, fittingly so, is called an antenna cleaner. *Photograph by Mike Bentley*.

Figure 10. The middle leg of a worker honey bee. This leg contains the spine (arrowed) that the worker bee uses to pry and manipulate pollen and propolis. *Photograph by Mike Bentley*.

Figure 11. The hind leg of a worker honey bee. This leg contains the pollen basket. The pollen basket is a large row of hairs (arrowed) on either side of the middle part of the leg. These hairs hold the pollen that is packed onto the hind leg. This photo also includes a good view of the bee foot that ends in a claw the bee uses to grasp various surfaces. *Photograph by Mike Bentley*.

hind legs from front to back, respectively. The legs are used to walk and/or otherwise move a bee when she is not flying. Each pair of legs has its own modification that is used for a very specific function.

The **forelegs** are the front pair of legs, closest to the bee's head (Figure 9). These are smaller legs that contain a circular notch with which the bees clean their antennae. This notch, appropriately so, is called the **antenna cleaner**.

The **middle legs** (Figure 10) are the second pair of legs. Their most notable characteristic is a spine that the bees may use to pry pollen or propolis.

The last two legs of a honey bee are called **hind legs** (Figure 11). These legs contain numerous structures bees use to manipulate and/or transport pollen. For example, the hind legs have multiple stiff hairs arranged in rows on their inner sides. This structure is known as the **pollen comb** and bees use it to comb pollen from their bodies. They then rub their legs together and use a **pollen rake** (stiff hairs between two parts of the hind leg) to push the pollen from the pollen comb and into a **pollen press**. Bees use the pollen press to compact the collected pollen for easy transport.

The most known structure on the hind leg is the **pollen basket**, or **corbicula**. The pollen basket is not really a basket at all but is actually a single row of long hairs on either side of one part of the hind leg. Looking closely at Figure 11, you will see the row of hairs on either side of the middle section of the hind leg shown. These hairs act like fingers that hold the large mass of pollen that bees pack into this section. A properly filled pollen basket is shown in Figure 12.

All bee legs end in **feet** that are more appropriately called **tarsi**. A good image of a bee tarsus can be seen at the end of the hind leg in Figure 11. The tarsus has a two pronged **claw** that the bees use to grasp surfaces.

Abdomen

Externally, the **abdomen** (the third part of a bee's body) is very simple in structure. There are no appendages, no legs, wings, or otherwise particularly noticeable characteristics to discuss. The abdomen's greatest

Figure 12. A worker honey bee with a fully loaded pollen basket. *Photograph by Mike Bentley*.

Figure 13. The lateral (side) view of a worker honey bee with an excellent view of the bee's entire abdomen. Notice where the upper plates (tergites) and lower plates (sternites) of the abdomen meet in a line down the side of the bee. The tergites literally wrap around the top of the abdomen. *Photograph by Mike Bentley*.

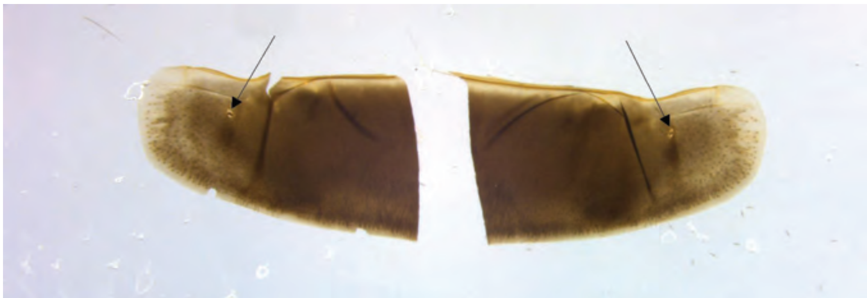


Figure 14. A dissected tergite from the abdomen of a worker honey bee. The tergite was cut into two pieces so that it could be photographed in a single plane. The upper part of the tergite would face in the direction of the bee's head and be covered by the second half of the preceding tergite, thus hiding it from view on a living bee. The two spiracles are arrowed in this photograph. The spiracles would be on the side of the bee's abdomen. *Photograph by Tomas Bustamante*.

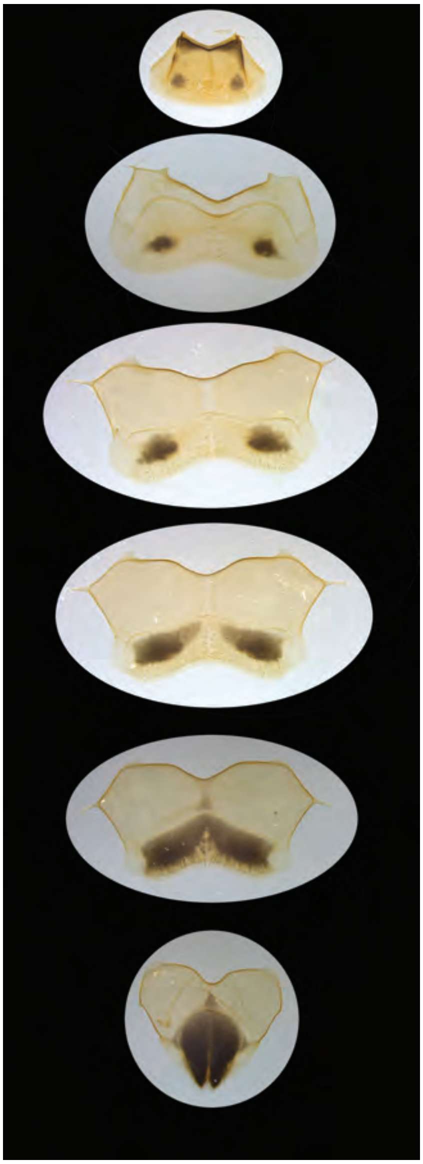


Figure 15. The sternites of a worker bee's abdomen. They are sternites 2 (uppermost) through 7, recognizing that sternite 1 is connected to the thorax. *Photograph by Tomas Bustamante*.

diversity is internally as this part of the body houses most of the digestive tract, **hemolymph** (bee blood), other internal organs, etc. Thus, it is an extremely important part of the bee, even if that is difficult to tell from the outside.

It is interesting to note that the first part of the abdomen occurs *before* the restricted waste of the bee. The abdomen is divided into numerous sections, seven in fact, with the first fused to the thorax. In fact, many people consider the first section to be a part of the thorax, though it is not. The part of the abdomen fused to the thorax is called the **propodeum** and it occurs before the restricted waist (sometimes called a **wasp waist** or **petiole**). The restricted waist occurs on abdominal section 2 and is unique to bees, wasps, and ants. Abdominal sections 2 – 7 form what most people recognize as the "abdomen proper" or the **gaster**.

The abdomen offers a great opportunity to talk about the different types of plates that compose the exoskeleton of a bee. Essentially, you can think about a bee, from top to bottom, in three layers of plates. The upper plates are called **tergites**, the middle plates **pleurites**, and the lower plates **sternites**. Pleurites are absent on the bee's abdomen, though present on the thorax.

Imagine viewing a bee from the side (Figure 14). The tergites literally wrap around the top 2/3's of the abdomen. The tergites have coloration and hair growth patterns that vary across the various subspecies of honey bee. In fact, it is usually the coloration of the abdomen that beekeepers most use to distinguish between the races. A dissected tergite from the abdomen can be seen in Figure 14. The tergite had to be cut into two pieces in order to put it in a plane for photographing, this due to its natural curve. Notice the pigmentation on the tergite. Tergites overlap one another much like scales on a fish.

Each tergite on the abdomen (and thorax as well) contains a small opening called a **spiracle** that leads to the tracheal system inside the bee. On the abdomen, the spiracles are located on the parts of the tergite that overlaps the sides of the bee (Figure 14). Though spiracles occur on other parts of the bee, they are the most visible on the bee's abdomen, hence my discussion of spiracles in the abdomen section. That said, there is a significant spiracle at the base of the bee's wings on the side of the thorax. This spiracle is notable because it is through this spiracle that tracheal mites enter the tracheal system of the bee.

The lower part of the gaster (the abdomen proper) is covered by a series of sternites, 6 to be exact (Figure 15). Some of the sternites contain **wax plates** (Figure 16) onto which **wax glands** secret wax. The wax plates are considered a part of a bee's external anatomy even though they are covered by the bottom half of the previous sternite. The wax secreted onto the plates dry into **wax scales** that bees manipulate with their mandibles and fashion into the wax comb that is part of their nest.

The final abdominal feature worth noting is the stinger. **Stingers** are composed of multiple parts, some that are inside of the bee's body and some that are considered external

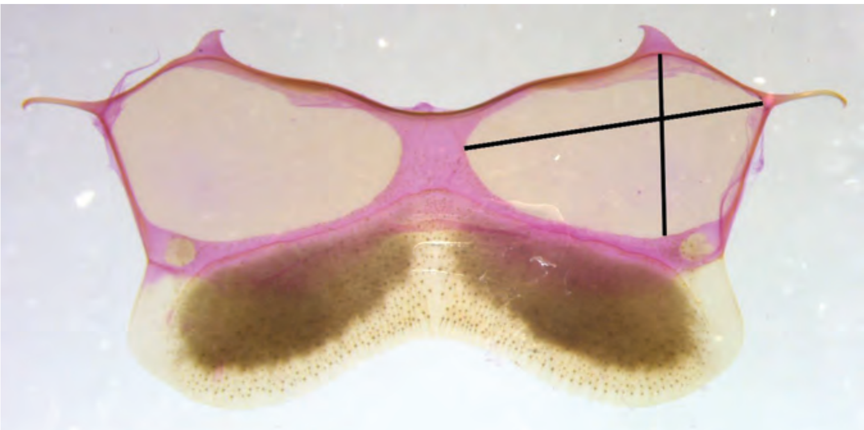


Figure 16. The wax plates on sternite 4. The height and width of the wax plate on the right are indicated by black lines. The upper half of the sternite has been dyed purple to make the wax plates more visible. The lower half of the sternite (seen here with yellowish and black pigmentation) would cover the wax plates of the following sternite, making them hidden from the naked eye. *Photograph by Tomas Bustamante*.

anatomy. For purposes of this publication, I will note the part that is considered external anatomy and that is the **sting shaft** (Figure 17). The sting shaft is the part of the stinger that sticks into the victim upon being stung. It is made of a few parts that slide against one another once the sting is deposited into the victim. This sliding action causes the sting shaft to work its way further into the victim. The parts come together to form a hollow tube through which venom is pumped into the victim. Sting shafts have small barbs close to the pointed end. The barbs help the stinger remain lodged in the victim.

Conclusion

I hope you appreciate the beauty that is the honey bee. For ease of recognition and as a review, I include Figure 18 which shows a line drawing of the most notable external features of the worker honey bee. I hope this article has been of some use to you. If nothing else, I hope you appreciate how wonderfully made the honey bee is.

Figure 17. The abdomen of a cordovan worker bee with the sting shaft extended. *Photograph by Mike Bentley*.

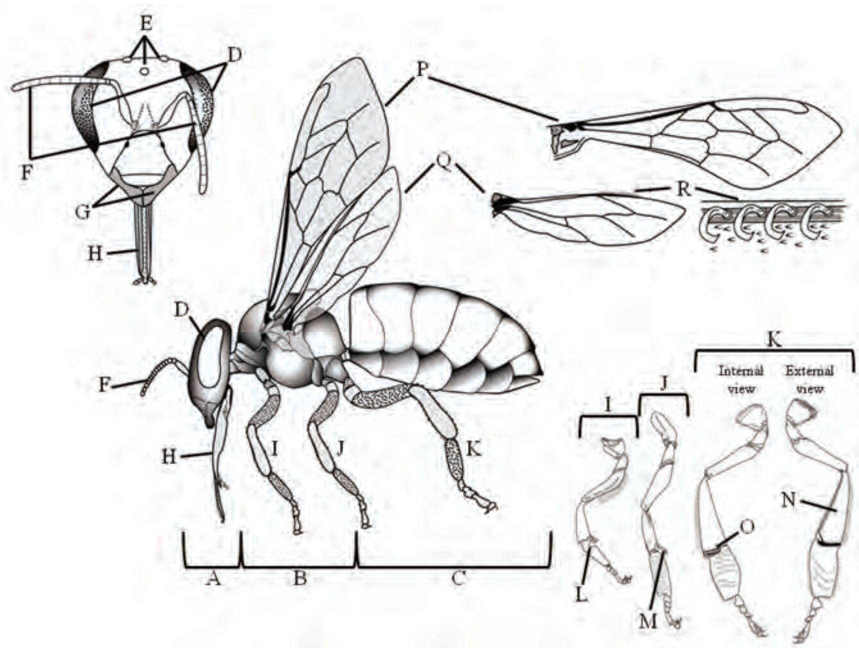


Figure 18. An overview of the external anatomy of a worker honey bee. A – head; B – thorax; C – abdomen; D – compound eyes; E – ocelli; F – antennae; G – mandibles; H – proboscis; I – foreleg; J – middle leg; K – hind leg; L – antenna cleaner; M – spine; N – pollen basket/corbicula; O – pollen press; P – forewing; Q – hind wing; R – hamuli (including location on hind wing and close up view). *Drawing by Kay Weigel*, University of Florida. Published in Ellis, J.D., Atkinson, E.B., Graham, J.G. 2014. Honey bee biology. In: W. Ritter (ed) Bee Health and Veterinarians. OIE World Organization for Animal Health, Paris, France. pp. 15-28.