Anatomy and Physiology
Honey bees 3 segments
Exoskeleton

Bees have a hard outer covering call an exoskeleton The exoskeleton helps protect the delicate internal structures, conserves internal body fluids so the body does not desiccate, and also serves as a protective barrier to the entry of pathogens. The exoskeleton is made of a material called Chitin The body of the bee is covered with setae or branched hair
• Bees are well covered by branched (plumose) body hairs.
• They also have thousands of unbranched hairs covering their body which are for sensory purposes. The hairs extend from the body **exoskeleton** that gives shape and form to a bee.
Exoskeleton
There are three eyes, called ocelli, located at the top of the head between the bee’s two larger compound eyes. The ocelli detect light but can’t focus or arrange an image like the larger compound eyes. Ocelli register intensity, wavelength, and duration of light. At dusk the ocelli estimate extent of approaching darkness, causing the bees to return to their hives.

Honey Bees use their antennae to learn about their environment: Tiny sensory hairs on each antenna allow them to smell, taste, feel air movements and to communicate with one another.

The compound eyes each have almost 7,000 hexagonal facets. Each facet is like a mini-eye, containing its own lens and sensory cells.

A bee’s curved, spoon-shaped jaws, called the mandible, are built for many uses: They can be used to ingest food, manipulate wax to build the hive cells, feed the young or queen, and even fight.

The long proboscis at the front of the bee’s head is used to ingest liquids such as nectar, honey or water. The proboscis is tipped with a spoon-shaped glossa.
Antennae receive and analyze highly volatile substances that are responsible for odor and taste. Antennae also perceive vibrations and movement of air (sounds, temperature and humidity). Aide in communication

Johnston's organ is a collection of sensory cells found in the pedicel (the second segment) of the antennae. Johnston's organ detects motion in the flagellum (third and final antennal segment). Johnston's organ can also sense wind. It consists of over 200 scolopidia arrayed in a bowl shape, each of which contains a mechanosensory neuron.

The scrape of the drone is shorter than in the workers but the flagellum is longer with 12 rings compared to 11 in worker and queen.
Thorax
Honey bees have six legs and specialized structures.
Hind leg

- Coxa
- Trochanter
- Femur
- Tibia
- Basitarsus
- Tarsi
- Pollen basket
- Pollen press
- Pollen comb
- RIGHT (hind) leg and its medial surface. From top to bottom are the tibia, basitarsus, and four short tarsal segments. Between the tibia and basitarsus is the flattened, notched pollen press.
- The ranks of hairs act as combs for grooming and pollen gathering. When the basitarsal combs are loaded to capacity with pollen, the rastellum (rake) is used to unload the comb by scraping it into the press where the pollen is compressed and transferred to the tibial baskets on the outside surface above the pollen press. Hence, pollen groomed from the right side of the body is combed from the inner surfaces of the middle and forelegs by the left hind leg, from which it is removed by the right rastelhum for deposition in the pollen basket of the same leg. The
Mediolateral view, of the pollen press. The floor of the press is edged with fine hairs, and its surface is covered with denticelike cuticular spines or scales. Long, curved hairs from the tibia bend down and lie over the press and a picket of shorter, stiff spines (rastellum) lines the dorsomedial margin of the press. Small mechanoreceptor hairs are visible at the leading edge of the spatulate hairs (upper left). (x 100)

Hairs on the medial surface of the tibia. The flattened-tip spatulate character of these hairs contrasts markedly with the basitarsal hairs, which have serrated edges and a fairly sharp tip. The specialized hairs of the tibia may have an important function in the process of gathering and packing.
Pretarsus – foot – very important part of the bee is the part that allows the bee to cling to surfaces smooth or rough. The claws aid in clinging to rough surfaces. The arolium aids in clinging to smooth surfaces. The *Antenna cleaner*
Wings
Abdomen of honey bee external

Spiracle use for breathing
Four basic functions of Glands in Honeybees

- Wax production
- Communication
- Defense
- Food processing

Fig. 3.19

The worker glandular system. (Redrawn from Michener, 1974.)
**Honey bee glands**

- **wax gland**: produce wax in segments of abdomen
- **nasonov gland**: orient swarm/hive entrance/flower attraction. produced in the last abdomen segment. dispersed by wing buzzing
- **mandibular gland**: makes lipids for larval food/alarm pheromone '2-heptanone' and queen substance. produced in the head
- **sting pheromone gland**: makes the alarm 'isopental'. produced in the stinger
- **arnhart gland**: leaves the 'scented footprint' on flowers and hive. produced in the tarsal segment of legs
- **salivary gland**: secretes invertase. produced in the mouth
- **hypopharyngeal gland**: produces royal jelly, produced in the head
- **Dufour gland**: secretions are utilized in defense by workers or reproduction In queens.
MANDIBULAR GLANDS

- Reduced or well developed in the young worker depending on colony condition; produces “royal jelly” components.
HYPOPHARYNGEAL GLANDS
- Most developed in worker nurse bees to produce “brood food”.
- Rudimentary in the queens but may produce some communication chemicals with these glands (under investigation).
- Absent or vestigial in the drone (debated question).
orient
swarm/hive entrance/flower attraction. produced in the last abdomen segment. dispersed by wing buzzing
secretes invertase. Used in converting sugars
leaves the 'scented footprint' on flowers and hive. produced in the tarsal segment of legs.
makes the alarm 'isopental'.

The worker glandular system. (Redrawn from Michener, 1974.)
Plate 21. Comparison of the stings of the queen and worker. A. Tips of the queen lancets (X 270). B. Tips of the worker lancets (X 270). C. Tip of the queen stylet (X 270). D. Tip of the worker stylet (X 270). E. Shaft of the queen sting (X 110). F. Shaft of the worker sting (X 110). G. Close-up of a sensillum for detecting pressure (X 7,615). Note that one of these sensors is associated with each barb on both the stylet and lancets.
produce wax in segments of abdomen worker only segments 4,5,6 and 7
Digestive system

- aorta
- salivary gland
- wing muscles
- air sacs
- honey stomach
- stomach
- chambers of dorsal vessel
- respirator muscle
- small intestine
- rectum
- poison sac
- sting
- pharynx
- glossa
- nerve ganglia
Honey bees have reversible movement of foods from mouthparts to/from a honey stomach. The *proventriculus*, honey stopper prevent nectar form entering The honey stomach is a crop or storage area to hold freshly collected nectar or water for transport to/from the nest.

**Honey Stomach:** The honey stomach contains enzymes that act on flower nectar to produce the beginnings of honey.
Digestion of foods occurs in the mid-gut. The hind-gut reclaims water and nutrients and passes small amounts of indigestible wastes to the rectum for storage until excretion.
In the spring you will find how much waste can be stored when the girls make their cleansing flights over your nice new, clean bee suit or jacket.

(You might want to get the kind with a detachable veil)

**Rectum:** The rectum stores a honeybee's waste until it can be expelled.
Unlike mammals the circulatory and respiratory systems are mostly separated.

- The circulatory system is “open”, consisting of a dorsal heart and aorta to assist in blood circulation.
- The main functions of the circulatory system are to transport food from the midgut to body cells, transport gases, hormones, defensive proteins, waste materials from cells to excretory organs.

- **Blood (hemolymph) has only a minor role in gas transport.**
1. Insects have no lungs or centralized respiratory system.
2. System of **trachea** which carry oxygen to and CO2 away from cells.
3. Trachea are connected to the outside by a series of 10 holes in the exoskeleton called **spiracles**.
4. At rest respiration occurs passively by diffusion.
5. Under stress, such as during flight, bees pump their abdomens to increase gas exchange and expand air sacs of the trachea like bellows, facilitating greater gas exchange.
6. Though the blood contains no hemoglobin, muscles indirectly connected to the wings contain cytochrome, a molecule which enhances gas exchange.

Respiratory system
Nervous system

- Consists of the brain and **7 ganglia** at various junctions throughout the body.
- Most locomotion is controlled by the ganglia not the brain.
- A beheaded insect can move its legs and wings vigorously.
- A decapitated bee can walk and sting but flying is not possible because it is out of balance without the head.
- The bee brain consists of a small bundle of cells with all the automatic functions transferred to the ganglia (~spinal cord).
- The ganglia are reduced to barely visible proportions.
- Bees are able to learn and have “short-term” memory.
- Enormous ovaries compared to workers.
- Mated queen is an egg-laying machine; up to 2,000 eggs per day.
- Queens mate in the 2nd week of adult life with 5-20 males in 1-3 mating flights and will never mate again.
- Sperm is stored in the spermatheca; enough to last a life span of 2-8 years.

**Queen reproductive system**
A, ovaries, genital ducts and genital pouches of the queen. B, single ovariole, diagrammatic, showing succession of egg cells and nurse cells. C, reproductive organs of a worker, together with shaft of sting, sting glands, and poison sac.

BGld, “alkaline” gland of sting; E, egg; EC, egg chamber; GCls, undifferentiated germ cells; NC, nurse chamber; Odc, common oviduct; Odl, lateral (paired) oviduct; Ov, ovary; P, lateral genital pouch; PO, opening of lateral pouch; PsnGld, poison gland of sting; PsnSc, poison sac; Spt, spermatheca; SptDet, spermathecal duct; SptGld, spermathecal gland; Stn, shaft of sting; tf, terminal filament; Vag, vagina; VO, opening of vagina; x, cut edge of body wall around genital openings.
The Drone