محاضرات الحشرات

General Entomology

Second class

Vol. (I)

Insect Morphology

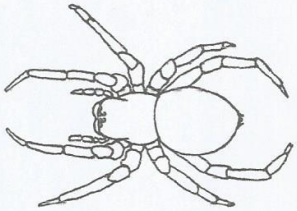
All arthropods possess :

- Exoskeleton - a hard protective covering around the outside of the body
- Segmented body
- Jointed limbs and jointed mouthparts - that allow extensive specialization
- Bilateral symmetry - whereby a central line can divide the body into two identical halves, left and right
- Ventral nerve cord - as opposed to a vertebrate nerve cord which is dorsal
- Dorsal blood pump

Five important extant classes of Arthropods are arachnids, chilopods, diplopods, crustaceans and hexapods.

Class Arachnida (arachnids): spiders, scorpions, ticks, , etc.

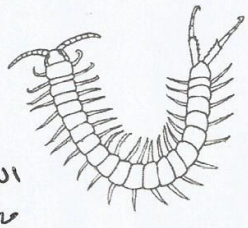
Arachnids possess:



- ٢ body segments - cephalothorax and abdomen
- ٨ legs
- ١ pair of chelicerae
- no antennae

Class Chilopoda (centipedes)

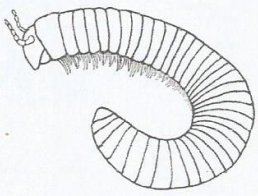
Chilipods possess:



- many body segments
- ١ pair of legs per body segment
- ١ pair of antennae
- ١st pair of legs modified into venomous

Class Diplopoda (millipedes)

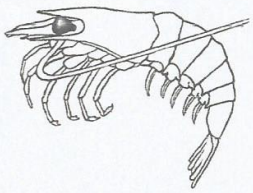
Diplopods possess:



- Many body segments
- ٢ pair of legs per body segment
- ١ pair of antennae

العَدَلون الروبيان سرطان

Class Crustacea (crustaceans): crabs, shrimp, etc.

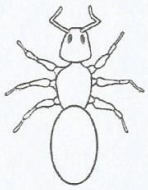


Crustaceans possess:

- Several body segments - head, thorax and abdomen
- Segments may be fused مندمجة
- Varied number of legs متنوع - متعدد
- ٢ pairs of antennae

العث

Class Insecta (Insects); beetles, bugs, wasps, moths, flies, etc.



Insects possess:

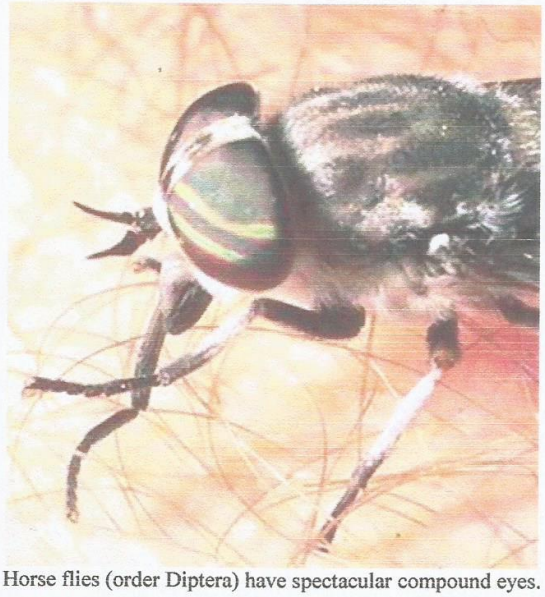
- ٣ body segments
- ٦ legs
- ١ pair of antennae
- Diverse modifications to appendages

متعدد - مختلف

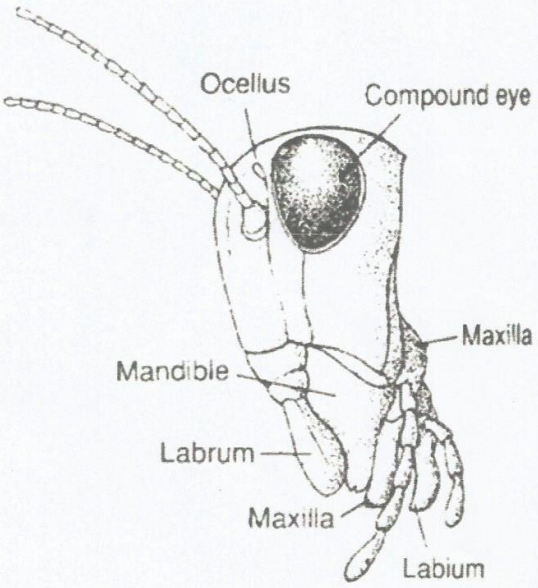
Basic Insect Morphology: Head, thorax, abdomen

HEAD

The head of an insect is composed of mainly rigid sclerites or sclerotized segments. The insect head is a capsule that contains the compound eyes, simple eyes (ocelli), mouthparts, and antennae.



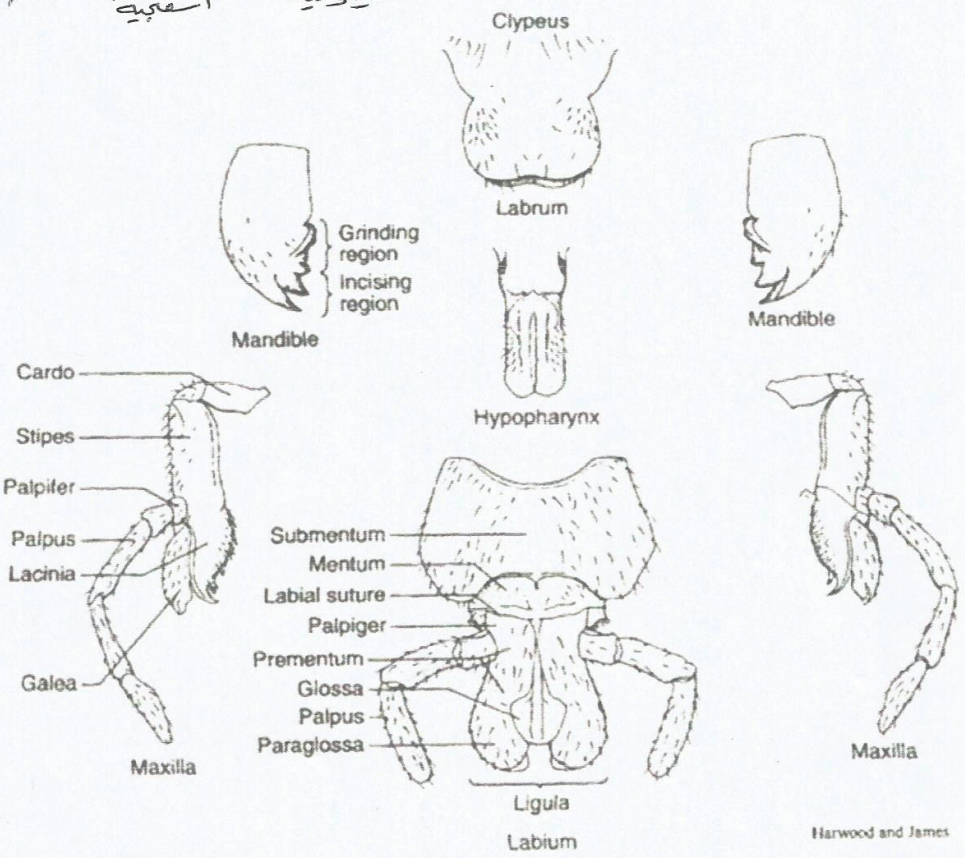
Horse flies (order Diptera) have spectacular compound eyes.



Mouthparts

The 4 main mouthparts are the **labrum (upper lip), mandibles (jaws), maxillae and labium.** The labrum is a simple fused sclerite, often called the upper lip, and moves longitudinally. It is hinged to the clypeus. The mandibles, or jaws, are highly sclerotized paired structures that move at right angles to the body. They are used for biting, chewing and severing food. The maxillae are paired structures that can move at right angles to the body and possess segmented palps. The labium (often called the lower lip), is a fused structure that moves longitudinally and possesses a pair of segmented palps. Mouthparts very greatly among insects of different orders but there are two main functional groups: mandibulate and haustellate. Shown above and below are

mandibulate (chewing) mouthparts. Haustellate mouthparts can be further classified as piercing-sucking, sponging, and siphoning.



Mandibulate (chewing) mouthparts are used for biting and grinding solid foods (see diagram above).

Examples: Dragonflies and damselflies (order Odonata), termites (order Isoptera), adult lacewings (order Neuroptera), beetles (order Coleoptera), ants (order Hymenoptera), cockroaches (order Blattaria), grasshoppers, crickets and katydids (order Orthoptera), caterpillars (order Lepidoptera). Adult Lepidoptera have siphoning mouthparts.

University of Florida

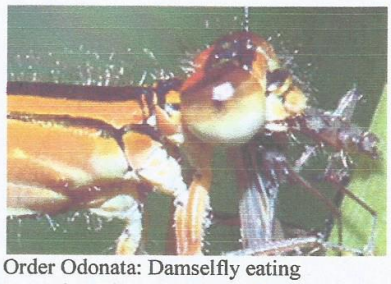
Order Coleoptera: Stag beetle, Jim Occi, BugPics, www.insectimages.org

Order Hymenoptera: Carpenter ant, *Camponotus* sp., Jim Kalisch, Department of Entomology, University of Nebraska-Lincoln

cockroach, *Periplaneta americana*, Daniel R. Suiter, University of Georgia, www.insectimages.org

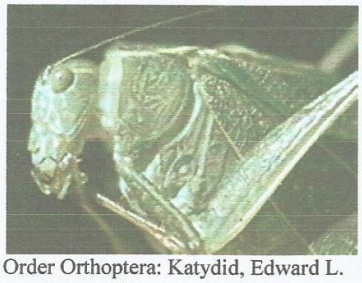
Order Neuroptera: Green lacewing adult, *Chrysopa oculata*, John Davidson, The Insects of Cedar Creek Photo Album

Order Coleoptera: Scarab beetle grub, Ronald F. Billings, Texas Forest Service, www.insectimages.org

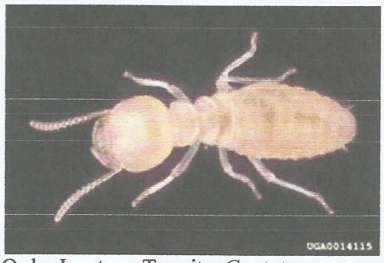


Order Odonata: Damselfly eating mosquito, Richard Seaman, Nature Wallpaper

Order Lepidoptera: Saturniid caterpillar, *Hyalophora columbia,* Connecticut Agricultural Experiment Station, www.insectimages.org



Order Orthoptera: Katydid, Edward L. Manigault, Clemson University Donated Collection, www.insectimages.org

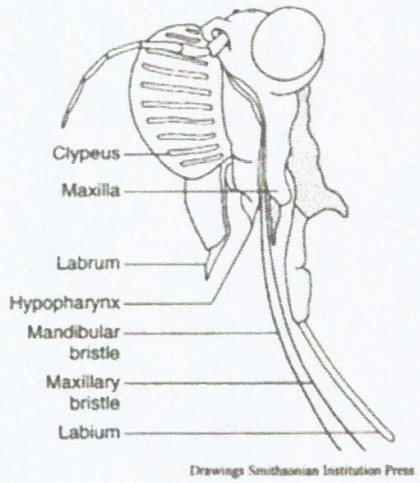


Order Isoptera: Termite, *Coptotermes formosanus*, Gerald J. Lenhard, Louisiana State University, www.insectimages.org

هرقوصية

Haustellate mouthparts are primarily used for sucking 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. The modified mandibles, maxilla, and hypopharynx form the stylets and the feeding tube. After piercing solid tissue, insects use the modified mouthparts to suck liquids from the host. To the left is a diagram of cicada mouthparts.



Order Hemiptera
University of Florida

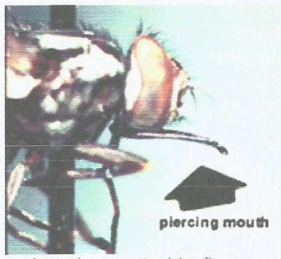
Some haustellate mouthparts lack stylets. Unable to pierce tissues, these insects must rely on easily accessible food sources such as nectar at the base of a flower. One example of nonstylate mouthparts are the long siphoning proboscis of butterflies and moths (Lepidoptera). Although the method of liquid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

Piercing-sucking mouthparts are used to penetrate solid tissue and then suck up liquid food.

Examples: Cicadas (see diagram), aphids, and other bugs (order Hemiptera), sucking lice (order Phthiraptera), stable flies and mosquitoes (order Diptera).

Order Hemiptera: Wheel bug, *Arilus cristatus*, Edward L. Manigault, Clemson University Donated Collection, www.insectimages.org

Order Hemiptera: Green peach aphid, *Myzus persicae*, Scott Bauer, USDA ARS, www.insectimages.org



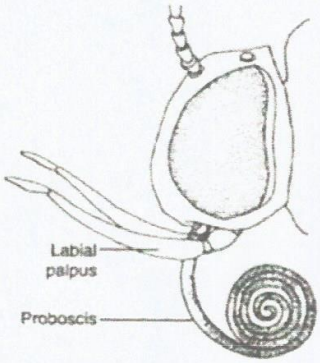
Order Diptera: Stable fly, *Stomoxys calcitrans,* North Dakota State University

Order Hemiptera: Spined soldier bug, *Podisus maculiventris*, attacking caterpillar, Russ Ottens, University of Georgia, www.insectimages.org

Order Diptera: Mosquito feeding on human, Jim Occi, BugPics, www.insectimages.org

Siphoning mouthparts lack stylets and are used to suck liquids.

Examples: Butterflies, moths and skippers (order Lepidoptera), bees (order Hymenoptera). Larval Lepidoptera have chewing mouthparts.



Moth (Order Lepidoptera)
University of Florida

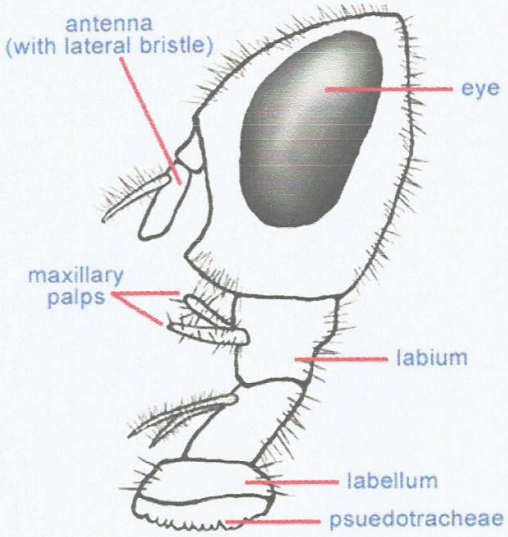
Order Lepidoptera: Hummingbird sphinx moth, James Politte, http://washingtondcmetroweb.com

Order Lepidoptera: Crossline skipper, James Politte, http://washingtondcmetroweb.com

Order Hymenoptera: Blueberry bee, *Habropoda laboriosa*, Jerry A. Payne, USDA ARS, www.insectimages.org

Sponging mouthparts are used to sponge and suck liquids.

Examples: House flies and blow flies (order Diptera).



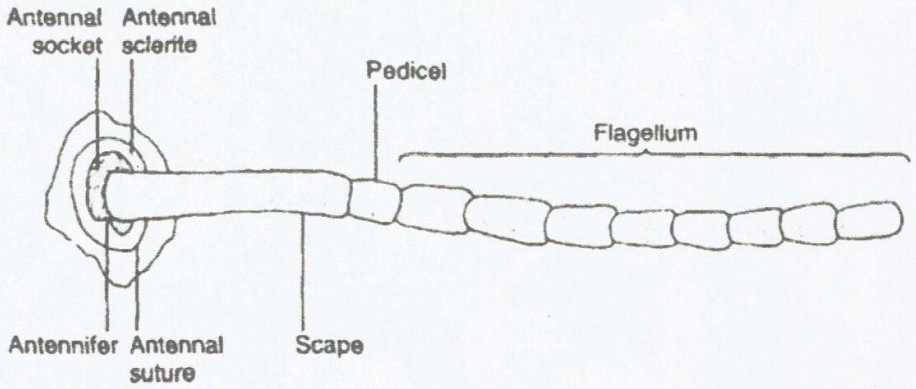

Order Diptera: House fly.


Order Diptera: Green bottle fly (blow fly),

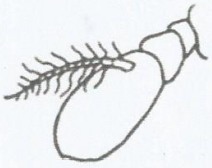

Order Diptera: Blue bottle fly (blow fly),

Antennae

Antennae vary greatly among insects, but all follow a basic plan: segments ١ and ٢ are termed the **scape** and **pedicel**, respectively. The remaining antennal segments (flagellomeres) are jointly called the **flagellum.**



١.**Aristate** antennae are pouch-like with a lateral bristle.



Examples: House flies (order Diptera).

Order Diptera: House fly.

Order Diptera: Shore fly.

٢.**Capitate** antennae are abruptly clubbed at the end.

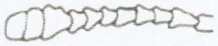
Examples: Butterflies (order Lepidoptera).

Order Lepidoptera butterfly,

Order Lepidoptera:

Order Lepidoptera:

٣.**Clavate** antennae are gradually clubbed at the end.

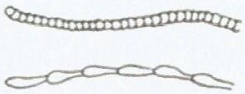


Examples: Carrion beetles (order Coleoptera).

Order Coleoptera: Carrion beetle,.

Order Coleoptera:

ᵎ.**Filiform** antennae have a thread-like shape.



Examples: Ground and longhorned beetles (order Coleoptera), cockroaches (order Blattaria).

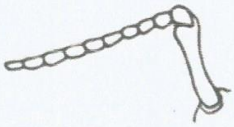
Fig ( )

Order Coleoptera: Ground beetle,

Order Coleoptera: longhorned beetle,

Order Blattaria: *Periplaneta americana*,

ᵏ.**Geniculate** antennae are hinged or bent like an elbow.



Examples: Bees and ants (order Hymenoptera).

Order Hymenoptera: Bumble bee,

Order Hymenoptera: Blueberry bee,

Order Hymenoptera: Carpenter ant,

٦.**Lamellate** or clubbed antennae end in nested plates.

Examples: Scarab beetles (order Coleoptera).

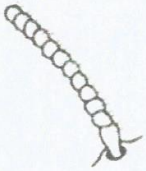
Order Coleoptera:

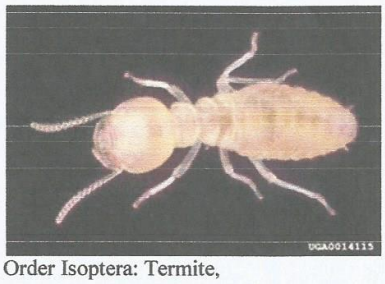
Order Coleoptera:

Order Coleoptera:

٧.**Moniliform** have a beadlike shape.

Examples: Termites (order Isoptera).



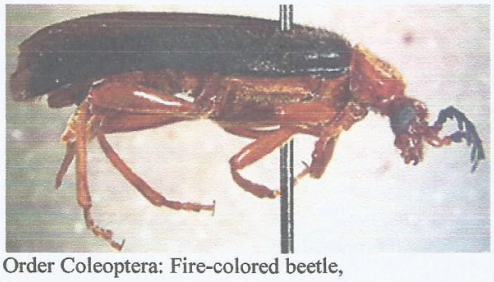


Order Isoptera: Termite,

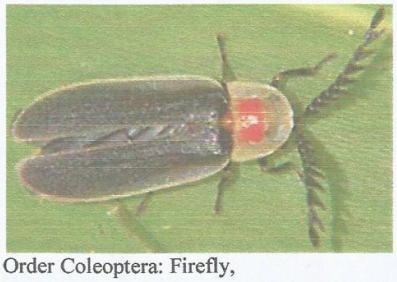
Order Isoptera: Termite,

٨.**Pectinate** antennae have a comb-like shape.

Examples: Fire-colored beetles and fireflies (order Coleoptera).



Order Coleoptera: Fire-colored beetle,



Order Coleoptera: Firefly,

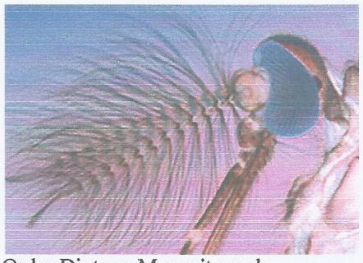
٩.**Plumose** antennae have a feather-like shape.

Examples: Moths (order Lepidoptera) and mosquitoes (order Diptera).

University of Sydney

Order Lepidoptera:

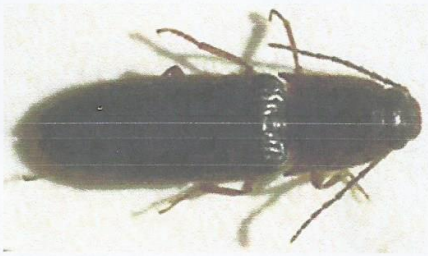
Order Lepidoptera:



Order Diptera: Mosquito male,

١٠.**Serrate** antennae have a saw-toothed shape.

Examples: Click beetles (order Coleoptera).



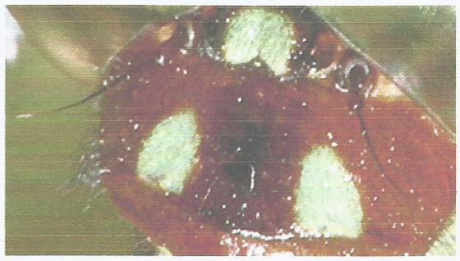
Order Coleoptera: Click beetle,

١١.**Setaceous** antennae have a bristle-like shape.

Examples: Dragonflies and damselflies (order Odonata).

Order Odonata: Damselfly,

Order Odonata

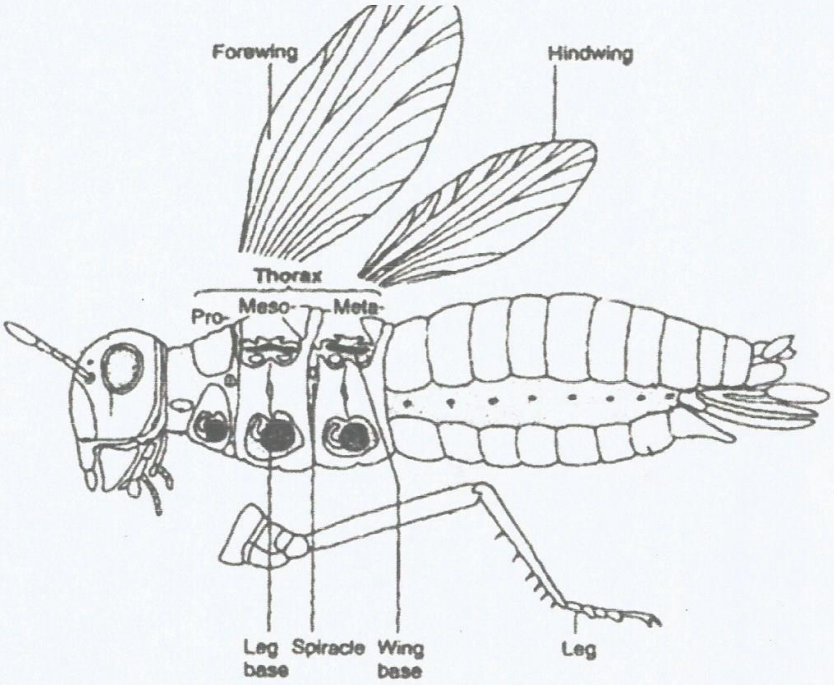


Order Odonata:

THORAX

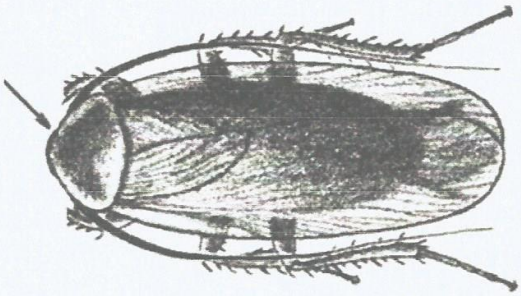
The insect thorax is divided into three parts: the prothorax (pro=first), mesothorax (meso=middle), and metathorax (meta=last). Each segment consists of hardened plates, or sclerites. Dorsal sclerites are called nota (singular notum), lateral sclerites are called pleura (singular pleuron), and ventral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

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



Pronotum

The pronotum is the dorsal sclerite of the prothorax, which can be highly modified in various orders such as the Hemiptera, Blattaria, and Coleoptera.

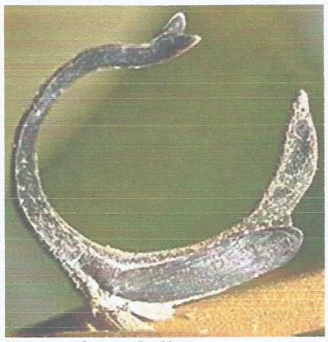


Treehoppers (order Hemiptera) have some of the most bizarre pronotums of all insects.

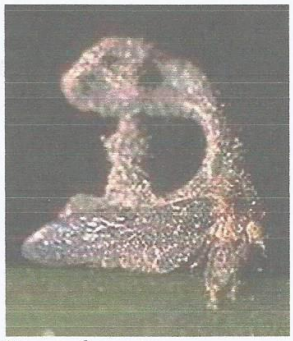
Cyphonia sp., Membracidae of South America

Alchisme sp., Membracidae of South America

Bocydium sp., Membracidae of South America

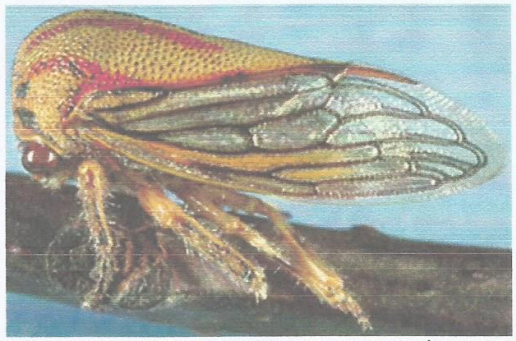


Spongophorus ballista, Membracidae of South America



Spongophorus sp., Membracidae of South Ar

Cyphonia sp., Membracidae of South America



Oak treehopper, *Platycotis vittata*, Larry R. Barber, USDA Fores Service, www.insectimages.org

Scarab beetles (order Coleoptera) and other beetles may also have unusual

pronotums.

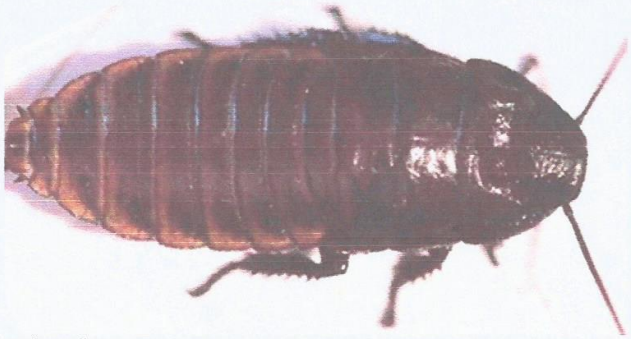
In addition, the specimens shown here also have bizarre modifications of the head capsule. Male insect use horns to fight with other males over females and territory.

Hercules beetle, *Dynastes granti*, Oldrich Jahn, InsectNet

Dung beetle,

Cockroaches (order Blattaria) have pronotums that extend forward over the head.

Orange-headed cockroach,

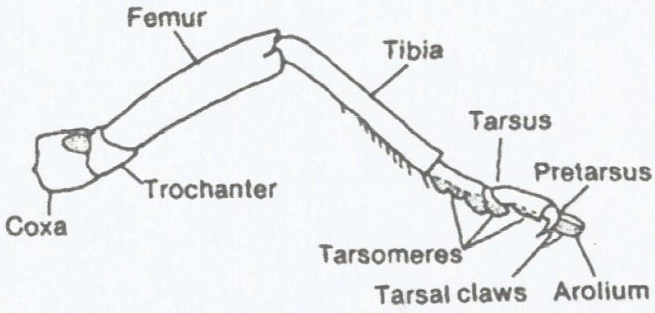


cockroach,

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, trochanter, femur, tibia, tarsus, pretarsus**.

The femur and tibia may be modified with spines. The tarsus appears to be divided into one to five "pseudosegments" called **tarsomeres**. Like the mouthparts and antennae, insect legs are highly modified for different functions, depending on the environment and lifestyle of an insect.



١. walking legs . The structure is similar to cursorial (running) legs.

Examples: Bugs (order Hemiptera), leaf beetles beetles (orderColeoptera).

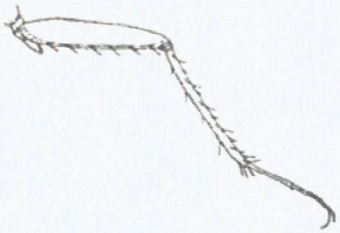

Order Hemiptera: bug,

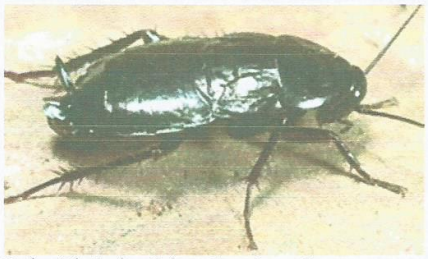

Order Hemiptera: plant bug,


Order Coleoptera:

٢. running legs. Note the long, thin leg segments.

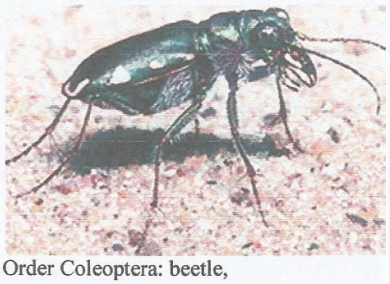
Examples: Cockroaches (order Blattaria), ground and tiger beetles (order Coleoptera).





Order Blattaria: Oriental cockroach,

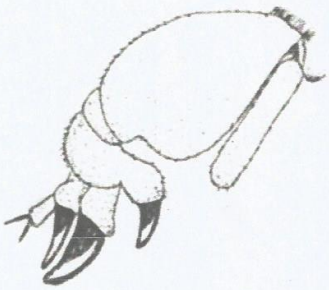
Order Coleoptera: Ground beetle,



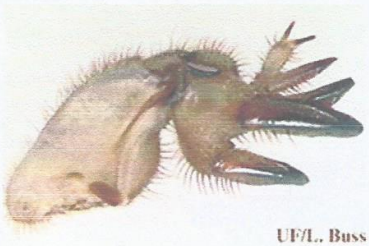
Order Coleoptera: beetle,

٣. Digging legs :fore legs are modified.

Examples: mole crickets (order Orthoptera)



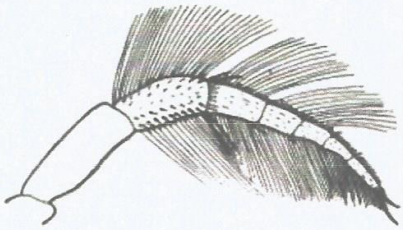
Order Orthoptera: mole cricket,

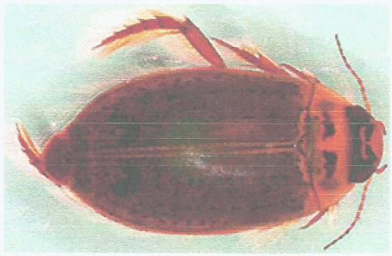


Order Orthoptera: mole cricket leg,

٤.**Swimming** legs: hind legs are modified. These legs have long setae on the tarsi.

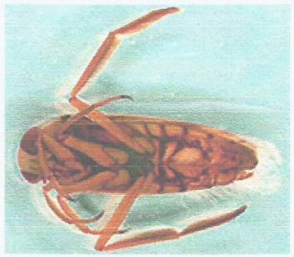
Examples: Aquatic beetes (order Coleoptera) and bugs (order Hemiptera).





Order Coleoptera: beetle,

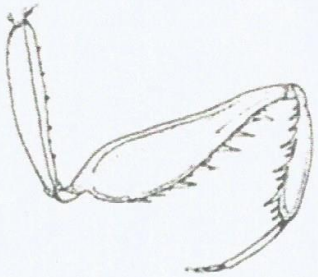
Order Coleoptera: beetle



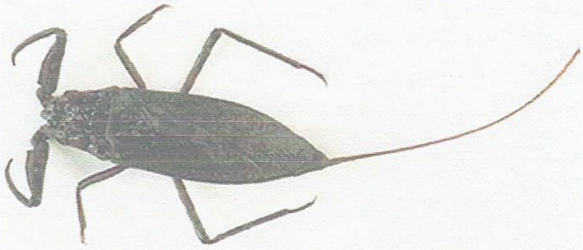
Order Hemiptera: (aquatic bug),

°.**Grasping legs:** fore legs modified

Examples: Mantids (order Mantodea), water scorpions (order Hemiptera).



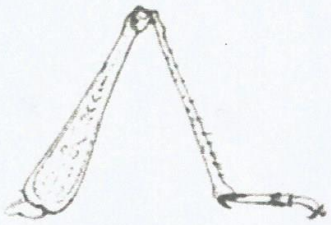
Order Mantodea:

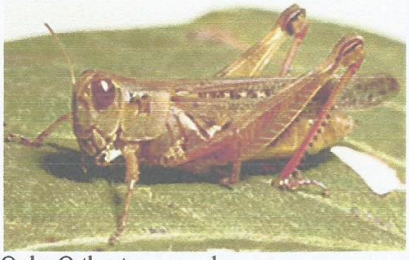


Order Hemiptera: Water scorpion,

٦. **Jumping legs:** hind legs adapted (femur and tibia)

Examples: Grasshoppers, (order Orthoptera).





Order Orthoptera: grasshopper,

Order Orthoptera: House cricket,

Wings

Insects have evolved many variations of the wings, and an individual insect may posess more than one type of wing. Wing venation is a commonly used taxonomic character, especially at the family and species level.

Primitive insects of the Paleoptera are unable to fold their wings. Instead, these insects carry their wings vertically or horizontally to their bodies.

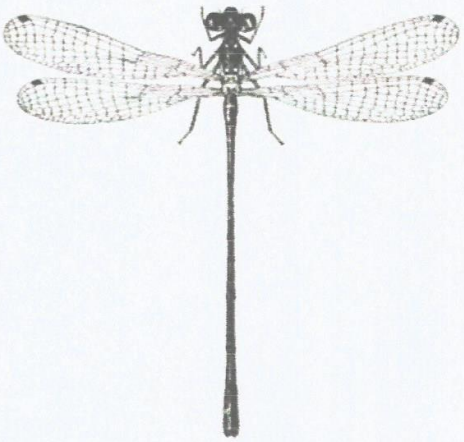
Mayfly,. (order Ephemeroptera),

Most modern insects of the Neoptera are able to fold their wings over the body. This enables the insects to fit into smaller spaces.

Leaf footed bug (order Hemiptera),

1. **Membranous wings** are thin and more or less transparent, but some are darkened.

Examples: Dragonfiles (order Odonata), flies (order Diptera), bees and wasps (order Hymenoptera), termites (order Isoptera).



Order Odonata: Damselfly,

Order Odonata: Dragonfly,

Order Isoptera: Termites,

Order Neuroptera:

Order Diptera: fly,

٢.**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.

Examples: All flies (order Diptera).

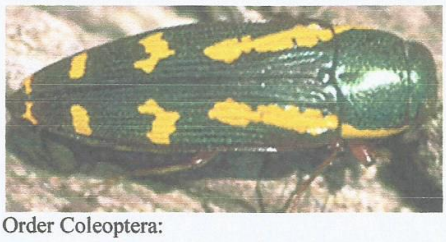
Order Diptera: fly,

Order Diptera:

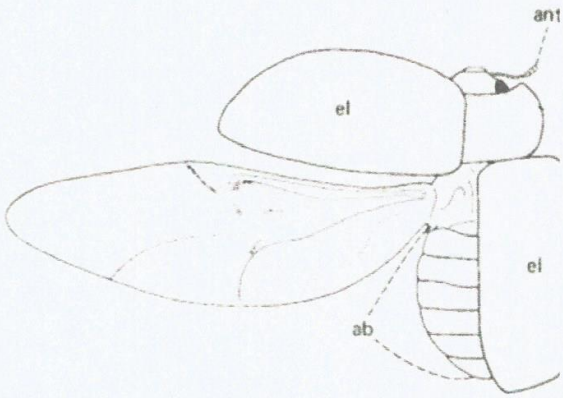
Order Diptera: Soldier fly,

٣.**Elytra** (singular elytron) are the hardened, beetles are modified to protect the hind wings when at rest.

Examples: All beetles (order Coleoptera).



Order Coleoptera:



Order Coleoptera: beetle

Order Coleoptera: Dung beetle,

Order Coleoptera: beetle,

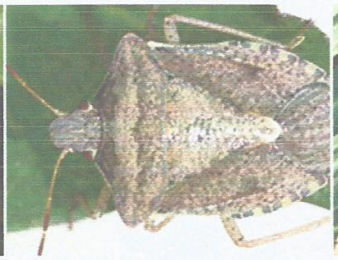
Order Coleoptera: beetle,

٤. **hemelytra**. The forewings of Hemipterans are said to be hemelytrous

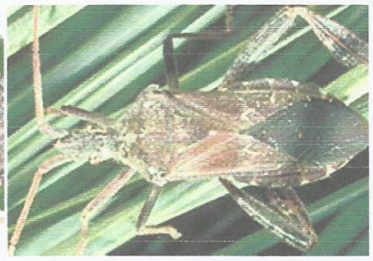
Examples: Bugs (order Hemiptera).

Order Hemiptera: Big-eyed bug,

Order Hemiptera: plant bug,



Order Hemiptera: bug,

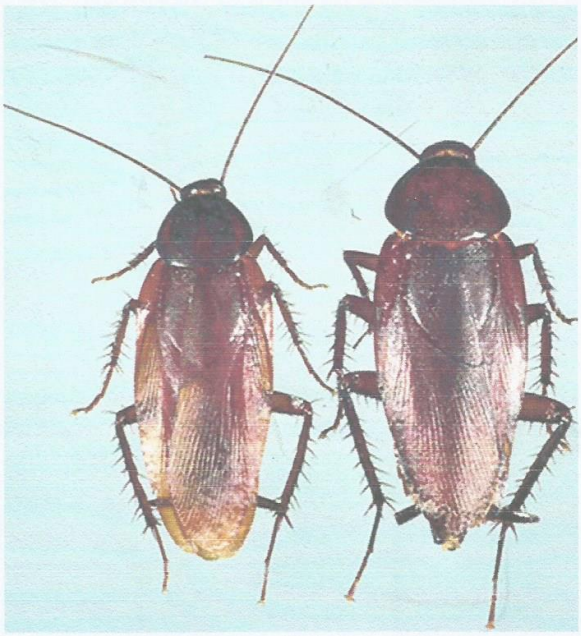


Order Hemiptera: bug.

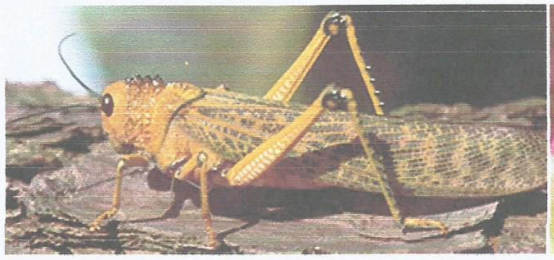
- **.Tegmina** (singular tegmen)

Examples: Grasshoppers, (order :Orthoptera), Cockroaches (order Blattaria), Mantids (order Mantodea).

Order Orthoptera: Grasshopper,



Order Blattaria: cockroach,



Order Orthoptera: Grasshopper,

Order Blattaria: cockroach,

Order Mantodea:

٦.Some insect wings are covered with **scales**.
The scales make the wings colorful.

Examples: Butterflies, moths
(order Lepidoptera

Order Lepidoptera:

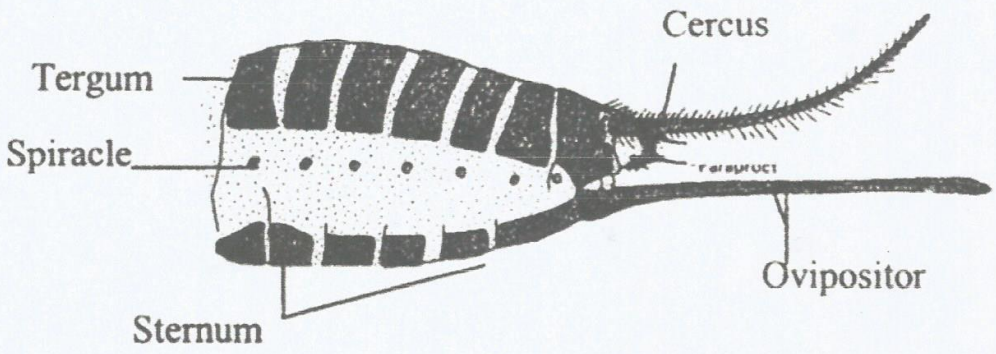
Order Trichoptera:

Order Lepidoptera: moth,

Order Lepidoptera:

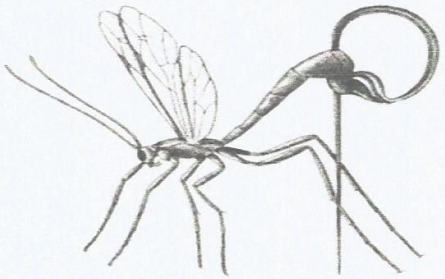
ABDOMEN

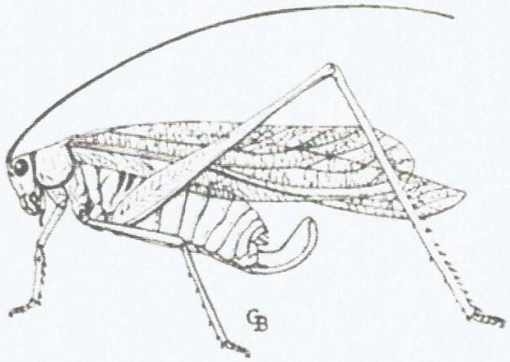
The abdomen contains the reproductive organs and the majority of the organ systems. The dorsal and ventral abdominal segments are termed terga (singular tergum) and sterna (singular sternum), respectively. Spiracles usually can be found in the conjunctive tissue between the terga and sterna of abdominal segments ١-٨. Reproductive structures are located on the ٩th segment in males (including the aedeagus, or penis, and often a pair of claspers) and on the ٨th and ٩th abdominal segments in females (female external genitalia copulatory openings and ovipositor).



Ovipositor

The ovipositor is the egg-laying device found only in female insects. In some insects, the ovipositor is highly modified and conspicuous. In others, the apparatus may be needle or blade-like.

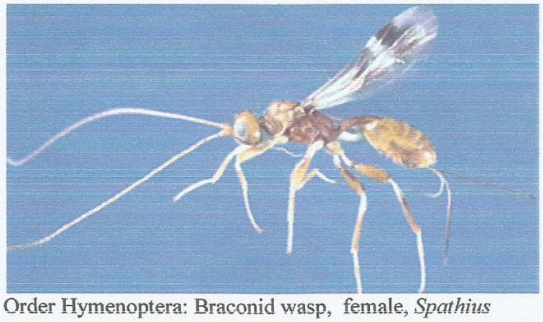




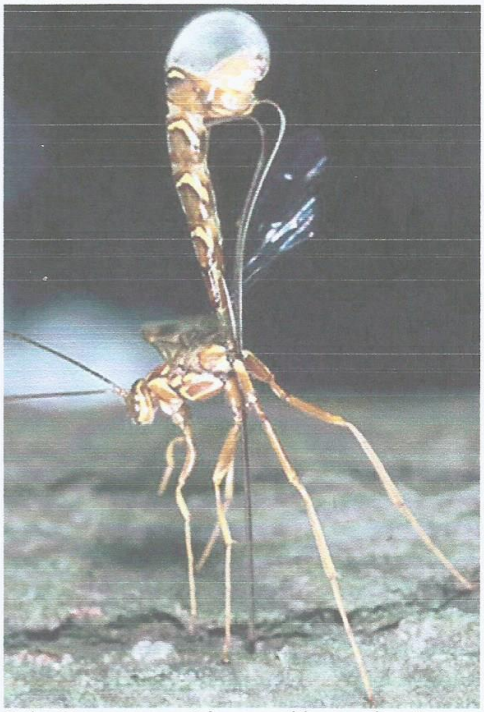
Blade-like ovipositor on katydid (order Orthoptera)

Needle-like ovipositor on parasitic ichneumonid wasp (order Hymenoptera)

Parasitic wasps (order Hymenoptera) use their ovipositors to insert eggs or small larvae into or onto a host. The stingers of bees and many wasps are modified ovipositors that have lost the egg-laying ability.

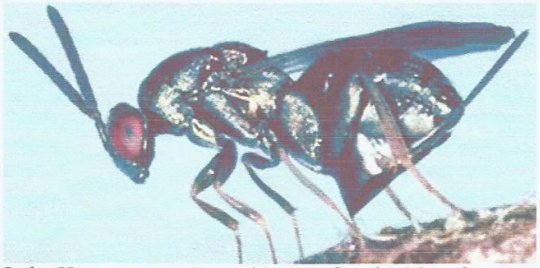


Order Hymenoptera: Braconid wasp, female, *Spathius pallidus*, Gerald J. Lenhard, Louisiana State University, www.insectimages.org



Order Hymenoptera: Ichneumonid wasp, female, *Megarhyssa macrurus*, Jim Occi, BugPics,

www.insectimages.org



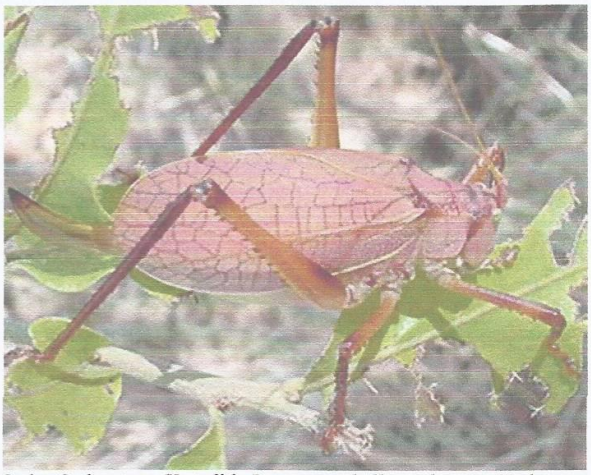
Order Hymenoptera: Torymid wasp, female, *Monodontomerus dentipes*, Arnold T. Drooz, USDA Forest Service, www.insectimages.org

dentipes, Arnold T. Drooz, USDA Forest Service, www.insectimages.org

Order Hymenoptera: Ichneumonid wasp, female, *Megarhyssa macrurus*, Jim Occi, BugPics, www.insectimages.org

Crickets and **katydids** (order Orthoptera) have needle-like and blade-like ovipositors, respectively.

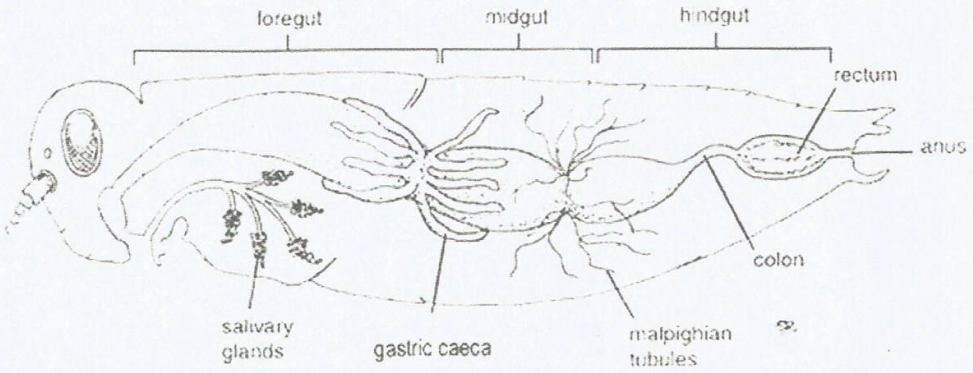
Order Orthoptera: Field cricket, female, *Gryllus pennsylvanicus*, Joseph Berger, www.insectimages.org



Order Orthoptera: Katydid, *Paracyrtophyllus robustus*, Herbert A. "Joe" Pase III, Texas Forest Service, www.insectimages.org

Internal Anatomy

Digestive & Excretory Systems

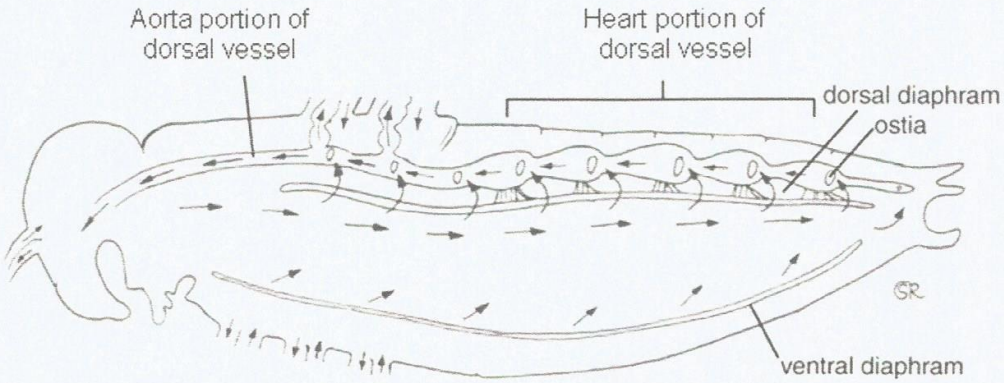


The **digestive system** (sometimes referred to as the **alimentary canal**) is a long tube-like structure that runs from the mouth to the anus and is centrally located within the body cavity, or **hemocoel**. The anterior-most region is called the **foregut** (or **stomodeum**) which includes the Buccal 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 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.

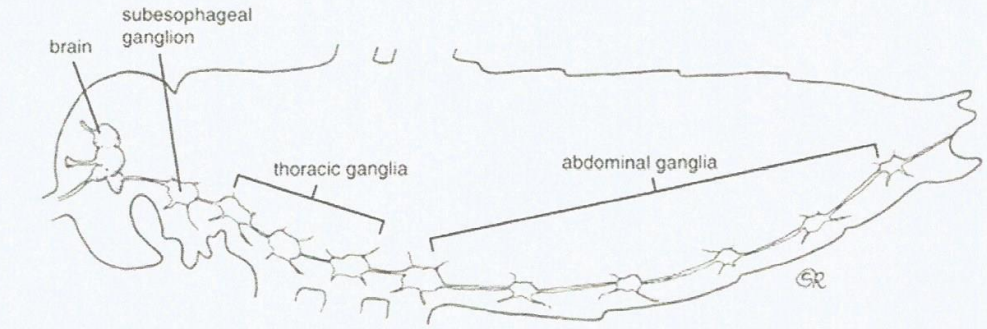
Circulatory System

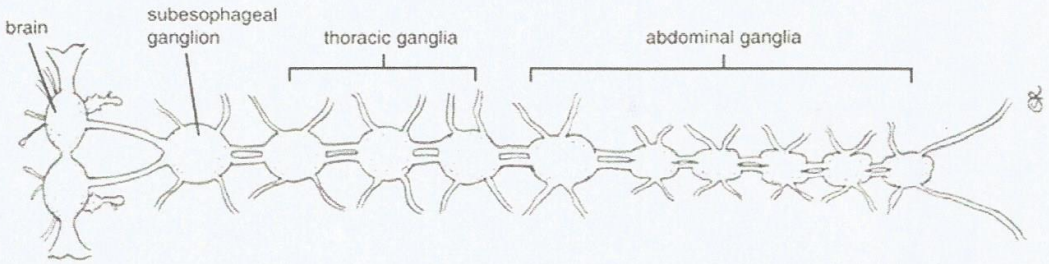


Unlike the closed circulatory system of humans, insect circulatory systems are said to be open, meaning that they lack a complex network of veins and arteries to help transport blood throughout the body. Instead, insect blood (called **hemolymph**) flows relatively freely throughout the hemocoel.

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.

Nervous System

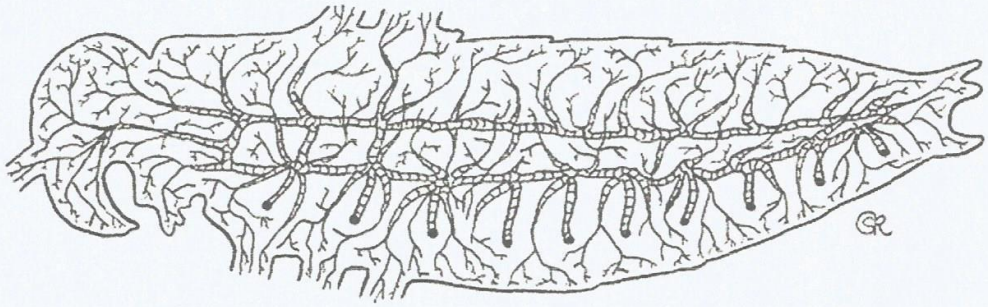




The **ventral nerve cord**, resembles a railroad track running from the head posteriorly to the abdominal region (above, lower diagram). The ventral nerve cord is made up of two nerve cords (**connectives**) that run longitudinally with a series of node-like **ganglia**.

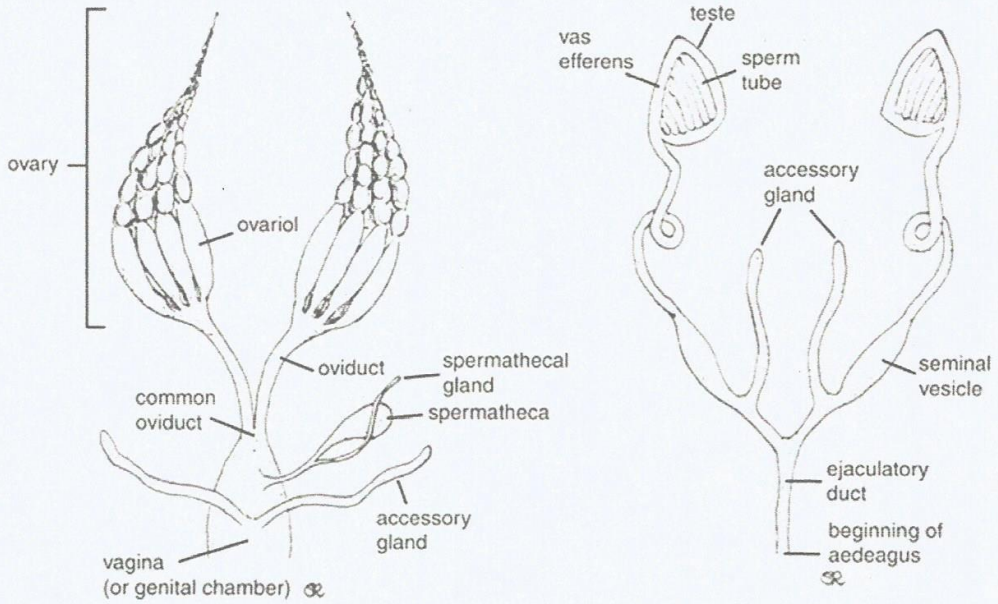
The anterior most region of the ventral nerve cord is called the **subesophageal ganglion**. Just dorsal to that structure is the insect brain (or **supraesophageal ganglion**).

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 **tracheae**, appear as thin white lines throughout the hemocoel and are particularly noiceable surrounding internal organs. Trachea deliver oxygen to internal organs and tissues.

Reproductive System



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. Be familiar with differences in male and female genitalia and be able to identify structures when given a diagram.

Insect Growth and Development (Metamorphosis)

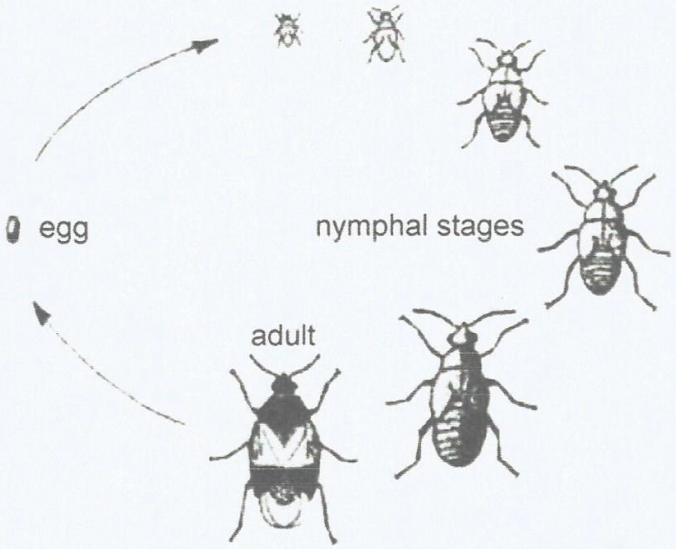
Information and diagrams are adapted from:
Hoffmann, M.P. and Frodsham, A.C. (١٩٩٣) Natural Enemies of Vegetable Insect Pests. Cooperative Extension, Cornell University, Ithaca, NY. ٦٣ pp.

Insects go through several separate life stages: egg, larva or nymph, pupa (complete metamorphosis only), and adult. Eggs are laid one at a time or in masses, in or on plants, or even inside another insect! Eventually a larva or nymph emerges from the egg. There are usually several larval or nymphal stages, called instars. During each stage the nymph grows larger and molts, or sheds its outer skin before the next stage. They grow the most during the last one or two instars, or stages. All the growing happens during the larval or nymphal stages. The eggs, pupae, and adults don't grow in size.

The two types of metamorphosis typical of insects are:

incomplete metamorphosis (egg --> nymph --> adult) and **complete metamorphosis** (egg --> larva --> pupa --> adult).

Order Hemiptera: flower bug, incomplete metamorphosis



Order Coleoptera: lady beetle, complete metamorphosis