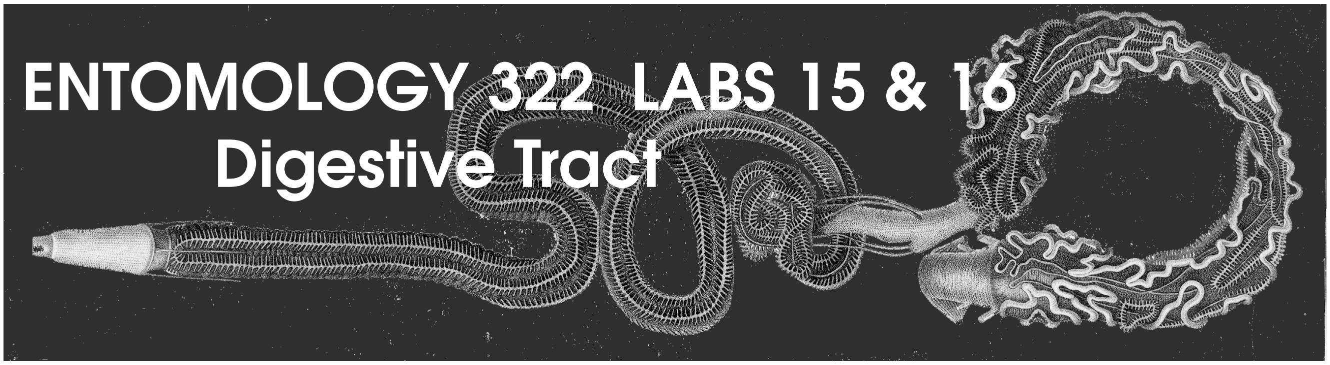
ENTOMOLOGY 322 LABS 15 & 16
Digestive Tract



In this lab we will examine the digestive tract of insects. The digestive tract is composed of both ectodermal and mesodermal components. The <u>foregut</u> and <u>hindgut</u> are derived from embryonic ectoderm and secrete cuticle. These two elements are thus an extension of the exoskeleton. The primary function of the foregut is breakdown and storage of foods, since the cuticular lining prevents absorbtion. The hindgut, in association with the malpighian tubules, is the primary site of osmotic regulation and excretion of wastes. The <u>midgut</u>, which is derived from embryonic mesoderm, is the primary site of absorbtion. Keep these different functions in mind when you examine the gross morphology of different regions of the gut, and consider how differing morphologies reflect different functions.

1.

Obtain a live specimen of the house cricket (*Acheta domestica*) and anesthetize it with chloroform. Next, pin it dorsal side up in a dissecting tray and cover it with Ringer's solution so that the tissues remain alive. Carefully cut along the midline and pin back the overlaying terga. In the thorax locate the large, brown, distensible <u>crop</u> (Fig. 15.1). Follow the crop forward to the point where it narrows and passes through the prothorax. This section of the foregut is the <u>esophagus</u>. Now follow the digestive tract backwards from the crop to a narrow region immediately in front of the heavily muscular <u>proventriculus</u>. The proventriculus in orthopteroid insects is a grinding structure, which bears heavily sclerotized teeth on its inner surface. Note the large, paired <u>midgut caecae</u> (the primary sites of water absorbtion in the midgut) which flank the proventriculus and, further back, the midgut proper.

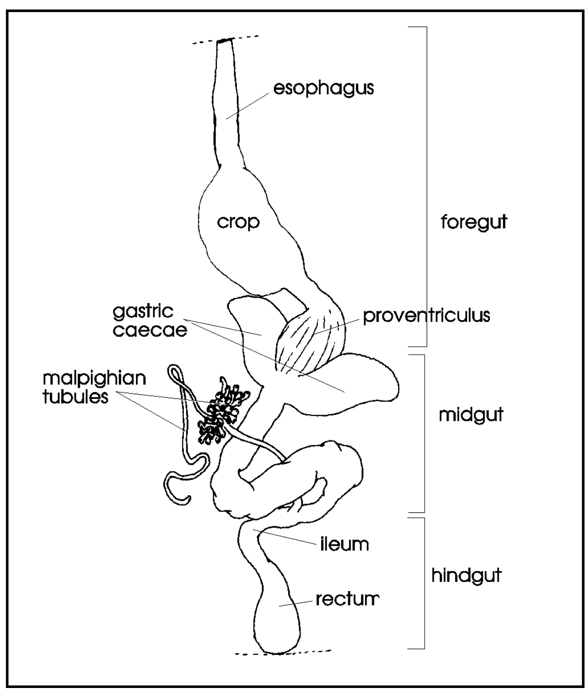


Figure 15.1 Cricket Gut.

Follow the midgut posteriad until you locate the clustered <u>malpighian tubules</u>, which should be waving wildly around. The movements of the malpighian tubules are caused by helically arranged muscle fibers. The movement brings the malpighian tubules into contact with a large volume of hemolymph and improves the efficiency of fluid transport into the tubules. Normally active malpighian tubules can transport 50% of the insect's blood volume per hour! Note also that the lumen of each tubule contains a whitish material. This is uric acid (the principle nitrogenous waste product in insects) precipitating out of solution. Note that the tubules form a dense cluster held together by connective tissue and tracheae. The location of the cluster of malpighian tubules may be a source of confusion. In all insects the point at which the malpighian tubules empty into the alimentary canal is the midgut-hindgut junction, or the pylorus. The cluster of Malpighian tubules in crickets is located anterior to the pylorus (and therefore along the surface of the midgut), but collectively the tubules empty into a common duct which extends posteriorly and joins the gut at the true midgut-hindgut junction. Identify this common duct and, under high magnification, watch it closely to see large clusters of uric acid crystals passing through it into the hindgut lumen. Do you note a change in the gut morphology at the midgut-hindgut junction?

The hindgut consists of a relatively thin anterior ileum, and posteriorly, the rectum (located in segment 10). Sever the connection of the rectum with the body and extend the gut outward to its full length. This may help clarify the connection of the malpighian tubules to the gut and may allow you to distinguish more easily the foregut, midgut and hindgut boundaries.

Do you note any gross movements of the gut itself? Which portions of the gut (foregut, midgut, or hindgut) show these movements? In what direction do the gut contractions procede?

2.

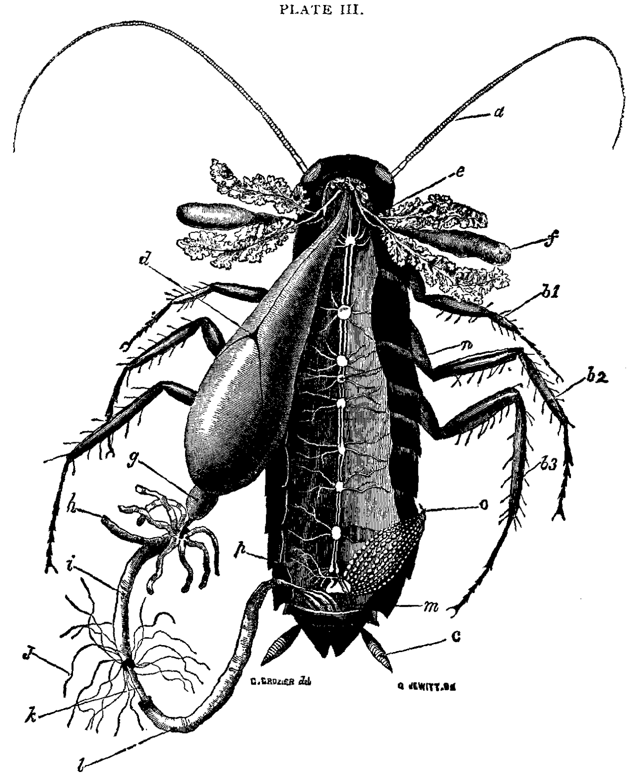
Examine the demonstration dissection of the roach *Nauphoeta cinerea* to refresh your memory of an orthopteroid gut. Identify the following:

Foregut:
- **esophagus**
- **crop**
- **proventriculus**
- **salivary glands**

Midgut:
- **gastric caecae**
- **malpighian tubules**

Hindgut:
- **ileum**
- **rectum**

PLATE III.



A Cockroach (*Periplaneta orientalis*).
(From Rolleston).
a, antennæ; *b1*, *b2*, *b3*, tibiæ; *c*, anal cerci; *d*, ganglion on recurrent nerve upon the crop; *e*, salivary duct; *f*, salivary bladder; *g*, gizzard; *h*, hepatic cœca; *i*, chylific stomach; *j*, Malpighian vessels; *k*, small intestine; *l*, large intestine; *m*, rectum; *n*, first abdominal ganglion; *o*, ovary; *p*, sebaceous glands.

Figure 15.2 (Comstock, 1895)

In the demonstration dissection, note the structure of the proventricular teeth, characteristic of orthopteroids and used for mechanical digestion of solid food. Observe also a section of the rectum demonstrating the rectal pads (=glands), the most important centers of water and ion resorption.

Some aspects of the roach system are not typical of most insects. The malpighian tubules do not absorb uric acid from the hemolymph and their function is not clear. Uric acid is stored in urate cells in the fat body (note the white color of the uric acid crystals). The fat body contains endosymbiotic bacteria in special cells called mycetocytes. The roaches cannot reproduce and soon die if the bacteria are removed. The specialized regions of the colon of the hindgut have not been investigated for *Nauphoeta*; the harboring of symbionts for digestion and absorption is a possibility.

3.

Observe the demonstration of a worker honey bee, *Apis mellifera* (Hymenoptera: Apidae), whose gut exhibits a number of specializations not found in the typical orthopteroid gut. With the help of Fig. 15.3, identify the following structures:

thoracic (labial) glands (ThGld)
midgut (=ventriculus) (Vent)
esophagus (Oe)
malpighian tubules (Mal)
crop (Cr)
anterior intestine (=ileum; AInt)
proventriculus (Prvent)
rectum (Rect)

The distensible crop functions as a "honey stomach" in which nectar is held while enzymes convert it into honey. The proventriculus projects into the crop as a complicated "honey stopper" which prevents nectar from entering the midgut while collecting and passing pollen grains. The pollen grains are digested in the midgut. The rectum is large and expandable and it is capable of storing large quantities of wastes because the bee doesn't defecate in the hive. In the anterior portion of the rectum, note the formation

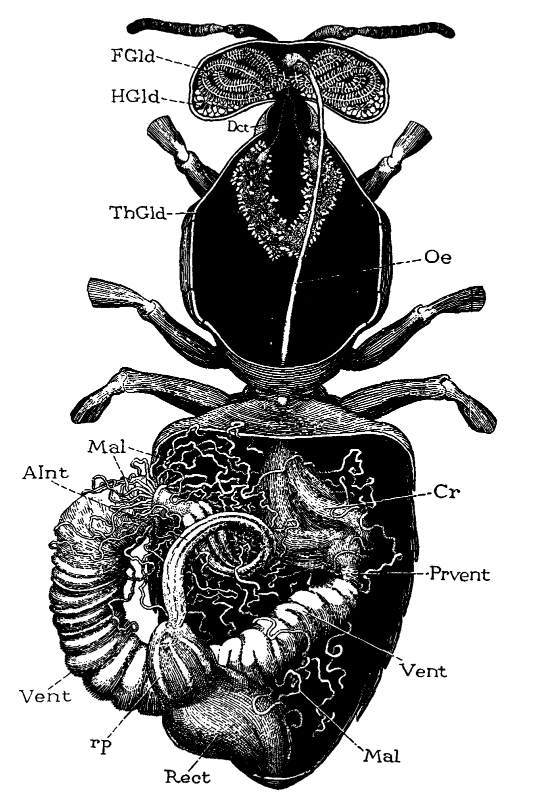


Fig. 70. Alimentary canal and glands of the head and thorax of a worker bee, dorsal.
For explanation of abbreviations see pages 199–200.
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Figure 15.3 (Snodgrass 1956. p. 182)

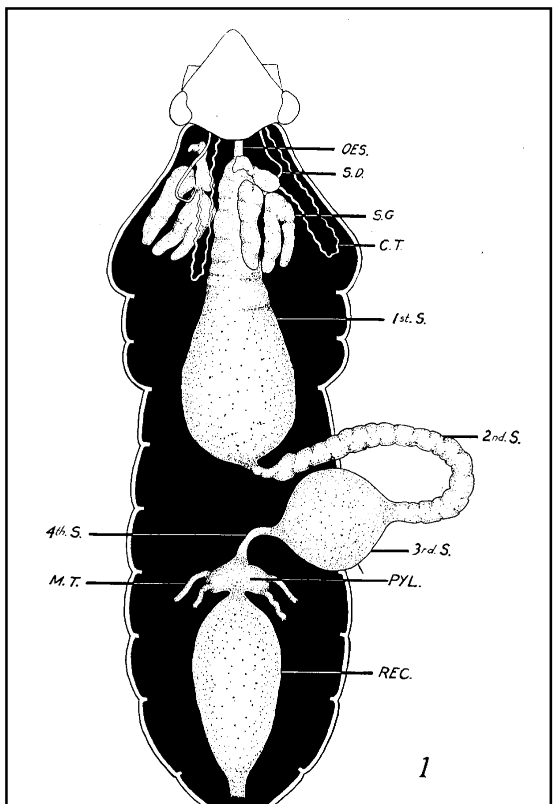

Figure 15.4 (Hood, 1937. p 158)

of the rectal pads.

4.

Examine the demonstration dissection of the gut of the milkweed bug, *Oncopeltus* (Heteroptera: Lygaeidae; Fig. 15.4). We shall examine the complex salivary glands in a later lab. Identify the following portions of the gut:

salivary (labial) glands (S.G.)
esophagus (Oes.)
midgut:
- **1st stomach (1st. S.)**
- **2nd stomach = "intestine" (2nd S.)**
- **3rd stomach (3rd S.)**
- **4th stomach (4th S.)**

pylorus (Pyl)
malpighian tubules (M.T.)
rectum (REC)

Note the absence of a crop and the presence of a functionally and morphologically subdivided midgut. The first stomach is used for fluid storage, the second for digestion, and the third and fourth for absorption.

5.

Examine the demonstration of the filter chamber (FC) of a cicada (Homoptera: Cicadidae; Fig. 15.5B). The filter chamber in this insect is of relatively simple form. The narrow esophagus (Oe) passes between the flight muscles in the thorax and meets the expanded filter chamber at the anterior end of the abdomen. The narrow ileum (AInt) of the hindgut joins the filter chamber at its anterior end. It is a long, convoluted tube which meets the rectum. The thick, lumpy 2nd section of the midgut (2Vent; containing ingested food) joins the posterior end of the filter chamber, at the same point where the four malpighian tubules (Mal) enter the filter chamber. The 2nd section ends in the much narrower 3rd section of the midgut (3Vent), a long tube that curves around and enters the filter chamber at its posterior end (where the malpighian tubules also enter). The 3rd section is where absorbtion of nutrients into the hemolymph takes place. The first section of the midgut is entirely enclosed within the filter chamber. The attached diagrams from Snodgrass (1935) should aid in interpretation. Note that the filter chamber enables most of the fluid taken in by the cicada to enter the hindgut (AInt) without having to pass through the 2nd section of the midgut. The remaining highly concentrated gut contents enter the 3rd section of the midgut, where they are absorbed. (Use Fig. 15.6 to help interpret the pathway of the gut contents in the cicada.)

6.

Examine the demonstration dissection of the digestive tract of the swallowtail butterfly, *Papilio* (Lepidoptera: Palilionidae). Note especially the large sac-like diverticular crop that stores the fluid food (nectar) of the butterfly.

Identify:

end of esophagus
crop
cardiac region (=esophageal valve)
midgut

malpighian tubules
hindgut (ileum)
rectum

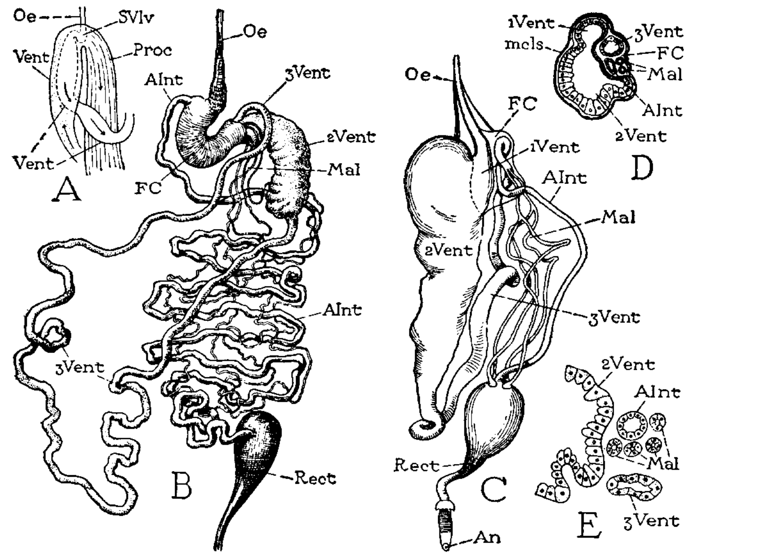

Fig. 210.—The alimentary canal and filter chamber of Homoptera. A, *Longistigma caryae*, the two extremities of the ventriculus and the upper end of the proctodaeum. (*From Knowlton*, 1925.) B, *Magicicada septendecim*, entire alimentary canal. C, *Tricentrus albomaculatus*, entire alimentary canal. D, same, section of filter chamber. E, same, section behind the filter chamber through two parts of ventriculus, anterior intestine, and Malpighian tubules. (C, D, E *from Kershaw*, 1913.)

Figure 15.5 (Snodgrass 1935. p. 386)

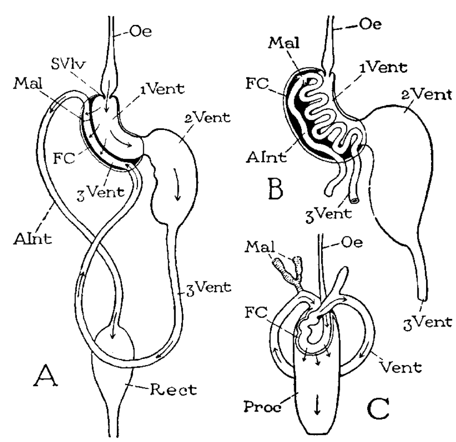

Fig. 209.—The filter chamber of Homoptera. A, diagram of a simple type of filter chamber in which the two extremities of the ventriculus and the anterior end of the intestine are bound together in a common sheath. B, the ventriculus convoluted in the filter chamber and the intestine issuing from its posterior end. C, the filter chamber of *Lecanium*, diagrammatic. (*From Weber*, 1930.)

Figure 15.6 (Snodgrass 1935. p. 384)

7.

Examine the demonstration dissection of the digestive tract of a chrysomelid beetle (Fig. 15.7). Note especially the cryptonephric condition of the malpighian tubules and the papillae on the midgut which mark the internal invaginations of the regenerative cell crypts.

Identify the following structures:

crop
malpighian tubules
cardiac region (=esophageal valve)
ileum
midgut
rectum

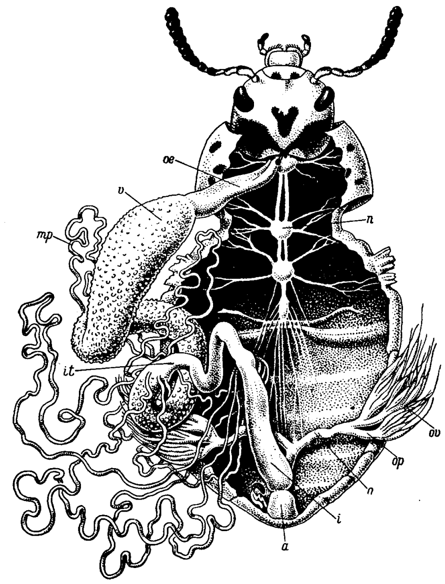

Fig. 3. A female with the internal organs spread out: a) terminal bladder of the hindgut; i) hindgut (broad portion); it) hindgut (narrow portion); mp) Malpighian tubule; n) mesothoracic ganglion; o) right oviduct; op) its origin; oe) esophagus; ov) oviduct; v) ventriculus. (Orig.).

Figure 15.7 (Pavlovskii & Teravskii, 1958. p. 570)

8.

Obtain a live or preserved specimen of your insect, anethetize it in chloroform, and dissect it in Ringers (if alive) or 70% ethanol (if fixed in Kahle's). If the preserved specimen is stiff, it may be softened in warm water and dissected under dilute (50%) alcohol. Once the gut of a live specimen has been removed and extended, the water should be replaced by 70% ethanol to retard decomposition.

Make two longitudinal cuts dorso-laterally through the abdomen and thorax, being careful not to penetrate too deeply. Pin the insect in a dissecting dish, pins set lateral to the slits, and cover with the appropriate solution. Pull away the median portions of the abdominal and thoracic terga, being careful not to remove internal organs. Do not dissect the head. Remove obscuring tracheae, fat body, etc., in order to expose the gut. Observe *in situ* and then cut **behind** the rectum and stretch so as to expose all components.