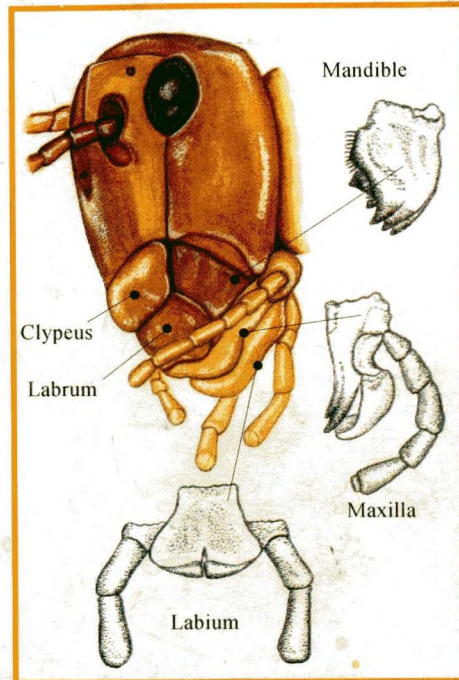


An Illustrated Dissection Guide To The...

Grasshopper



by David H. Hall

An Illustrated Mini Guide To Grasshopper Dissection

Of all the animal species known to exist today, 70 - 75% of them are insects. Without a doubt, insects are the most successful of any animal group. They are found in all types of habitat. There are carnivorous insects, herbivorous insects, and parasitic insects. There are terrestrial walking insects, aerial flying insects, and aquatic swimming insects plus some that function in all three habitats. Some insects such as termites and bees form complex societies. Insects are, by all means, a highly diverse and intensely fascinating group of animals.

Insects belong to the large phylum: Arthropoda. This name comes from the Latin names: arthros (meaning joint) and poda (meaning foot). In addition to insects this phylum includes the millipedes, centipedes, arachnids, and the crustaceans. Arthropods all share in common the following characteristics:

1. Body and limbs segmented externally.
2. Exoskeleton composed with chitin.
3. Without a true coelom but with a hemo-coel: a simple series of sinuses or spaces between the tissues.
4. Jointed appendages modified for feeding.
5. Musculature distinctly striated.
6. Ventral nerve cord with dorsal brain.
7. Bilateral symmetry.

Insects can be separated from the other classes of arthropods by having these characteristics:

- I. Body separated into three regions.
- II. Having three pairs of legs.
- III. A single pair of antennae.

A grasshopper is an excellent example of general insect anatomy. The grasshopper that is most commonly studied is the Plains Lubber grasshopper: *Brachistoma magna*. The reasons for the popularity of this particular grasshopper are its large size, ready availability, and low cost. The Black Lubber grasshopper (genus: *Romalea*) is sometimes used by biological supply houses as a substitute specimen for *Brachistoma*.

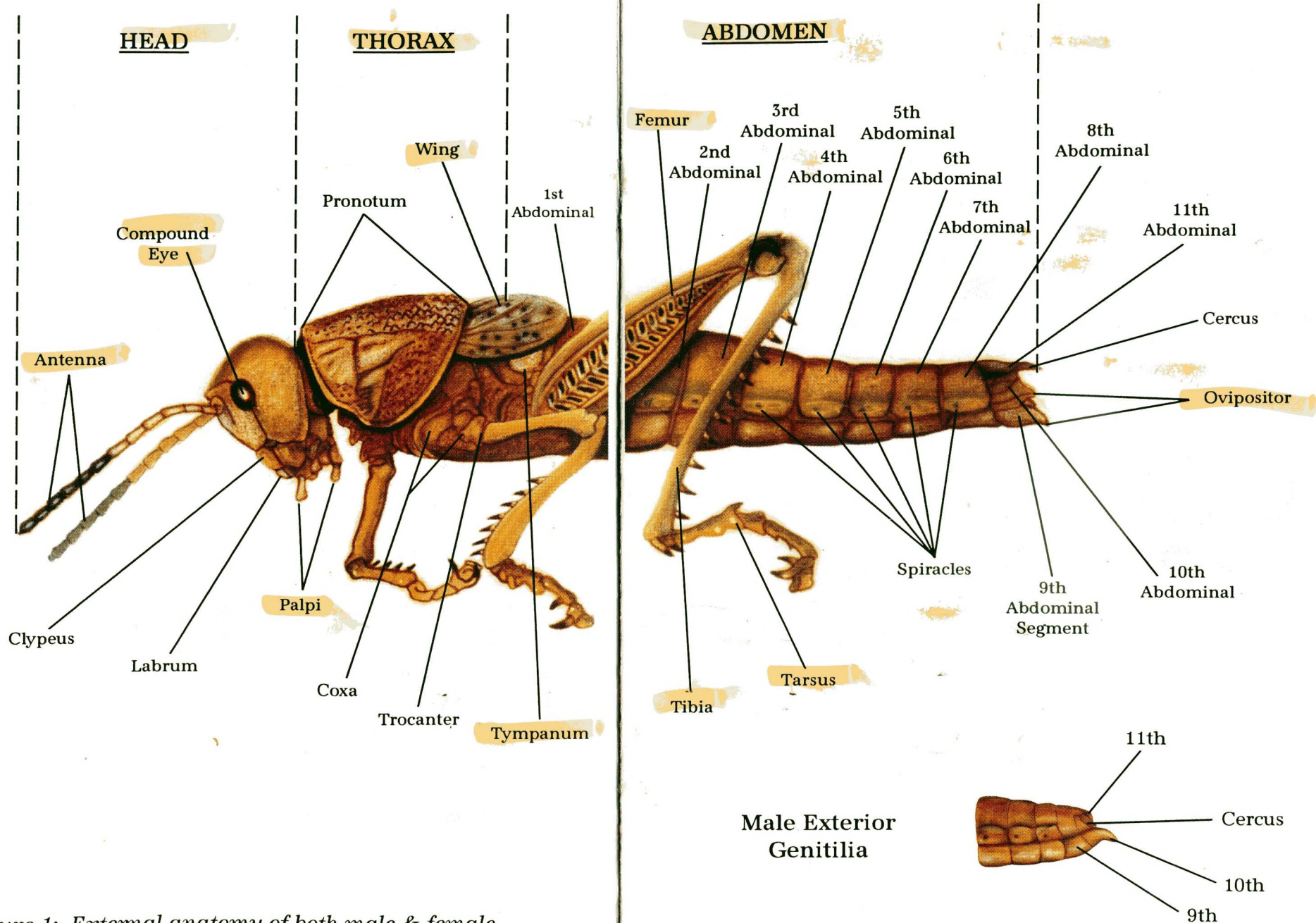


Figure 1: External anatomy of both male & female.

External Anatomy

EXOSKELETON

Terrestrial animals must all have means of controlling, or at least minimizing, the loss of water from their bodies. Arthropods have evolved a hard multilayer covering that is water-proof called an exoskeleton. In addition to controlling water loss the benefits of the exoskeleton are:

1. Armor-like protection from physical and chemical damage.
2. An excellent platform for the attachment of muscles providing good leverage resulting in efficient locomotion and greater speed.
3. Effective barrier against disease.

The major disadvantage to having an exoskeleton is that growth is limited until the exoskeleton is shed or molted. The new exoskeleton is soft and unhardened and must first expand to a larger size than the old exoskeleton was in order to permit growth. At this point the exoskeleton is allowed to harden. Until this process has occurred the animal is extremely vulnerable to damage and water loss.

One of the major components of the arthropod exoskeleton is chitin. Chitin is a chemical similar to cellulose in that it is composed of many micro fibers. Insects further strengthen the chitin fibers during a process called sclerotization. This process converts the chitin into a hard plastic-like substance.

Exterior Body Regions

Compare your grasshopper to figure 1. Use this illustration to familiarize yourself with the various external features of the grasshopper throughout the following sections. It is also important to identify the sex of your specimen by the secondary sexual characteristics shown in this illustration. Note the three distinct body regions: The Head, Thorax, and The Abdomen.

THE HEAD

The head (figures 1 and 2) is a functional unit that performs various tasks: the major sensory area, the ingestion of food, it is also the major area of information processing for coordinating body activities. Although the head appears to be composed of one single segment it is in fact made up from six separate segments that have fused into one. The six segments only appear during embryological development.

The grasshopper is a biting/chewing insect and as a result has mandibular mouth parts. The *labrum*, *labium*, and *maxillae* hold food between and against the *mandibles* which move from side to side to grind food for swallowing. The *palpi* help manipulate the food and also contain sense organs which serve as taste detectors. Food is further manipulated by the tongue-like *hypopharynx*. (Figure 4.) With a dissecting needle probe around the mouth area to identify the various mouth parts and their function. The use of a dissection microscope greatly aids in this.

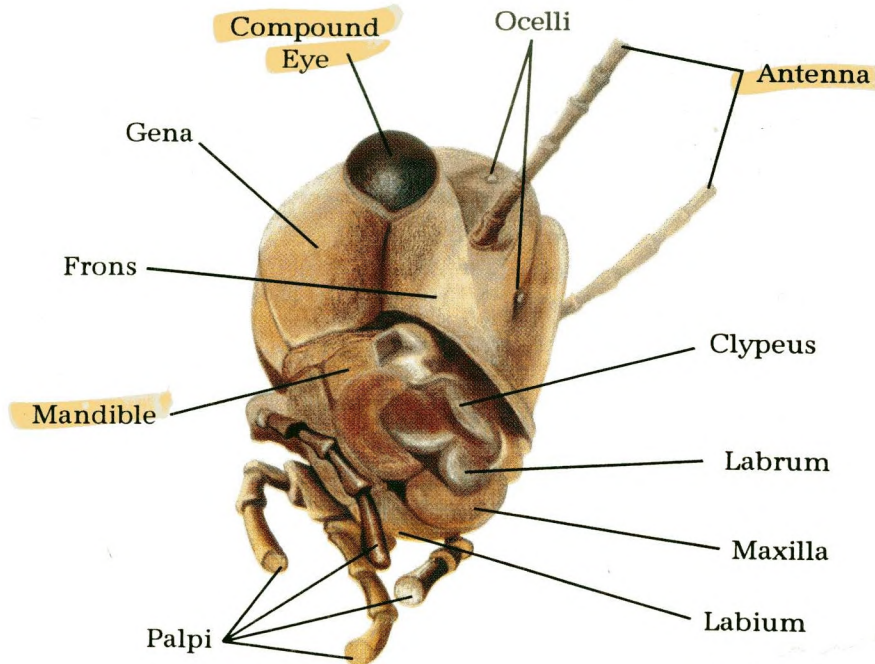


Figure 2: External anatomy of the head.

Insects have *compound eyes*. This type of eye differs from the vertebrate eye by being made up of hundreds of separate lenses or facets each with its own separate photoreceptor. Together each lens and photoreceptor form a unit that is called an ommatidium. The exoskeleton is transparent over the eye and forms a protective cornea. Such an eye produces a mosaic type of image and the more ommatidia a compound eye has the greater the resolution or detail the image forms. In addition to having compound eyes grasshoppers have three simple eyes called *Ocelli*. These eyes cannot form images but are for sensing changes in illumination, they may also play a role in coordinating the daily rhythms and activities according to the position of the sun.

The *antenna* are sensory structures for the senses of touch and smell. Insects are often seen moving about with their antenna waving. The antenna are well muscled and flexible structures containing many sensory bristles.

THE THORAX

The thorax is the middle section of the grasshopper and is composed of three segments: the large shield like *pronotum*, the *mesonotum*, and the *metanotum*. Each of these segments have a pair of legs and can be identified by this. Between each of these segments are a pair of respiratory openings called *spiracles*. The legs are composed of five segments. The coxa joins the leg to the body, followed by the small *trochanter*, the large *femur*, the thin *tibia*, and clasping *tarsus*.

The thorax also contains a pair of *wings*. On most grasshoppers these are well developed and used for flight. On Lubber grasshoppers, however, the wings are small and useless for flight. A secondary function of the grasshopper wing is for producing mating calls. The male grasshopper vibrates his wings together advertising his presence to a prospective mate.

THE ABDOMEN

Posterior to the thorax is the abdominal section which is composed of eleven segments. The first eight segments each have a pair of spiracles. The last three segments form the external genitalia of both sexes. The cerci are also found emanating from the eleventh segment. The cerci are sensory structures and have numerous touch sensors at their terminal end. Female grasshoppers have a muscular egg laying structure at the end of the abdomen called the ovipositor. With this the female lays her eggs in the ground.

Internal Anatomy

In order to dissect the grasshopper all six legs must first be removed. With a pair of fine tipped scissors cut through the coxa of each leg. Once this is done discard the legs and pin the body down to a dissecting tray. Generally four pins, two at the rear of the abdomen, and two go through the pronotum, are required. With a sharp pointed scalpel or scalpel handle with a #11 scalpel blade cut carefully through the exoskeleton at the top of the eighth abdominal segment. Take this cut all the way forward and around returning to the starting point as illustrated in figure 3. Some students prefer to use a sharp pair of small point-tipped scissors to do the cutting. Regardless, with tweezers remove the exoskeleton plates as they become free. Muscle tissue will come off with the exoskeleton which is what you want to happen in order to expose the internal organs. Do this carefully and your specimen will not be ruined. If your specimen is color-injected you will find small threads of colored latex connected to the exoskeleton plates you remove. Please read the section on the respiratory system (page 10) before continuing.

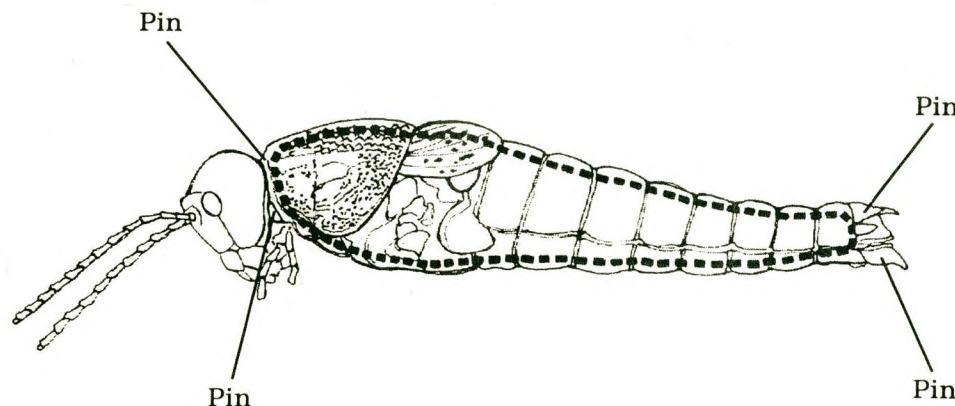
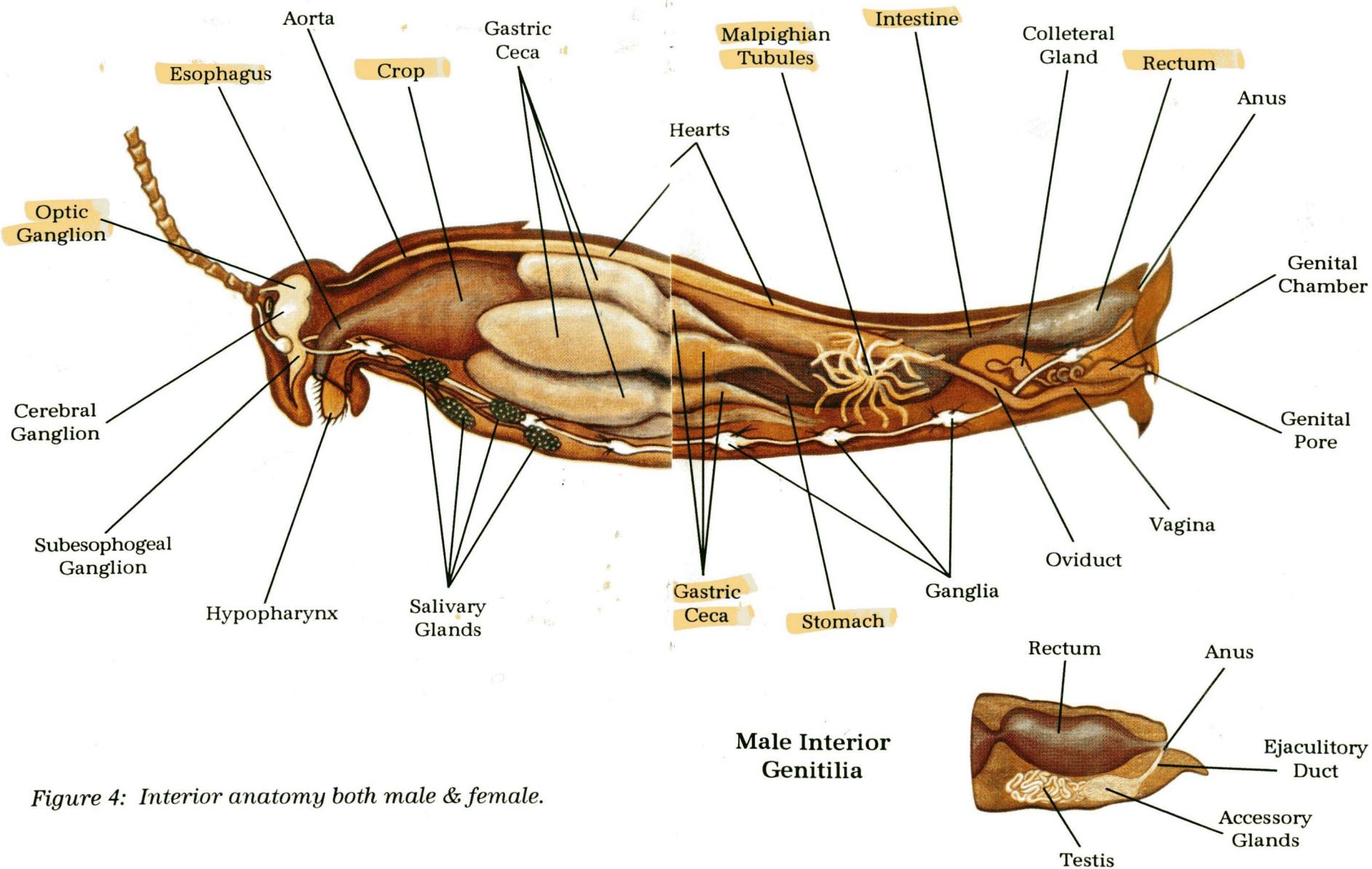


Figure 3: Incision line to expose internal anatomy.



RESPIRATORY SYSTEM

Animals with lungs utilize their blood to distribute dissolved oxygen to the bodies cells along with disposing of carbon dioxide produced by the bodies metabolism. Insects, however, utilize a different respiratory system called a tracheal system. A series of tubes or *trachea* are used to distribute gases directly to and from the body tissues. Hemolymph plays no role in the gaseous exchanges. The tracheal system begins with the *spiracles* which are the openings of the system. These are valve-like and can open and close under control of the nervous system. The spiracles open into air-sacs.

These air sacs are elastic and by compressing and relaxing the abdomen, in conjunction with the opening and closing of the spiracles, grasshoppers can pump air into the tracheal system. Not all insects have this ability. The grasshopper, however, requires it due to its large size.

From the air sacs the trachea branch out into the body tissues becoming smaller with each division until the trachea reach the cellular level. If your grasshopper specimen came color injected then it has had its tracheal system filled with colored latex which allows viewing this system. Without this the tracheal system is extremely difficult to identify.

DIGESTIVE SYSTEM

Food is chewed into small pieces and moistened with secretions from the *salivary glands*. The muscular *hypopharynx* manipulates the food for swallowing. Food travels through the *esophagus* to the *crop*. The muscular crop grinds the food into fine particles for final digestion. When released from the crop by a muscular sphincter the food enters the *stomach*. Here digestive enzymes released by the *gastric ceca* mix with the food and digestion begins. The broken down nutrients are absorbed by the stomach and the gastric ceca. When the absorption process is finished the food is released and moved into the *intestine*. The intestine is where the waste material becomes progressively more dehydrated as water is extracted from it by the intestine walls. This process continues until the fecal material is reduced to a dry pellet in the *rectum* ready for expulsion.

CIRCULATORY SYSTEM

All insects have what is called an open circulatory system. It is so named because the insect blood or hemolymph is not restricted to system vessels as it is in animals with a closed system such as earthworms or humans. The insect circulatory system consists of the *heart* and *aorta*. The heart is a dorsal vessel divided into a series of pumping chambers restricted to the abdominal segment. The aorta extends forward into the thorax and head. Hemolymph enters the heart chambers through valve openings called *ostia* and it is pumped forward through the aorta into the head. From the head the released hemolymph travels rearward through the hemocoel. Hemolymph is directed into and out of various areas such as the limbs by a series of baffles. As the hemolymph bathes the digestive organs nutrients are picked up and distributed throughout the body. As the hemolymph travels rearward it is directed back to the heart for redistribution.

THE EXCRETORY SYSTEM

The *malpighian tubules* are the grasshoppers organs for removing urea (protein metabolic wastes) from the hemolymph. These tubules radiate out into the hemocoel and empty into the rear of the hind gut. The tubules utilize a series of pH changes in order to extract uric acid from the hemolymph and deposited in the hind gut with very little water loss.

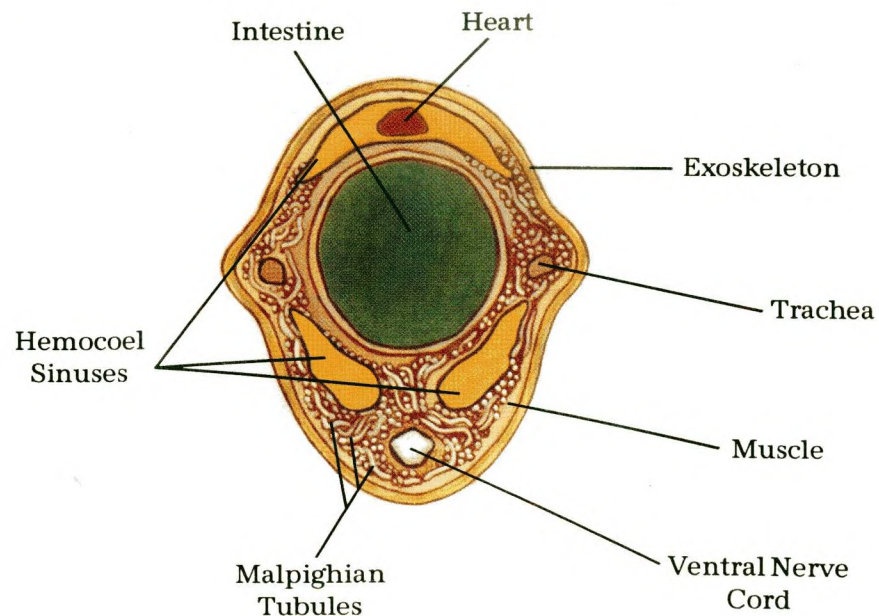


Figure 5: Cross-section of the grasshopper through the 7th abdominal segment.

THE NERVOUS SYSTEM

The grasshopper *brain* consists of three ganglions (ganglions are masses of nerve cells that serve as processing centers). These receive and process impulses from the eyes, antenna, and mouth. The brain is connected to the *ventral nerve chord* by the *subesophageal ganglion*. The ventral nerve chord is a chain-like structure of paired ganglions and nerve chords that travel back to the seventh abdominal segment. Each thoracic segment has its own ganglia for controlling the movement of its limbs. There are five ganglions located in the abdominal segments controlling digestive, respiratory, and reproductive functions. This decentralization of the nervous system allows some insects to maintain some functions even though the head has been removed. For example, female preying mantis often eat the heads off of their male partners which still are able to move and complete the mating process.

Reproductive Organs

MALE

Male grasshoppers produce sperm in a pair of *testes*. Within this organ the gametes are allowed to grow and mature before they are released into a tube, the *vas deferens*, which carries the sperm to the *ejaculatory duct*. Here the sperm becomes clumped into a compact mass and covered with a protective covering excreted by the *accessory glands*. This becomes a packet of sperm called a spermatophore. This packet is deposited by the muscular aedeagus (a copulatory organ) into the female.

FEMALE

The spermatophore is deposited into the *genital chamber* of the female during copulation. The spermatophore covering disintegrates releasing the sperm which then travels up and is stored in a small pouch called the *spermatheca*. Eggs are produced in the *ovaries* and travel down the *oviduct* which leads to the *vagina* where both oviducts join. Here sperm is released to fertilize the egg and a covering is added by secretions from the *colleteral gland*. When the time and conditions are right the females excavates an underground nest with her legs and *ovipositor*. After the excavation she lays her eggs and covers them with dirt. After a period of time the miniature grasshoppers emerge and forage on their own. Grasshoppers provide no parental care for their young.