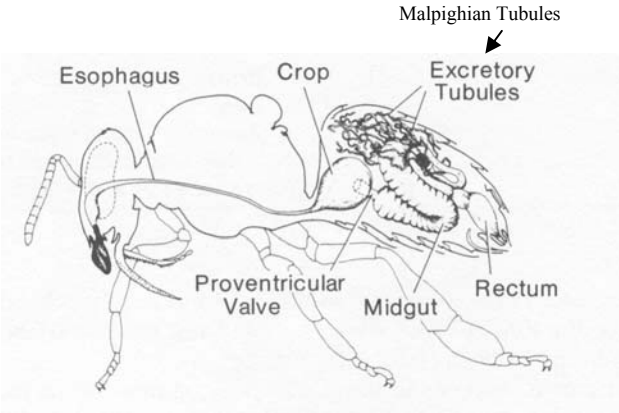
INTERNAL ANATOMY OF HONEY BEES

1. Digestive and excretory systems.
2. Circulatory, respiratory, and nervous systems.
3. Endocrine system.
4. Reproductive organs.

DIGESTIVE SYSTEM



1. Food enters through the **esophagus** and enters the **crop** (aka honey stomach).
2. The crop is the structure used to carry nectar from flowers to the hive.

CROP

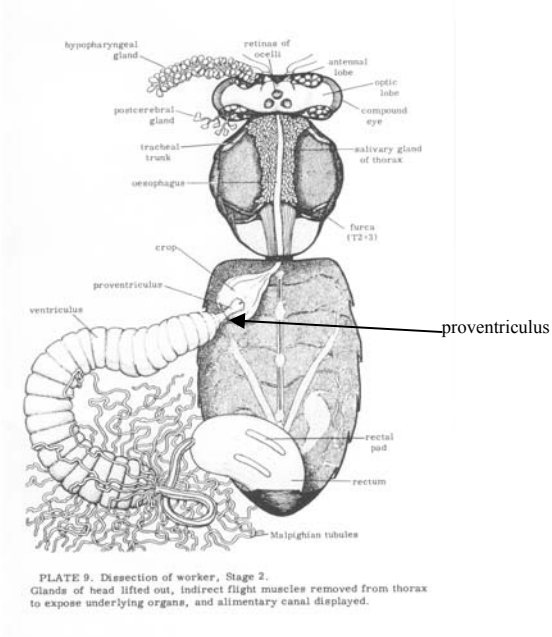


PLATE 9. Dissection of worker, Stage 2. Glands of head lifted out, indirect flight muscles removed from thorax to expose underlying organs, and alimentary canal displayed.

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- Crop is also called the 'honey stomach'.
- Transparent sac, which when full, fully occupies a large part of the anterior of the abdomen.
- Muscles surrounding the crop contract when it's empty and reduce it to small proportions.
- The maximum load of nectar the crop can carry is about 100 mg., but the average ranges from 20 to 40 mg.
- 1 lb of nectar represents between 12,000 to 24,000 nectar foraging bouts. Many more trips for 1 lb of honey.

PROVENTRICULUS

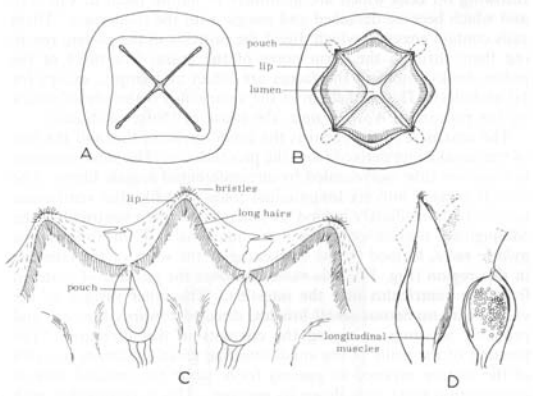

Fig. 16. The proventriculus. A, anterior aspect, lips closed; B, ditto, lips open to show the short spines and long hairs of the lips, and the lumen partly closed by the muscles below the lips, also the pouches which open into the lumen. C, part of the proventriculus laid out after slitting up on one side; three of the four lips are shown, with the pollen pouches between them. D, sketch of a longitudinal section, on the left through a lip, on the right through a pouch.

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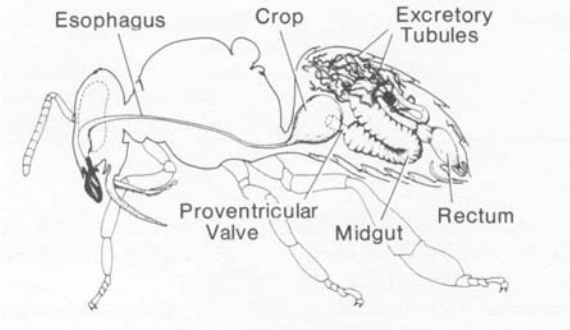
- Proventriculus is a valve that prevents the crop contents from passing into the stomach (a.k.a. ventriculus).
- It comprises a filtering apparatus for extracting pollen that may be mixed with nectar; sometimes in large quantities.
- Pollen collects in pouches behind the lips of the proventriculus. When the pouches are full, the pollen masses pass into the stomach.

DIGESTIVE SYSTEM



- Most digestion and absorption occurs in the midgut (a.k.a. small intestine).
- The small intestine opens to the rectum through which waste is expelled.

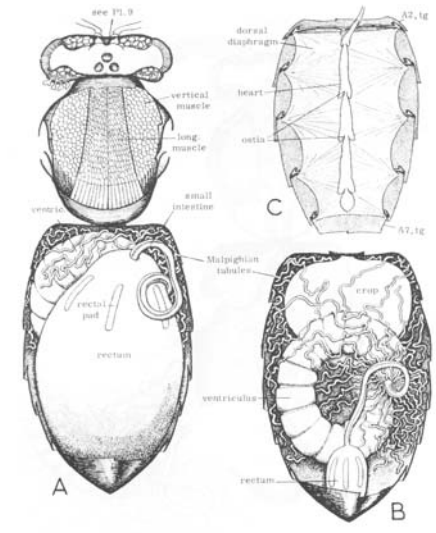


PLATE 8. Dissection of the worker from the dorsal aspect, Stage 1. A, roofs of the head, thorax, and abdomen removed, and underlying organs undisturbed; abdomen shows condition of bee confined to hive; for details of head, see Plate 9. B, abdomen shows condition of bee returning to the hive, rectum empty, crop full of nectar. C, roof of abdomen inverted, showing heart and dorsal diaphragm attached to tergites.

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- Like the crop the rectum is capable of very great extension.
- Bees will not defecate in the nest and are able to accommodate a large quantity of waste matter during long periods of confinement such as rain and winter.

EXCRETORY SYSTEM

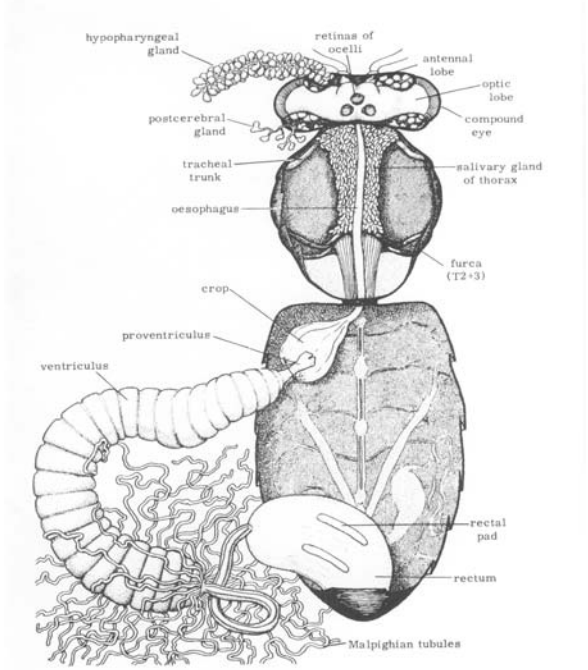


PLATE 9. Dissection of worker, Stage 2.
Glands of head lifted out, indirect flight muscles removed from thorax to expose underlying organs, and alimentary canal displayed.

Dade (1985) Anatomy and Dissection of the Honeybee

- Solid waste, mostly indigestible pollen, fats, dead gut cells, pass through the intestine to the **rectum** for excretion.
- Liquid nitrogenous wastes are absorbed from *the* blood by the **Malpighian tubules** (excretory tubules), passed to the intestine and then the rectum.
- Bees have about 100 Malpighian tubules. They are named after an Italian physiologist, Malpighi (1623-1694), as well as the protozoan which parasitizes them *Malpighamoeba mellificae*.

FAT BODY

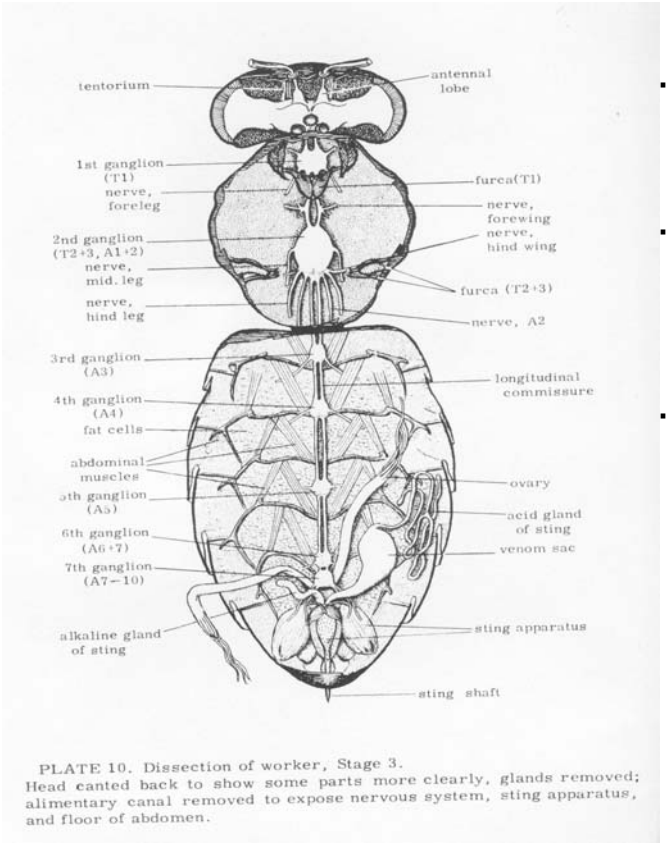


PLATE 10. Dissection of worker, Stage 3.
Head canted back to show some parts more clearly, glands removed; alimentary canal removed to expose nervous system, sting apparatus, and floor of abdomen.

Dade (1985) Anatomy and Dissection of the Honeybee

- Food storage occurs with the fat body.
- It is a layer of conspicuous creamy cells concentrated on the floor and roof of the abdomen.
- There are 2 kinds fat body cells; 1) “fat cells” contain mostly fat and some albumen (protein), and some glycogen, 2) oenocytes, thought to have functions associated with wax production, and the transport of molecules.

CIRCULATORY SYSTEM

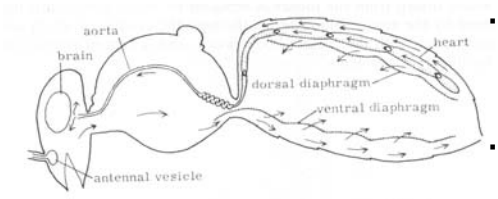


Fig. 20. Diagram illustrating the action of the heart and diaphragms.
Dade (1985) Anatomy and Dissection of the Honeybee

- Unlike mammals the circulatory and respiratory systems are mostly separated in insects.
- The circulatory system is "open", consisting of a dorsal heart and aorta to assist in blood circulation.
- Insects have no lungs, and only a few species have hemoglobin, or an analogous substance.
- 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.

RESPIRATORY SYSTEM

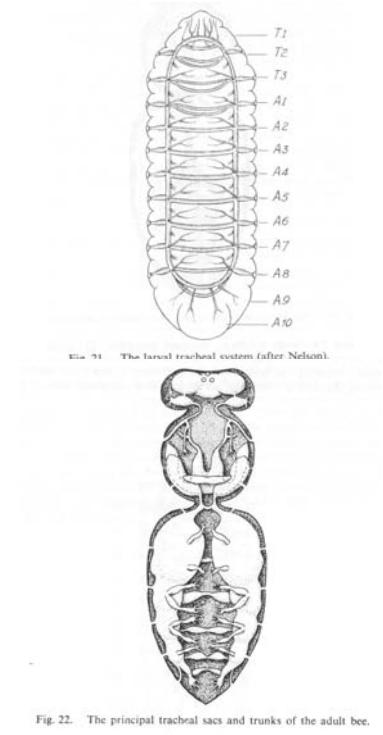


Fig. 22. The principal tracheal sacs and trunks of the adult bee.

Dade (1985) Anatomy and Dissection of the Honeybee

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 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.
7. Insects are adapted to tolerate much higher concentrations of CO2 than humans.

NERVOUS SYSTEM

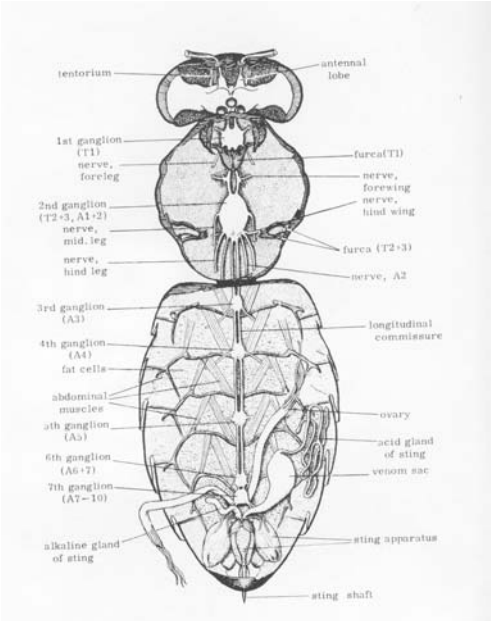


PLATE 10. Dissection of worker, Stage 3. Head canted back to show some parts more clearly, glands removed; alimentary canal removed to expose nervous system, sting apparatus, and floor of abdomen.

- 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 it's 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.
- Bees have a "brain" but it barely resembles a human brain.
- 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.

BRAIN

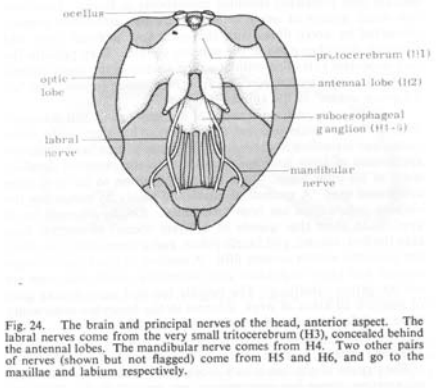


Fig. 24. The brain and principal nerves of the head, anterior aspect. The labral nerves come from the very small tritocerebrum (H3), concealed behind the antennal lobes. The mandibular nerve comes from H4. Two other pairs of nerves (shown but not flagged) come from H5 and H6, and go to the maxillae and labium respectively.

Dade (1985) Anatomy and Dissection of the Honeybee

- In the protocerebrum, under the ocelli, are paired areas of the brain called "mushroom bodies". They contain groups of nerve cells that function to associate sensory information with other parts of the nervous system.
- Mushroom bodies play an important role in the ability of honey bees to learn, remember, and to act on that information.

ENDOCRINE SYSTEM

- Insect endocrinology is more complex and less understood than mammalian endocrinology.
- Regulatory hormones.
- Endocrine and exocrine glands that produce enzymes and pheromones.

GLANDS

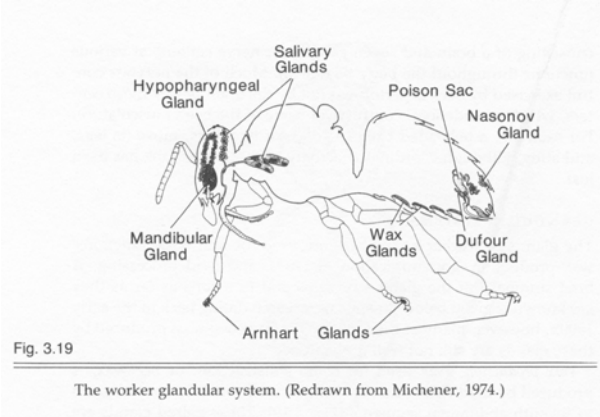


Fig. 3.19

The worker glandular system. (Redrawn from Michener, 1974.)

- Four basic functions
  - Wax production
  - Communication
  - Defense
  - Food processing

WAX PRODUCTION

- Wax is used for comb construction
- Bees in their 2nd to 3rd week of adult life produce wax.
- Paired glands on the inner sides of abdominal plates (sternites) 4 to 7 secrete wax.
- Wax glands lie under the "mirrors" in the front of these plates.
- Scales of wax form on the mirrors, which are concealed by the preceding plate.
- Liquid wax is secreted onto the mirror where it hardens and is removed with brushes on the hind legs.
- The legs pass the wax to the mandibles for placement and manipulation.
- Composed mostly of hydrocarbons.

COMMUNICATION

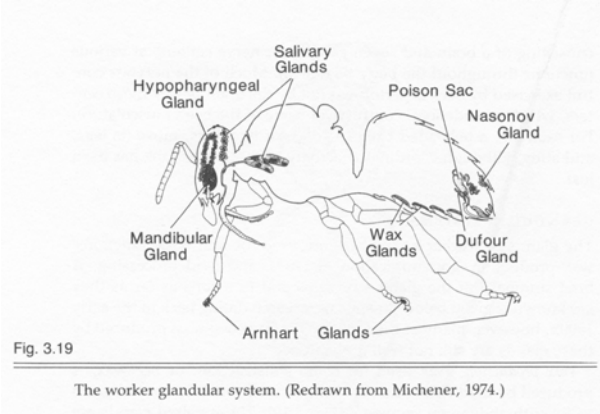
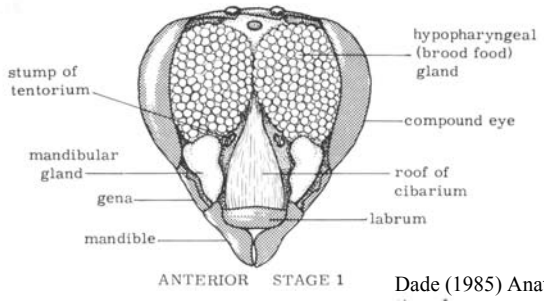


Fig. 3.19

The worker glandular system. (Redrawn from Michener, 1974.)

- More on this in the pheromone lectures.
- Glands producing communication chemicals include:
  - Mandibular glands
  - Hypopharyngeal glands
  - Nasanov gland
  - Sting gland (a.ka. Poison or venom gland)
  - Dufour's gland
  - "Arnhart" glands (?)

HEAD GLANDS



Dade (1985) Anatomy and Dissection of the Honeybee

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).

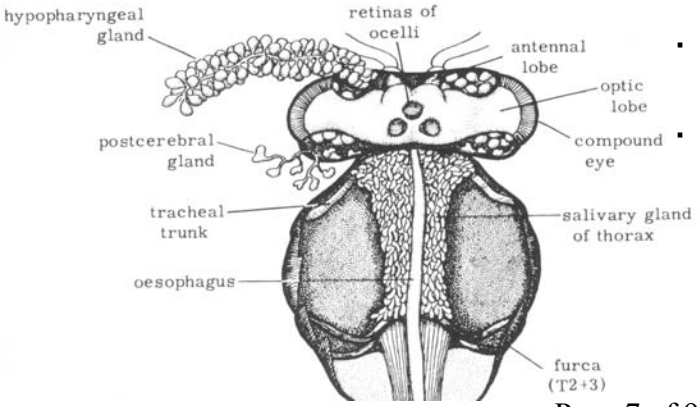
MANDIBULAR GLANDS

- Reduced or well developed in the young worker depending on colony condition; produces "royal jelly" components.
- Produces alarm pheromones in older workers.
- Workers produce some queen mandibular gland components but in ratios and quantities differ from queens.
- Most developed in queens eliciting multiple responses from workers and drones.
- Whole head solvent extracts of drone heads are attractive to other drones. Rudimentary drone mandibular glands may produce congregation chemicals.

DEFENSIVE GLANDS

- Alarm and defensive pheromones are secreted from the hypopharyngeal glands of older bees and the sting gland.

FOOD PROCESSING GLANDS



- Two types of food processing glands:
- **Digestive glands**
- Labial or **salivary gland** and the postcerebral glands have been implicated in producing invertase.

Invertase is an enzyme used in the pre-digestion of sucrose.

- Convert sugars, clean the queen, and possibly soften materials that require chewing.

- **Brood food producing gland**
  - Hypopharyngeal glands
    - Well developed in "nurse" bees.
    - Nurse bees consume pollen stored in the colony and convert the pollen; proteins from the pollen are converted, in the hypopharyngeal glands into proteinaceous food.
    - Brood food is deposited as a pool of food for larvae.
  - Mandibular glands

LARVA IN A POOL OF BROOD FOOD

- Primarily secretions of the hypopharyngeal glands.
- Royal jelly fed to queens is primarily secreted from worker mandibular glands.

FEMALE REPRODUCTIVE ORGANS

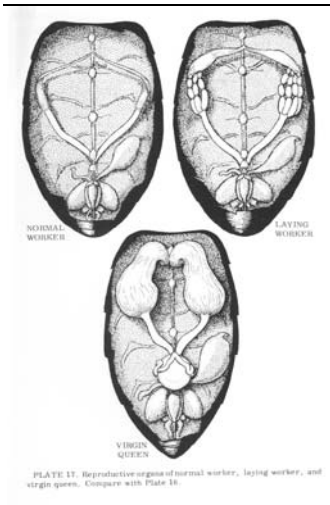


PLATE 17. Reproductive organs of normal worker, laying worker, and virgin queen. Compare with Plate 16.

- **Ovaries** of the queen are paired organs, each one consisting of a bundle of ~150 or more **ovarioles**.
- Ovaries of workers are also paired but number of ovarioles depends on colony conditions.

QUEEN OVARIES

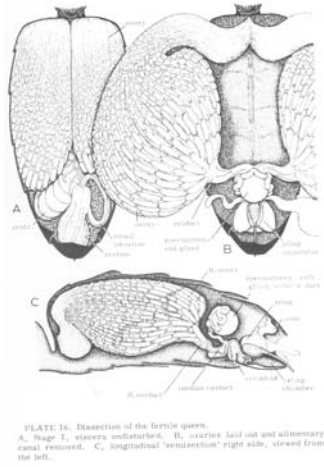


PLATE 16. Dissection of the fertile queen.
A, Stage I, ovaries undisturbed. B, ovaries laid out and alimentary canal removed. C, longitudinal 'semisection' right side, viewed from the left.

- **Ovarioles** of a fertile queen are very large, filling the bulk of the abdominal cavity.

OVARIOLE AND EGGS

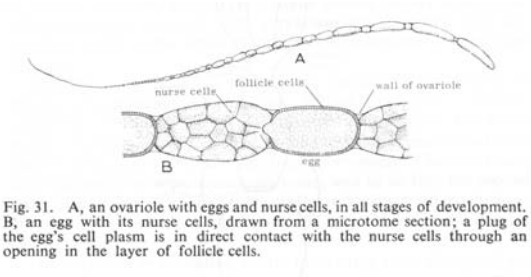
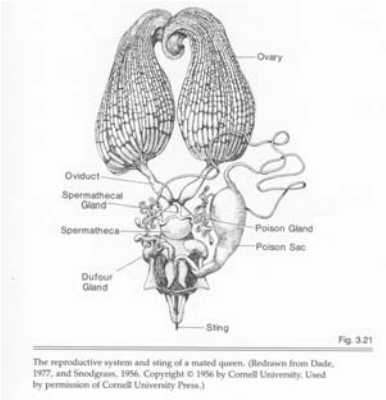


Fig. 31. A, an ovariole with eggs and nurse cells, in all stages of development. B, an egg with its nurse cells, drawn from a microtome section; a plug of the egg's cell plasm is in direct contact with the nurse cells through an opening in the layer of follicle cells.

- Egg cells are budded off from the germinal tissue in the tip of the ovariole and begin to slide down the tubule. As they move down the eggs become differentiated into 3 kinds of cells: 1) egg, 2) nurse, and 3) follicles (cells surrounding the egg).

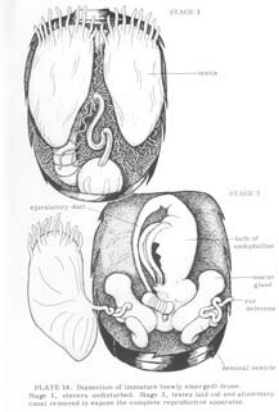
QUEEN MORPHOLOGY

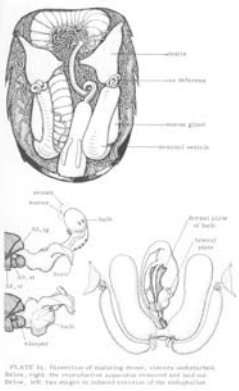


The reproductive system and sting of a mated queen. (Redrawn from Dade, 1977, and Snodgrass, 1956. Copyright © 1956 by Cornell University. Used by permission of Cornell University Press.)

- 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.

DRONE MORPHOLOGY





- In immature adult males the majority of the abdominal cavity is taken up by testes which are white, bean-shaped bodies.
- Testes are composed of bundles of tubules in which sperm are produced and mature.
- At sexual maturity (~12-13 days after emergence), testes are greatly reduced to small, greenish-yellow tissue.
- Sperm and associated nurse cells pass to the seminal vesicles.
- The endophallus is everted on mating.
- A pair of copulatory claspers grip the queen during copulation.
- Once completed the endophallus breaks off and left in the queen.
- Drones mate only once in life, then die.