

EXTERNAL & INTERNAL MORPHOLOGY

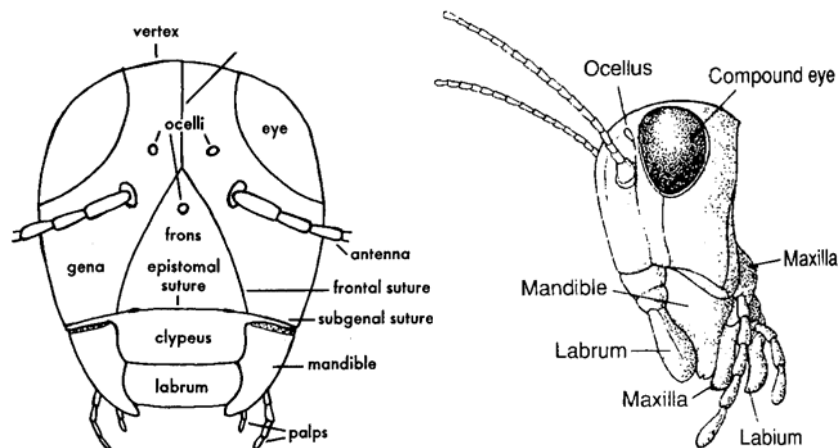
External Morphology

Objectives:

- To learn the external morphology of insects (i.e., to learn about the features of insects which help to distinguish one kind of insect from another).
- To study specializations and adaptability of structures such as the mouthparts, antennae, legs, wings and pronotum.
- To understand how an insect lives, functions, and reproduces.

HEAD

The head of an insect is composed of a series of segments, which are specialized for food gathering and manipulation, sensory perception, and neural integration. The head bears the eyes (compound eyes and ocelli), antennae, and mouthparts. The anterior part of the head is the **frons**. The anterior area below the dorsum of the head, between and behind the eyes is the **vertex**. The area below the compound eye, on the side of the head, is the **gena**. The liplike sclerite is the **clypeus**.



MOUTHPARTS

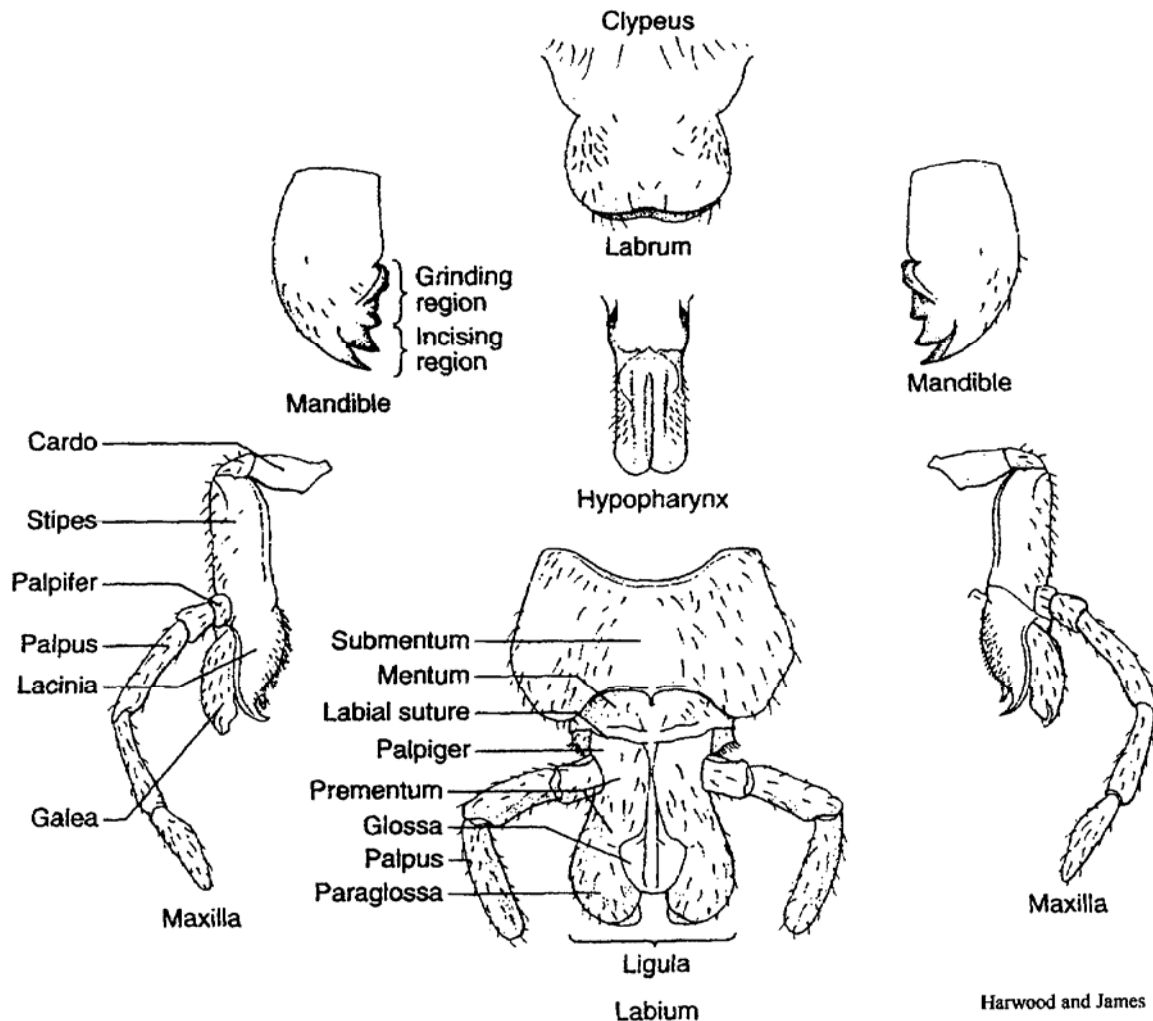
Just as insects take on many different forms, they also possess a variety of different mouth types, each of which can be grouped under one of two main categories: chewing (mandibulate) and sucking (haustellate).

Mandibulate mouthparts, like the ones illustrated below, are believed to be the most primitive. All others, including those categorized as haustellate, are presumed to have evolved as modifications of this basic type.

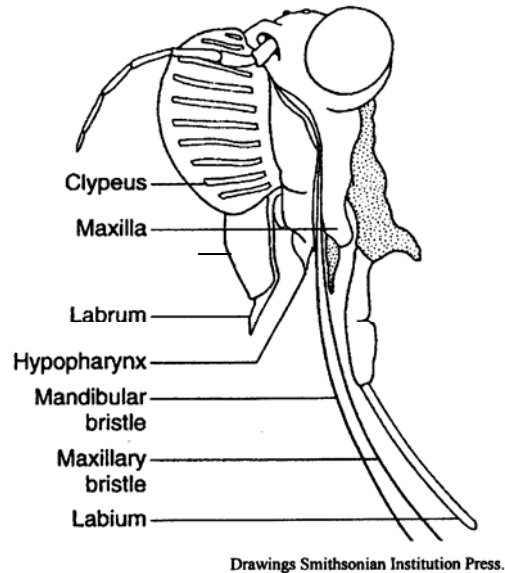
The five primary parts of the insect "mouth" are:

- 1) The clypeus
- 2) The "upper lip", or labrum
- 3) Two "jaw-like structures", or mandibles
- 4) The maxillae (sing. maxilla)
- 5) The "lower lip", or labium

The maxillae and labium are divided into various substructures, which include the galea, paraglossa, glossa, and the maxillary and labial palps.

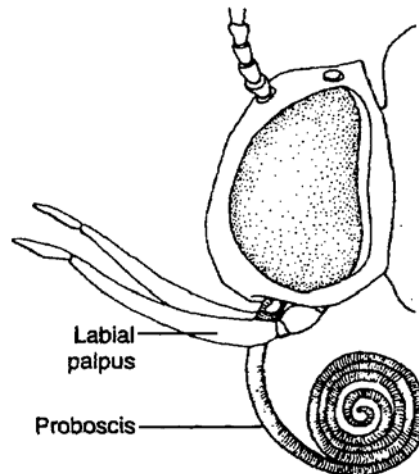


Haustellate mouthparts are primarily used for "sucking up" liquids, and can be broken down into two subgroups: those that possess stylets and those that do not. **Stylets** are needle-like projections used to penetrate plant and animal tissue. Examples of insects with stylets include Hemiptera (true bugs), Diptera (flies), and Siphonaptera (fleas).



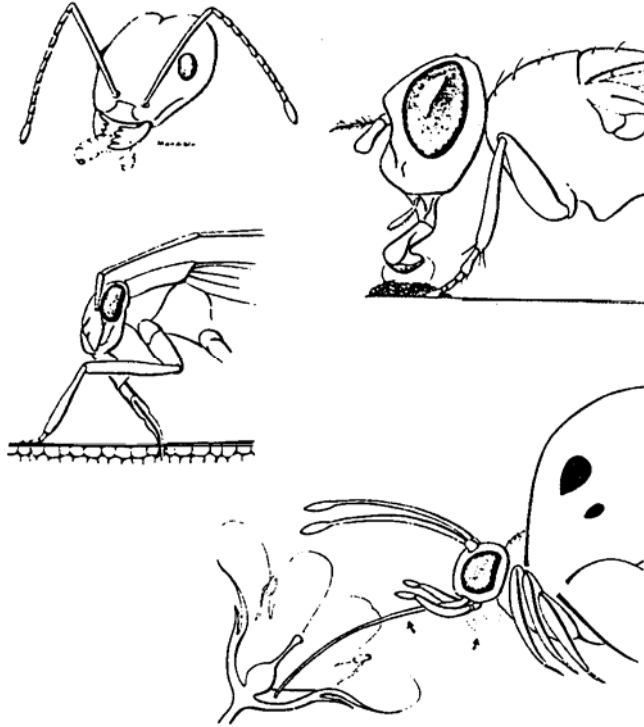
Order Hemiptera

Some haustellate mouthparts lack stylets. Unable to pierce tissues, these insects must rely on easily accessible food sources such as nectar at the base of a flower. One example of nonstylet mouthparts is the long siphoning proboscis of butterflies and moths (Order Lepidoptera). Although the method of liquid transport differs from that of the butterfly's proboscis, the rasping-sucking rostrum of some flies is also considered to be haustellate without stylets.



Moth (Order Lepidoptera)

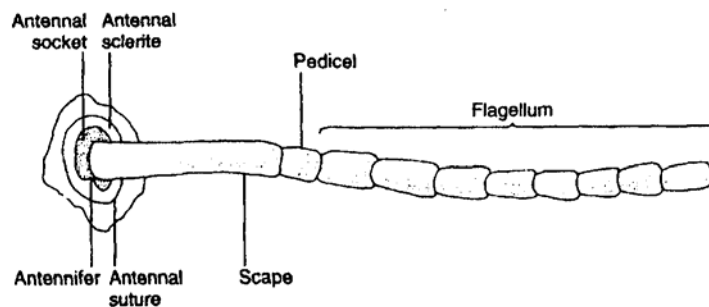
ADAPTATIONS OF THE MOUTHPARTS



Insect Mouthparts: Top left, chewing, top right, sponging; center, piercing-sucking; bottom, siphoning. (F. W. Zettler, Cornell)

THE ANTENNAE

Antennae vary greatly among insects, but all follow a basic plan: segments 1 and 2 are termed the scape and pedicel, respectively. The remaining antennal segments (flagellomeres) are jointly called the flagellum.



Antennae function almost exclusively in sensory perception. Some of the information that can be detected by insect antennae includes: **motion and orientation, odor, sound, humidity, and a variety of chemical cues.** Some of the most common types of insect antennae with which you should be familiar are illustrated below:



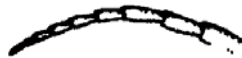
Setaceous

(e.g., Odonata)



Clavate

(e.g., Coleoptera)



Filiform

(e.g., Lepidoptera)



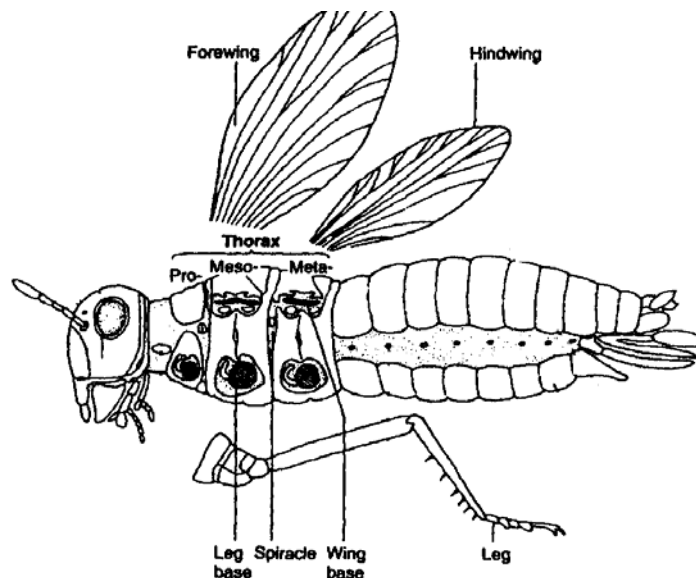
Aristate

(e.g., Diptera)

THORAX

The insect thorax is divided into three parts: the prothorax (pro=first), mesothorax (meso=middle), and metathorax (meta=last). Each segment consists of hardened plates, or sclerites. Dorsal sclerites are called nota (sing. notum), lateral sclerites are called pleura (sing. pleuron), and ventral sclerites are called sterna (sing. sternum).

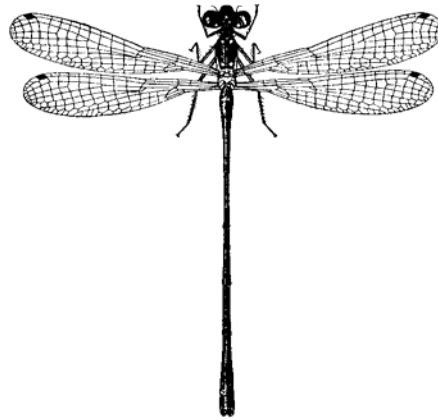
Each of the three thoracic segments contains one pair of legs. Wings are found only on the meso- and metathoracic segments.



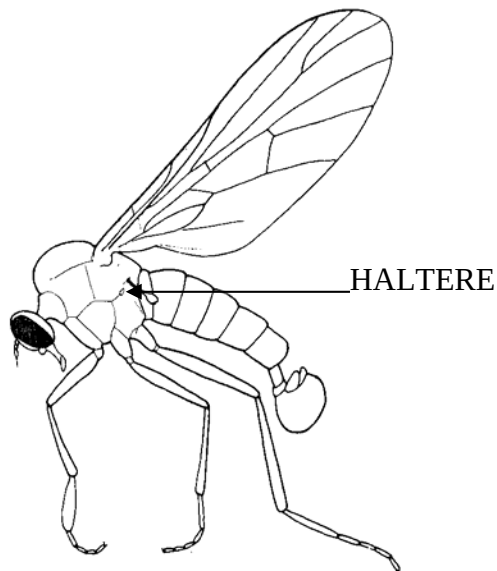
WINGS

Insects have evolved many variations of the wing. Wing venation is a commonly used taxonomic character, especially at the family and species level.

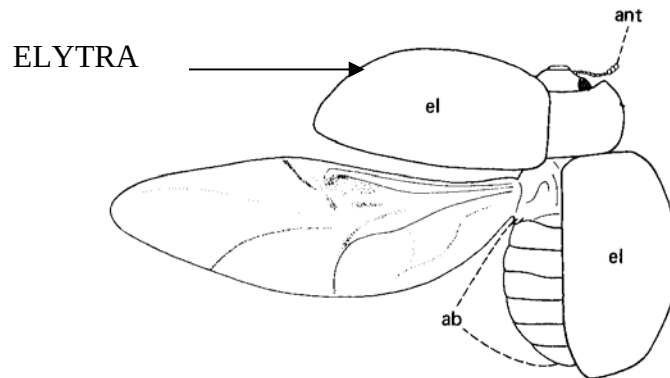
Membranous wings are thin and more or less transparent. This type of wings is found among the Odonata and Neuroptera.



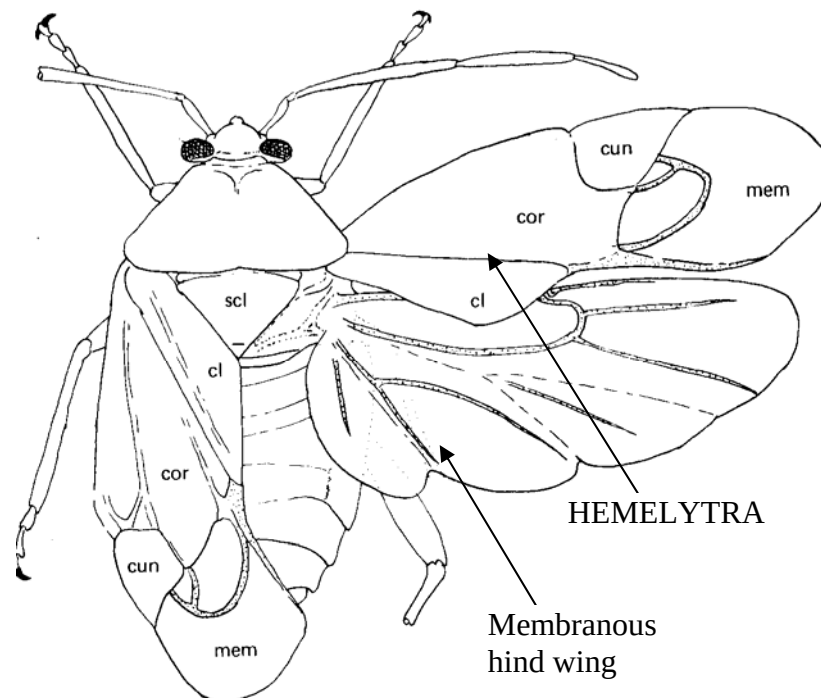
Halteres are an extreme modification among the order Diptera (true flies), in which the hind wings are reduced to mere nubs used for balance and direction during flight.



Elytra (sing. elytron) are the hardened, heavily sclerotized forewings of beetles (Order Coleoptera) and are modified to protect the hind wings when at rest.



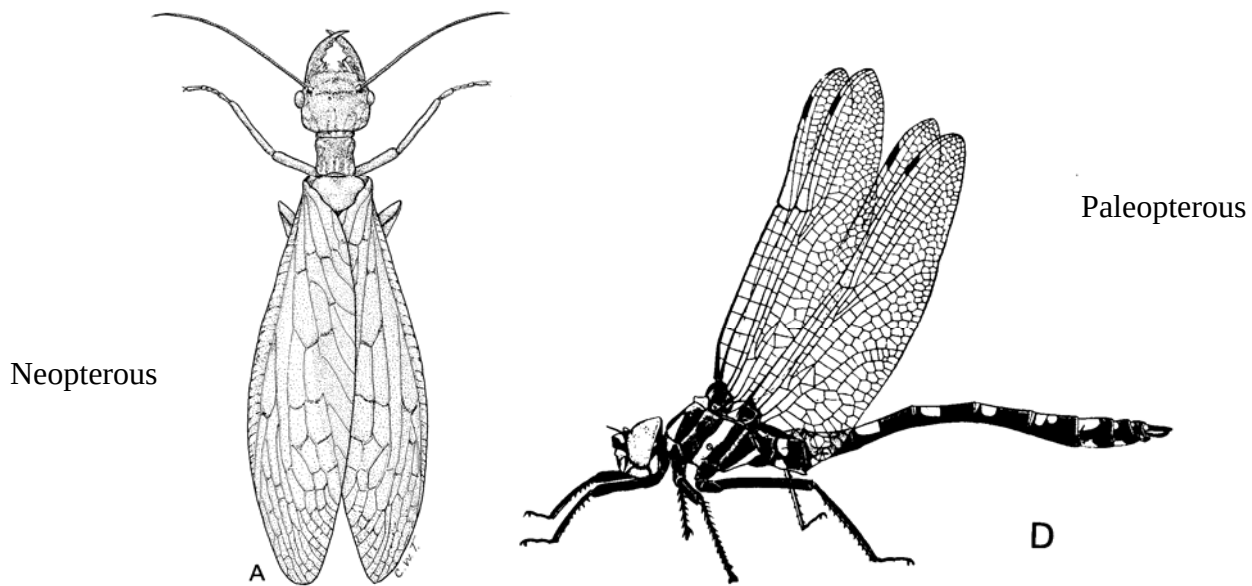
A variation of the elytra is the **hemelytra**. The forewings of Hemipterans are said to be hemelytrous because they are hardened throughout the proximal two-thirds (approximately), while the distal portion is membranous. Unlike elytra, hemelytra function primarily as flight wings. In both cases, the membranous hind wings (when present) are used in flight and are folded beneath the forewings when at rest.



The wings of butterflies and moths are covered with scales, and mosquitoes possess scales along wing veins.

NEOPTEROUS VS PALEOPTEROUS WING CONDITIONS

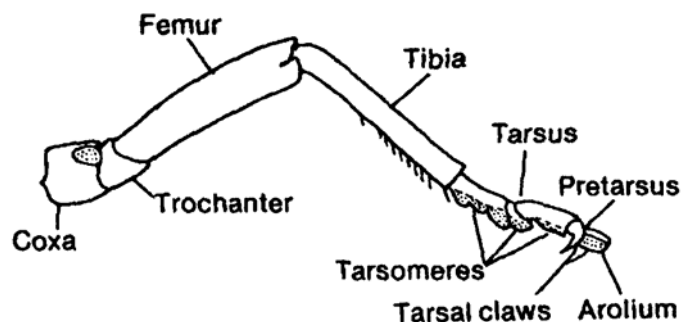
In most living insects (the Neoptera), there are three axillary sclerites that articulate with various parts of the wing. In the Neoptera, a muscle on the third axillary causes it to pivot about the posterior notal wing process and thereby to fold the wing over the back of the insect. (In some groups of Neoptera, such as butterflies, the ability to fold the wings over the back has been lost.) Two Orders of winged insects, the Ephemeroptera and Odonata, have not evolved this wing-flexing mechanism, and their axillary sclerites are arranged in a pattern different from that of the Neoptera; these two orders (together with a number of extinct orders) form the Paleoptera.



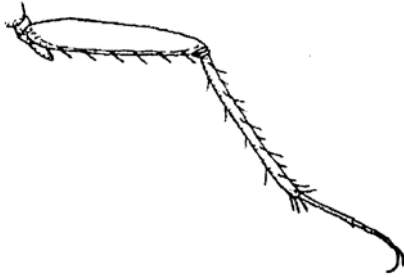
LEGS

The **fore-legs** are located on the prothorax, the **mid-legs** on the mesothorax, and **the hind legs** on the metathorax. Each leg has six major components, listed here from proximal to distal: **coxa** (p1. coxae), **trochanter**, **femur** (p1. femora), **tibia** (p1. tibiae), **tarsus** (p1. tarsi), **pretarsus**.

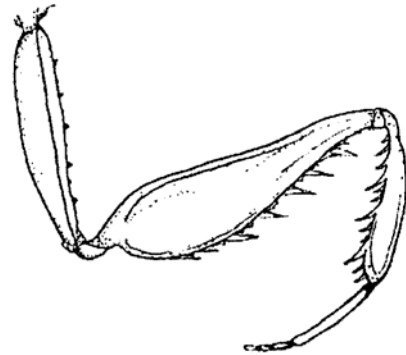
The femur and tibia may be modified with spines. The tarsus appears to be divided into one to five "pseudosegments" called **tarsomeres**.



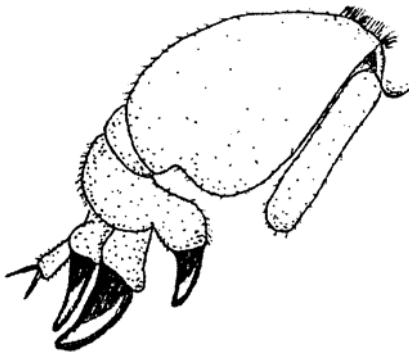
LEG TYPES AND FUNCTION



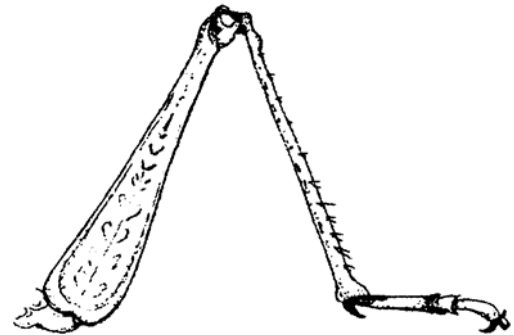
Cursorial: Used for walking/ running. Some textbooks distinguish the two by calling walking legs ambulatory or gressorial, but the leg structure is basically the same.



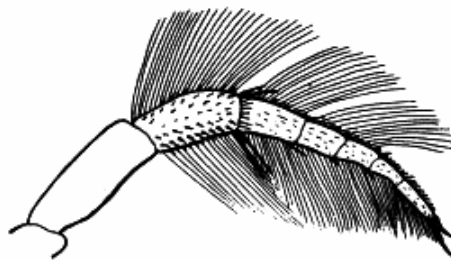
Raptorial: Fore legs modified for grasping. These are often associated with Preying Mantids.



Fossorial: Fore legs and tibiae specialized for digging; common in ground-dwelling insects.



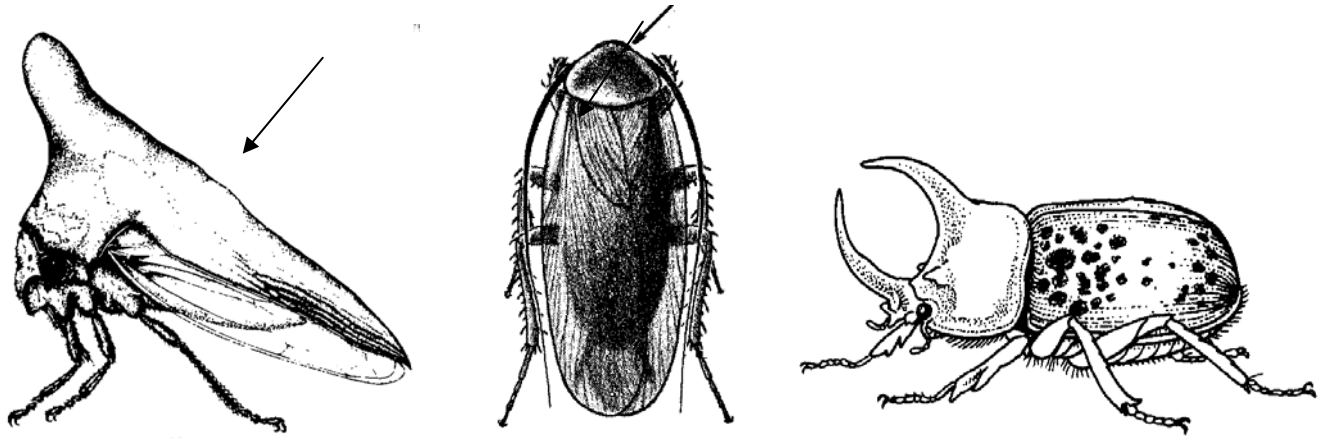
Saltatorial: Hind legs adapted for jumping; characterized by an elongated femur and tibia.



Natatorial: fore or hind legs adapted for swimming; characterized by elongated setae on tarsi

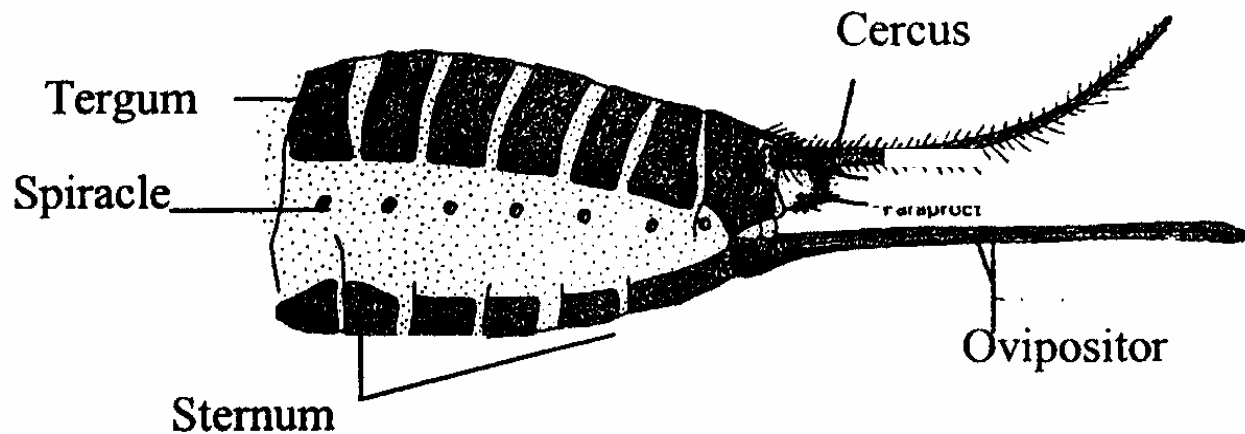
PRONOTUM

Is the dorsal sclerite of the prothorax, which can be highly modified in various groups such as the Homoptera, Blattaria, and Coleoptera.

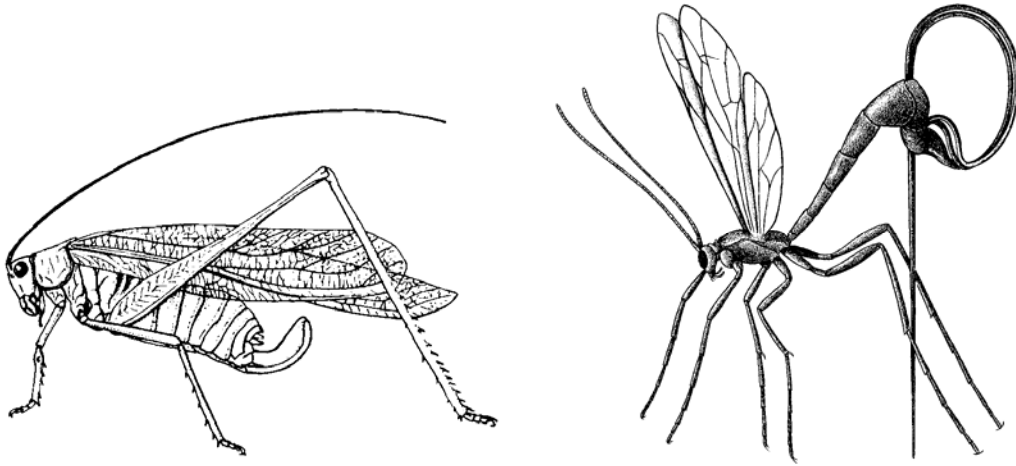


ABDOMEN

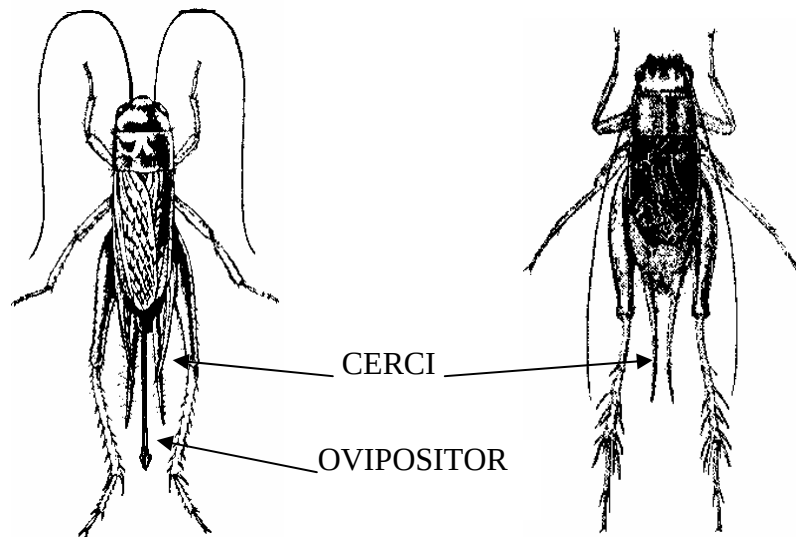
The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna (singular sternum), respectively. Spiracles usually can be found in the conjunctive tissue between the terga and sterna of abdominal segments 1-8. Reproductive structures are located on the 9th segment in males (including the aedeagus, or penis, and often a pair of claspers) and on the 8th and 9th abdominal segments in females (female external genitalia copulatory openings and ovipositor).



MODIFICATIONS OF THE OVIPOSITOR



SEXUAL DIMORPHISM

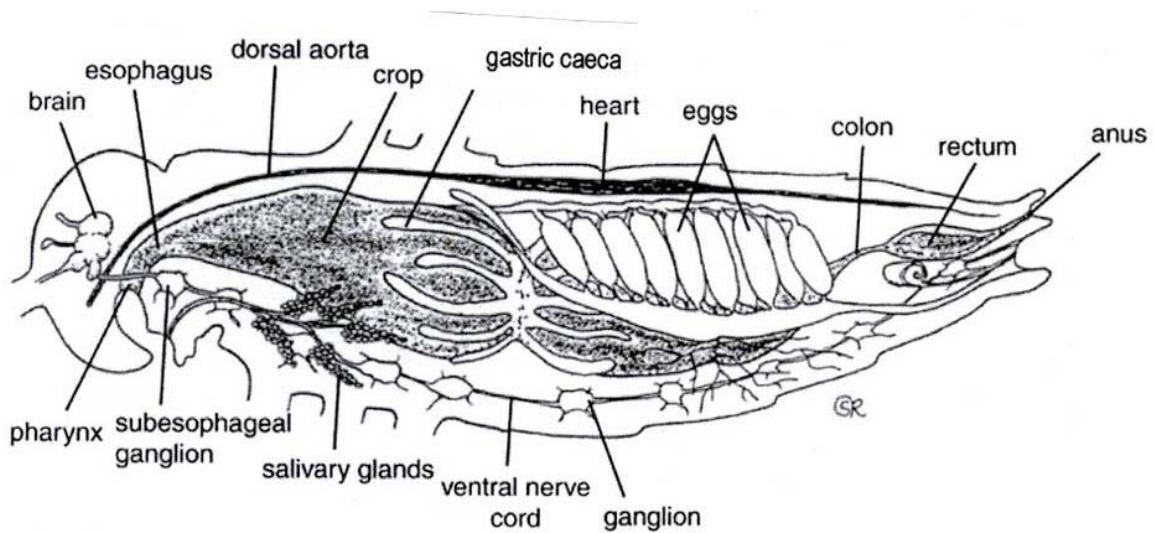


Female (note the long ovipositor
Between the cerci)

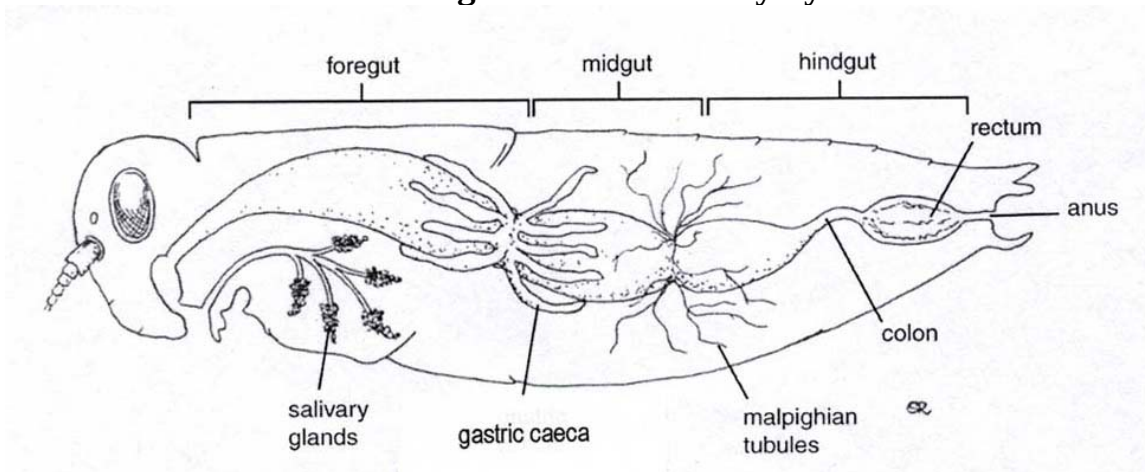
Male (two cerci at the end of
the abdomen)

Adult Internal Morphology

Take a look at the illustrations from the internal morphology of a grasshopper. Later, you will actually dissect a roach; thus, you should pay attention to any differences you notice in the internal morphology of the roach and the grasshopper.



Digestive & Excretory Systems



The **digestive system** (sometimes referred to as the **alimentary canal**) should be easily seen in the dissected specimens. It is a long tube-like structure that runs from the mouth to the anus and is centrally located within the body cavity, or **hemocoel**. The anterior-most region is called the **foregut** (or **stomodeum**) which includes the Buccal cavity, the esophagus, and the crop. The primary function of the foregut is to begin the breakdown of food particles and transport them to the next region, the **midgut** (or **mesenteron**). The midgut is the major area of digestion and absorption. Undigested food particles then pass into the third region, the **hindgut** (or **proctodeum**), which consists of the ileum, colon, **rectum**, and (often) rectal pads. The hindgut functions in water and solute reabsorption and waste excretion.

The three sections of the digestive tract can be easily identified by structures found at the junction of each region. **Gastric caecae**, for example, mark the end of the foregut and beginning of the midgut. It is believed that the purpose of these structures is to increase surface area for greater nutrient absorption. The constriction at the gastric caecae also marks the spot of the cardiac valve (or sphincter).

Near the junction of the midgut and hindgut are long, thin structures called **Malpighian tubules**. These range in number from a few to hundreds, but only aphids (Order Homoptera) are currently known to have none. Malpighian tubules are creamy to yellow in color and work in conjunction with the ileum to provide the primary site for osmoregulation and excretion.

Circulatory system

Unlike the “closed” circulatory system of humans, insect circulatory systems are said to be “open”, meaning that they lack a complex network of veins and arteries to help transport blood throughout the body. Instead, insect blood (called **hemolymph**) flows relatively “freely” throughout the hemocoel.

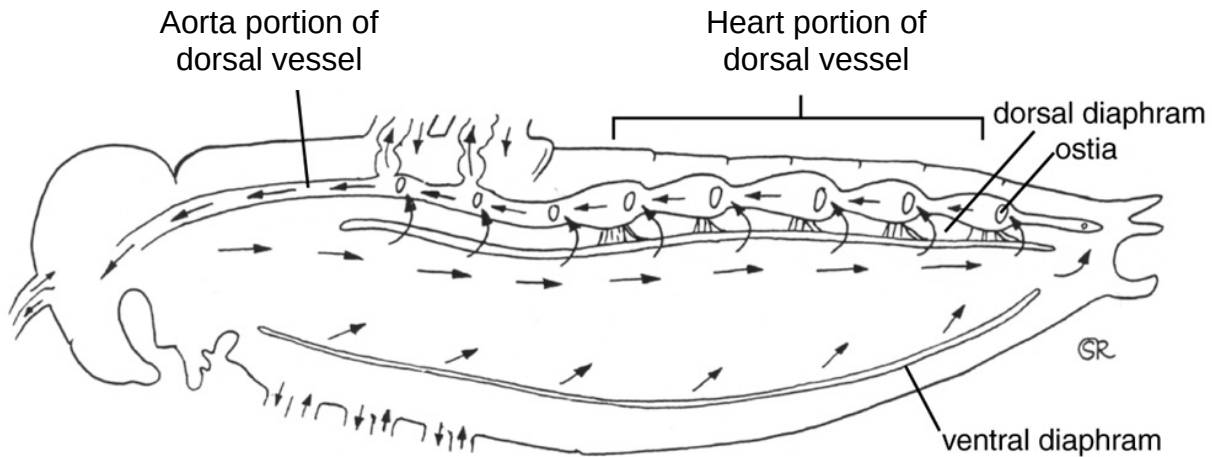


Figure 8-2. Circulatory system. Arrows indicate direction of flow of hemolymph.

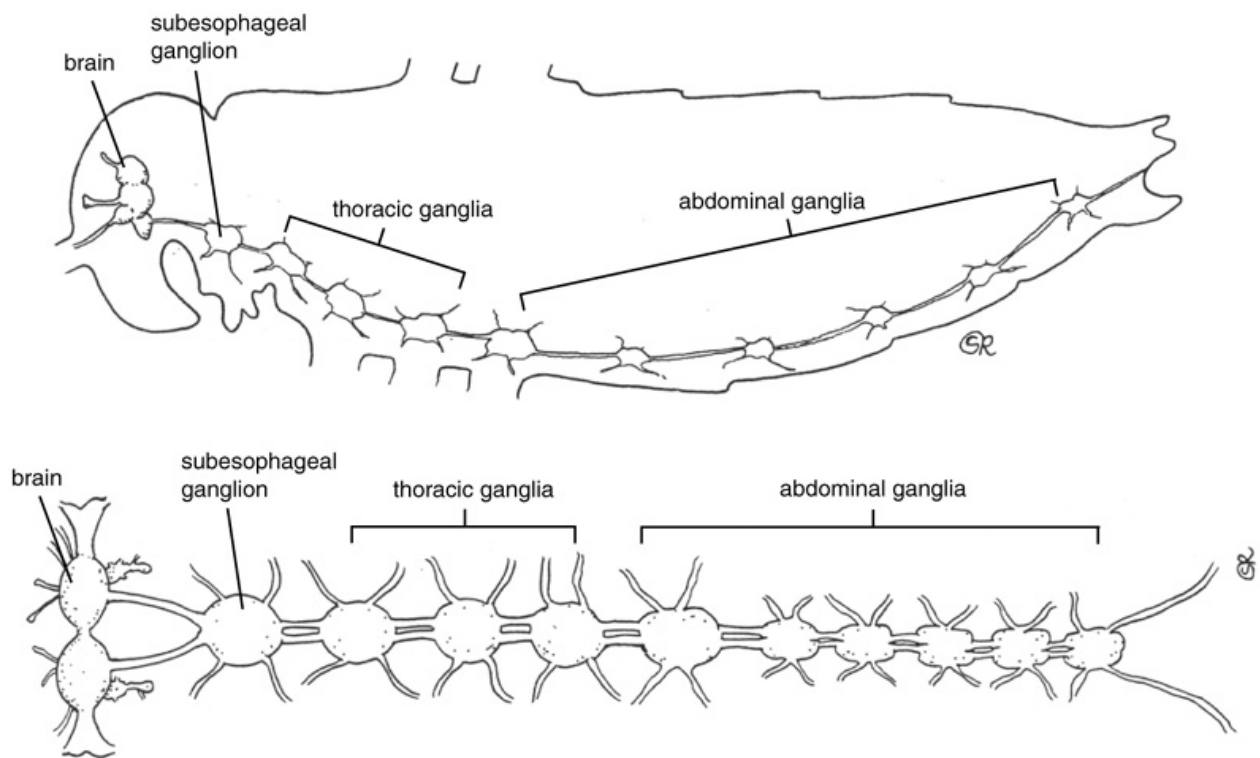
Only one vessel is present in the insect circulatory system: the **dorsal vessel**. Posteriorly (in the abdominal region), the dorsal vessel acts as the **heart**, pumping hemolymph forward into the anterior region (in the head and thorax), where it acts as the **aorta** and dumps the hemolymph into the head. It flows posteriorly and is returned to the heart via **ostia**, which are small slits in the heart region of the dorsal vessel designed for hemolymph uptake.

To view the dorsal vessel, examine the “back” (or dorsal region) of the insect’s body cavity for a very thin line that runs longitudinally from the head to the tip of the abdomen. Use the grasshopper or specimen that was ventrally dissected, as dorsal dissections will likely mutilate the vessel. Do not be discouraged if you have trouble finding it on your specimen. The dorsal vessel is very, very thin. Compare your specimen to those of your classmates.

Nervous System

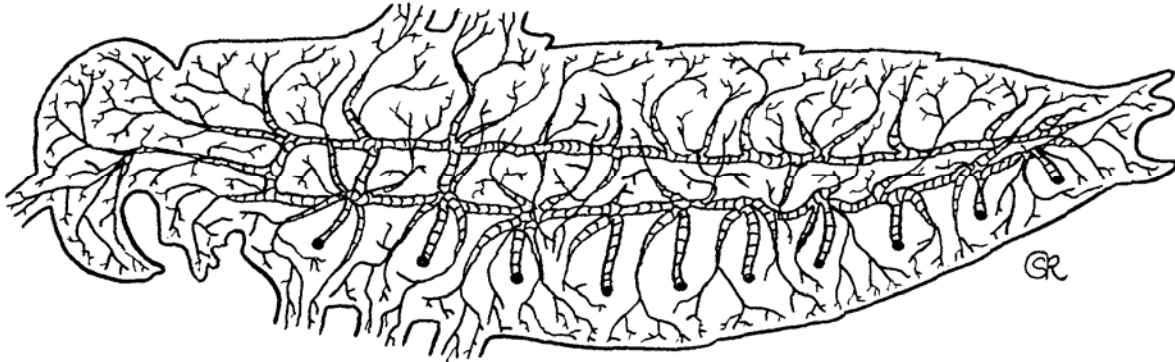
To view the **ventral nerve cord**, examine the ventral region of the roach's body cavity (or specimen you performed the dorsal dissection on) for something that resembles a railroad track running from the head posteriorly to the abdominal region. The "railroad track" is made up of two nerve cords (**connectives**) that run longitudinally with a series of node-like **ganglia**.

The anterior most region of the ventral nerve cord is called the **subesophageal ganglion**. Just dorsal to that structure is the insect "brain" (or **supraesophageal ganglion**).



Respiratory System

The insect respiratory system is made up of a series of tubes that originate from **spiracles** (openings of the exoskeleton that allow for gas exchange) and extend throughout the body. Internally, the tubes, or **trachea**, appear as thin white lines throughout the hemocoel and are particularly noticeable surrounding internal organs. Trachea deliver oxygen to internal organs and tissues.



Compare the tracheae with the Malpighian tubules. They are often very similar in appearance. Did you confuse tracheae with Malpighian tubules earlier?

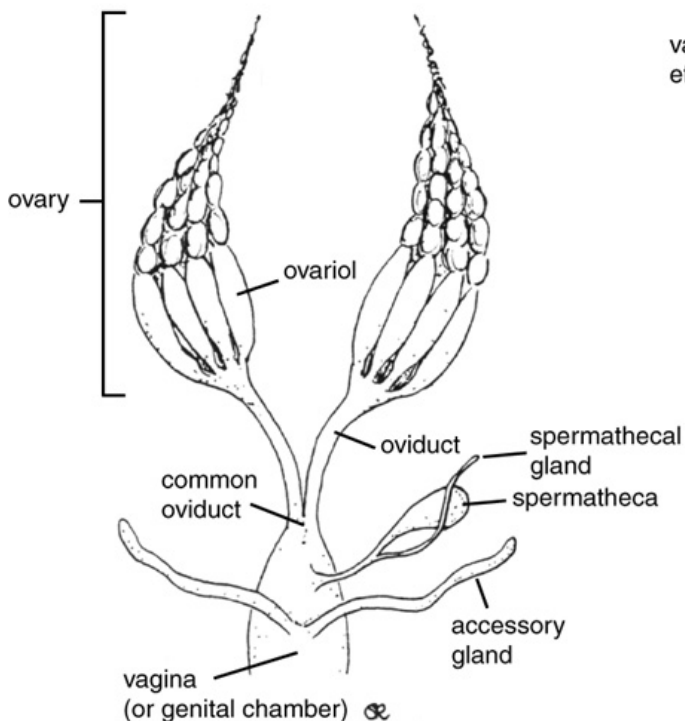
Two ways to distinguish the structures are color and location. Tracheae have a 'shinier' appearance under the scope and may even appear 'silvery'. As for location, Malpighian tubules are found at the junction of the midgut and hindgut (although they may extend outward into the hemocoel), whereas tracheae are positioned throughout the body.

Reproductive System

It is important to note here that variation among insect reproductive systems is great. Closely related species are often isolated from one another via small variations in the morphology of reproductive organs that prohibit interspecies mating. However, a generalized system can be constructed that closely represents all sexually reproducing insects. Do not be alarmed if you are unable to locate the indicated structures on your dissected specimens. Be familiar with differences in male and female genitalia and be able to identify structures when given a diagram. Directions are provided if you wish to attempt seeing the reproductive system of your specimen.

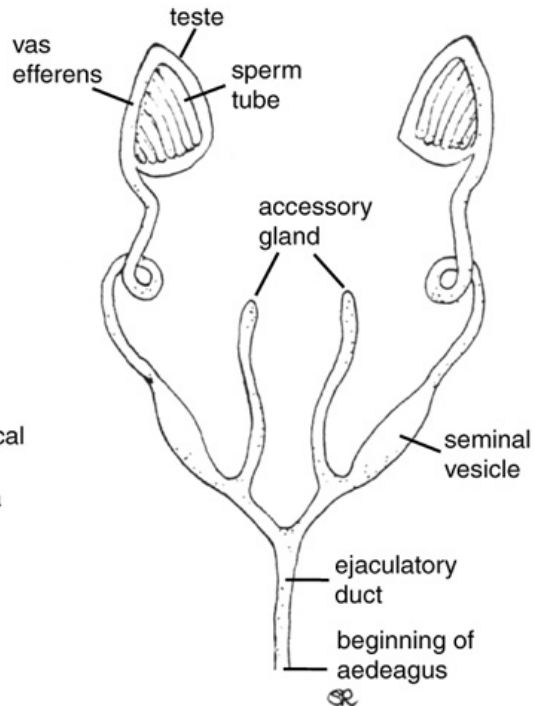
The Female Reproductive System

Remove the digestive tract from your female specimen by cutting it with a scalpel at the posterior- and anterior-most regions. Place digestive tract to the side. If necessary, remove muscle tissue, as well, until the **ovaries, lateral oviducts, median oviduct, seminal receptacle** and **vagina** are visible. Compare your specimen with the figures below. Then observe classmates' specimens.



The Male Reproductive System

Remove the digestive tract from your male specimen by cutting it with a scalpel at the posterior- and anterior-most regions. Place digestive tract to the side. If necessary, remove muscle tissue, as well, until the **testes, vas deferens, seminal vesicle, accessory glands, and ejaculatory duct** are visible. Compare your specimen with the figures below. Then observe classmates' specimens



Roach—Lateral dissection

1. Cut the legs and wings (if present) off your specimen.
2. Place specimen ventral side down in dissecting tray.
3. Insert the tip of your scissors between two abdominal segments close to the ‘tail end’ on the lateral side of the roach.
4. CAREFULLY cut the exoskeleton (making certain not to puncture internal organs) from the point of insertion anteriorly toward the head. Then proceed to cut the remaining 3-4 posterior segments.
5. Use forceps to pull skeleton apart, exposing internal systems.
6. With dissecting pins, tack the flaps to the tray, thus keeping the body cavity open.
7. Flood tray with saline to facilitate observation of organs.

Insect Dissections

Often the best approach to understanding internal morphology is by way of a dissection. For this reason, the entire chapter should be treated as a laboratory activity.

Objectives

- Locate and identify structures associated with the internal morphology of insect.
- Explain the functions of specific structures associated with the internal morphology of insect.

Figure 1. Diagram of dorsal insect dissections: (a) female American cockroach, (b) male field cricket.

