

## **BODY SEGMENTATION - STRUCTURE AND MODIFICATIONS OF INSECT ANTENNAE, MOUTH PARTS AND LEGS, WING VENATION, MODIFICATIONS AND WING COUPLING APPARATUS & SENSORY ORGANS**

Insect body is differentiated into three distinct regions called head, thorax and abdomen (grouping of body segments into distinct regions is known as **tagmosis** and the body regions are called as **tagmata**).

### **I. HEAD**

First anterior tagma formed by the fusion of six segments namely preantennary, antennary, intercalary, mandibular, maxillary and labial segments. Head is attached or articulated to the thorax through neck or **Cervix**. Head capsule is sclerotized and the head capsule excluding appendages formed by the fusion of several sclerites is known as **Cranium**.

#### **Sclerites of Head**

- i. **Vertex:** Summit of the head between compound eyes.
- ii. **Frons:** Facial area below the vertex and above clypeus.
- iii. **Clypeus:** Cranial area below the frons to which labrum is attached.
- iv. **Gena:** Lateral cranial area behind the compound eyes.
- v. **Occiput :** Cranial area between occipital and post occipital suture.

#### **Sutures of Head**

- i. **Epicranial suture:** (Ecdysial line) Inverted 'Y' shaped suture found medially on the top of head, with a median suture (coronal suture) and lateral suture (frontal suture).
- ii. **Epistomal suture:** (Fronto clypeal suture) found between frons and clypeus.
- iii. **Clypeo labral suture:** Found between clypeus and labrum.
- iv. **Post occipital suture:** Groove bordering occipital foramen. Line indicating the fusion of maxillary and labial segment.

Posterior opening of the cranium through which aorta, foregut, ventral nerve cord and neck muscles pass is known as **Occipital foramen**. **Endoskeleton** of insect cuticle provides space

for attachment of muscles of antenna and mouthparts, called as **Tentorium**. The appendages like a pair of compound eyes, 0-3 ocelli, a pair of antenna and mouth parts are called as **Cephalic appendages**.

### Functions of Head

- i. Food ingestion
- ii. Sensory perception
- iii. Coordination of bodily activities
- iv. Protection of the coordinating centers

### TYPES OF INSECT HEADS

Based on the inclination of long axis of the head and orientation of mouth parts there are three types of insect heads.

#### 1) HYPOGNATHOUS (Hypo – below; gnathous – jaw)

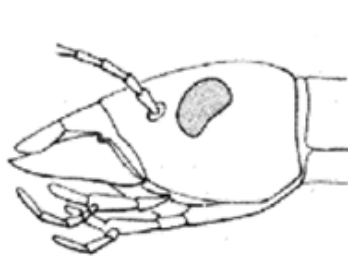
This type is also called orthopteroid type. The long axis of the head is vertical. It is at right angles to the long axis of the body. Mouth parts are ventrally placed and project downwards.

#### 2) PROGNATHOUS (Pro- in front ; gnathous – jaw)

This type is also called coleopteroid type. The long axis of the head is horizontal. It is in line with the long axis of the body. Mouth parts are directed forward. Eg: ground beetles.

#### 3) OPISTHOGNATHOUS (Opistho – behind ; gnathous – jaw)

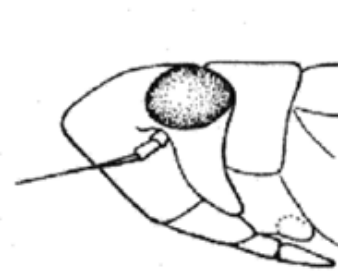
This type is also called hemipteroid type or opisthorhynchous. Head is deflexed. Mouth parts are directed backwards and held in between the fore legs. Eg: Stink bug.



prognathous



hypognathous



opisthognathous

## II. THORAX

Second and middle tagma which is three segmented, namely prothorax, mesothorax and metathorax. Meso and metathorax with wing are called as **Pterothorax**. Thorax is made up of three scleritic plates namely, dorsal body plate (**Tergum** or **Nota**, ventral body plate (**Sterna**) and lateral plate (**Pleura**).

**Thoracic nota:** Dorsal body plate of each thoracic segments are called as pronotum, mesonotum and metanotum respectively.

**Pronotum:** this sclerite is undivided and **Saddle** shaped in grass hopper, **Shield** like in cockroach.

**Pterothoracic notum:** Have 3 transverse **sutures** (Antecostal, Pre scutal and Scuto-scutellar) and 5 **tergites**(Acrotergite, Prescutum, Scutum, Scutellum and Post-scutellum)

**Thoracic sterna:** Ventral body plate of each thoracic segments are called as prosternum, mesosternum and metasternum. Thoracic sterna is made up of a segmental plate called **Eusternum** and a intersternite called **Spinasternum**. Eusternum is made up of three sclerites viz., presternum, basisternum and sternellum.

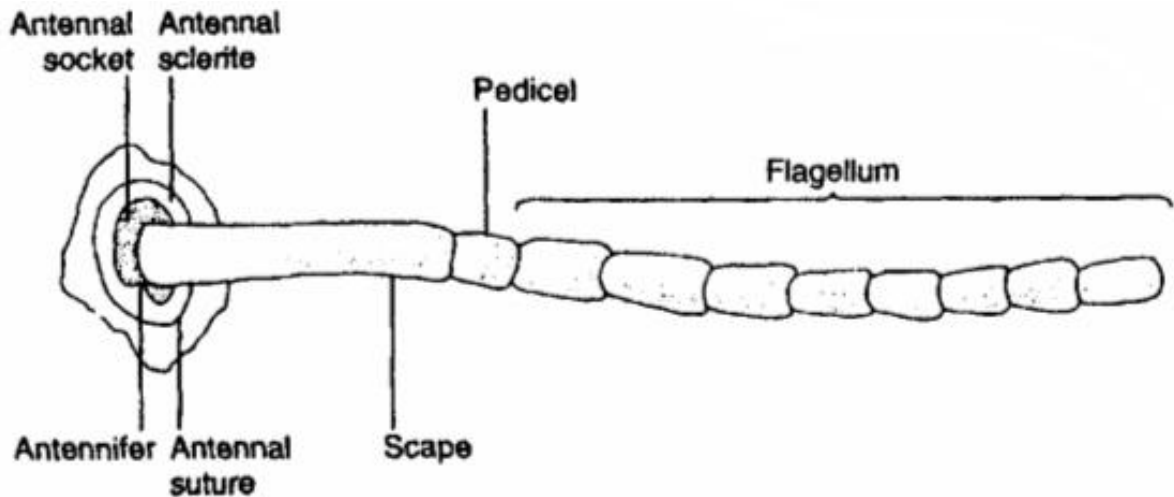
**Thoracic pleura:** Lateral body wall of thoracic segment between notum and sternum. Sclerites of pleuron is called as pleurites and they fuse to form **Pleural plate**. Pleural plate is divided into **anterior episternum** and **posterior epimeron** by **Pleural suture**. Pterothoracic pleuron provides space for articulation of wing and le.g. Thoracic appendages are three pairs of legs and two pairs of wings. Two pairs of spiracles are also present in the mesopleuron and metapleuron.

**Functions of thorax:** Mainly concerned with locomotion.

## III. ABDOMEN

Third and posterior tagma. This tagma is made up of 9-11 Uromeres (segments) and is highly flexible. abdominal segments are telescopic in nature and are interconnected by a membrane called conjunctiva. Each abdominal segment is made up of only two sclerite namely dorsal body plate (**tergum**) and ventral body plate (**sternum**). Eight pairs of spiracles are present

in the first eight abdominal segments, in addition to a pair of **tympanum** in the first abdominal



segment. Eight and ninth abdominal segments contain the female genital structure and ninth segment with male genital structure. Abdominal appendages are genital organs and cerci.

**Function:** Concerned with reproduction and metabolism.

### STRUCTURE OF INSECT ANTENNAE

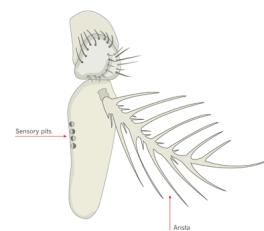
Antennae function almost exclusively in sensory perception. Some of the information that can be detected by insect antennae includes: **motion and orientation, odour, sound, humidity, and a variety of chemical cues**. Antennae vary greatly among insects, but all follow a basic plan: segments 1 and 2 are termed the scape and pedicel, respectively. The remaining antennal segments (flagellomeres) are jointly called the flagellum.

### MODIFICATIONS OF INSECT ANTENNAE

#### 1. ARISTATE

Aristate antennae are pouch-like with a lateral bristle.

Examples: House and shore flies (order Diptera).



The antennae are important sensory structures used to detect movement and odors.

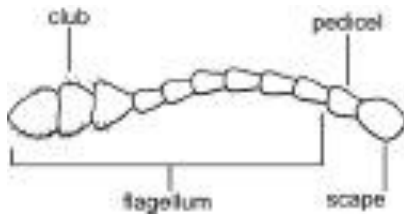
Among the olfactory receptors are sensilla located in several pits which lie ventrally on the basal one-third of the third segment of the antenna. The antenna is three-segmented with a

branched arista projecting dorsally from the third segment. A U-shaped groove around the lateral and dorsal part of the depression housing the pair of antennae is the frontal lunule (the suture through which the ptilinum was everted as the fly emerged from the puparium).



## 2. CAPITATE

Capitate antennae are abruptly clubbed at the end. Examples: Butterflies (order Lepidoptera).





### 3. CLAVATE

Clavate antennae are gradually clubbed at the end. Examples: Carrion beetles (order Coleoptera). Adult carrion beetles feed on decaying animal matter or maggots.



**Clavate**



### 4. FILIFORM

Filiform antennae have a thread-like shape. Examples: Ground and longhorned beetles (order Coleoptera), cockroaches (order Blattaria).



**Filiform**



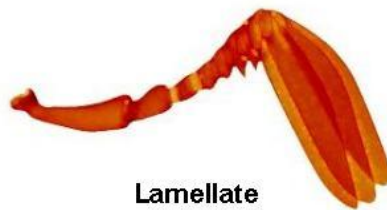
## 5. GENICULATE

Geniculate antennae are hinged or bent like an elbow. Examples: Bees and ants (order Hymenoptera).



## 6. LAMELLATE

Lamellate or clubbed antennae end in nested plates. Examples: Scarab beetles (order Coleoptera).



## 7. MONILIFORM

Moniliform have a beadlike shape. Examples: Termites (order Isoptera).



## 8. PECTINATE

**Pectinate** antennae have a comb-like shape. Examples: Fire-colored beetles and fireflies (order



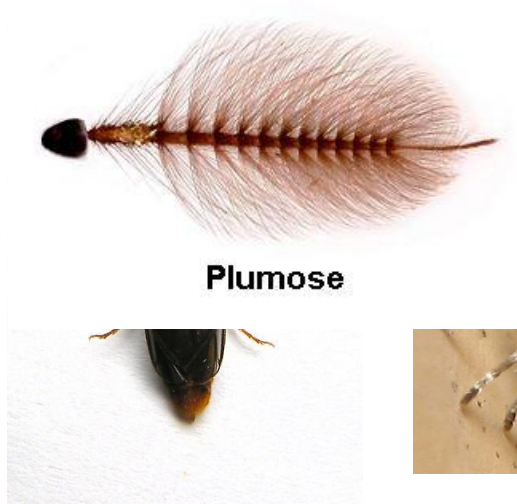
Coleoptera).





## 9. PLUMOSE

**Plumose** antennae have a feather-like shape. Examples: Moths (order Lepidoptera) and mosquitoes (order Diptera).



## 10. SERRATE

**Serrate** antennae have a saw-toothed shape. Examples: Click beetles (order Coleoptera).



Serrate



## 11. SETACEOUS

**Setaceous** antennae have a bristle-like shape. Examples: Dragonflies and damselflies (order Odonata).

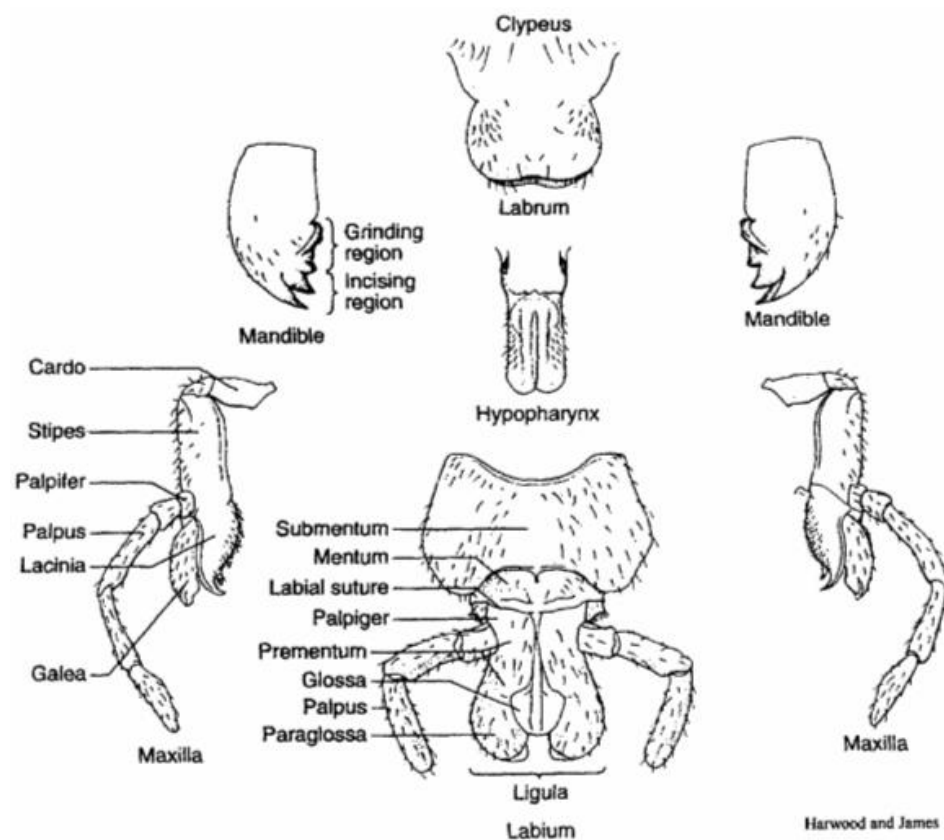


## MOUTH PARTS

The 4 main mouthparts are the **labrum, mandibles, maxillae (plural maxilla) 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.

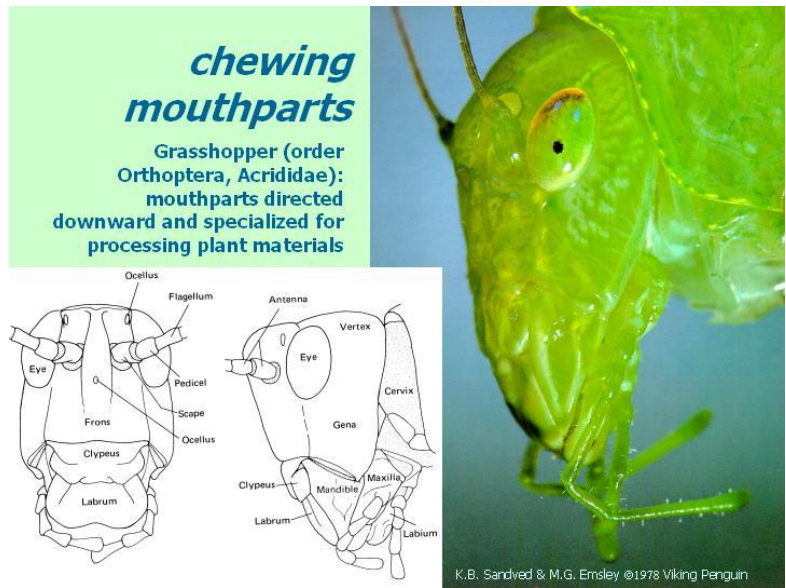
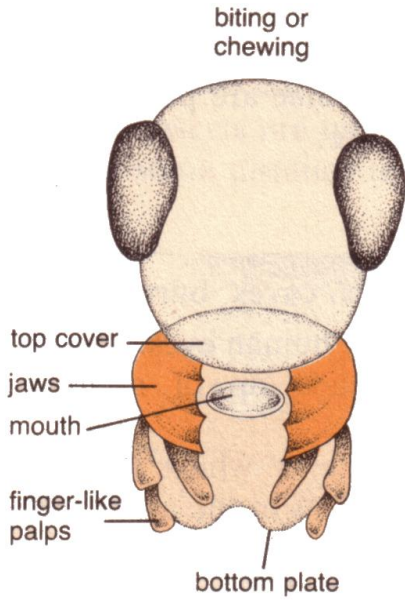
## MODIFICATIONS

Mouthparts vary greatly among insects of different orders but there are two main functional groups: **mandibulate** and **haustellate**. Haustellate mouthparts can be further classified as **piercing-sucking, sponging, and siphoning**.



## MANDIBULATE MOUTH PART

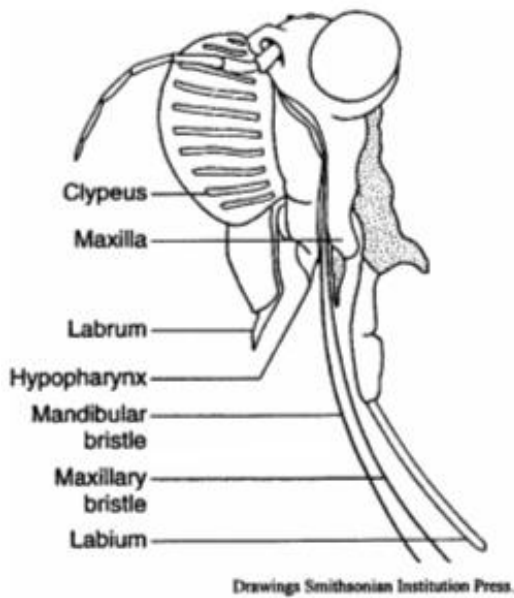
**Mandibulate (chewing)** mouthparts are used for biting and grinding solid foods. Examples: Dragonflies and damselflies (order Odonata), termites (order Isoptera), adult lacewings (order Neuroptera), beetles (order Coleoptera), ants (order Hymenoptera), cockroaches (order Blattaria), grasshoppers, crickets and katydids (order Orthoptera), caterpillars (order Lepidoptera). Adult Lepidoptera have siphoning mouthparts.



## HAUSTELLATE MOUTH PARTS

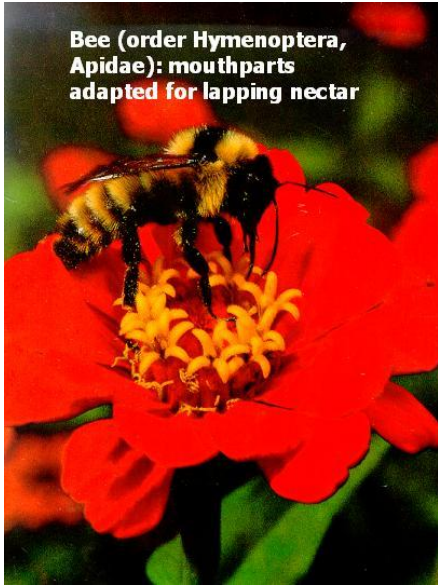
**Haustellate** mouthparts are primarily used for sucking liquids and can be broken down into two subgroups: those that possess stylets and those that do not. **Stylets** are needle-like projections

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. 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 nonstylete mouthparts are the long siphoning proboscis of butterflies and moths (Lepidoptera). Although the method of liquid transport

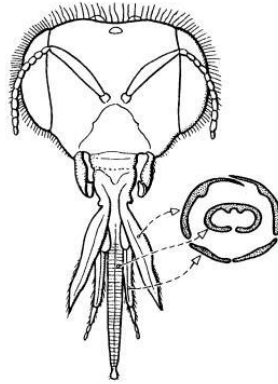


Order Hemiptera

differs from that of the a Lepidopteran proboscis, the rasping-sucking rostrum of some flies are also considered to be haustellate without stylets.



**lapping mouthparts**



**1. Piercing-sucking mouthparts**

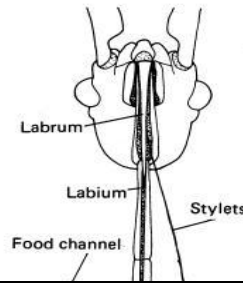
Piercing-sucking mouthparts are used to penetrate solid tissue and then suck up liquid food.

Examples: Cicadas, aphids,

and other bugs (order Hemiptera), sucking lice (order Phthiraptera), stable flies and mosquitoes (order Diptera).



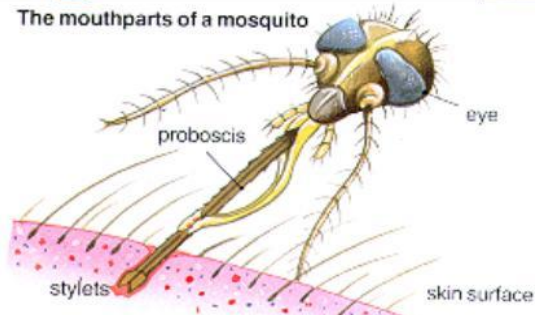
**piercing-sucking mouthparts**



**piercing-sucking . . .**



The mouthparts of a mosquito



## 2. Siphoning mouthparts

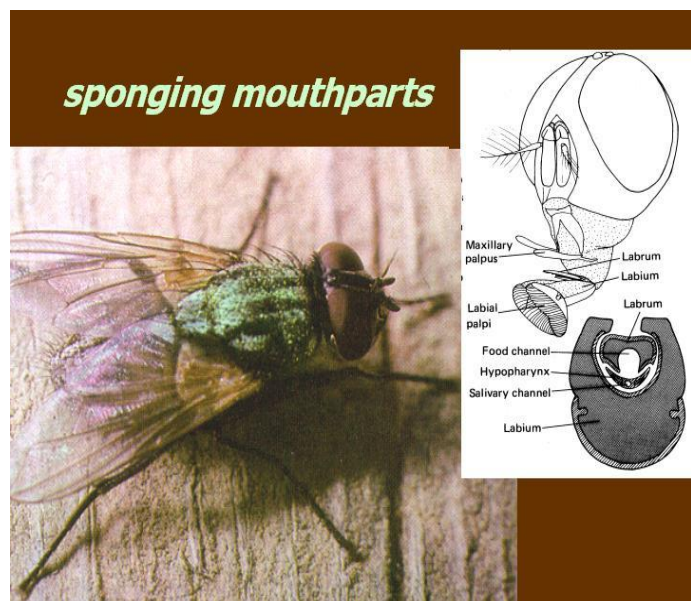
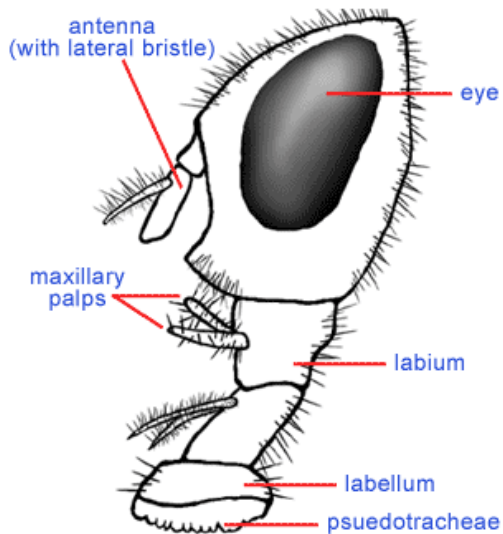
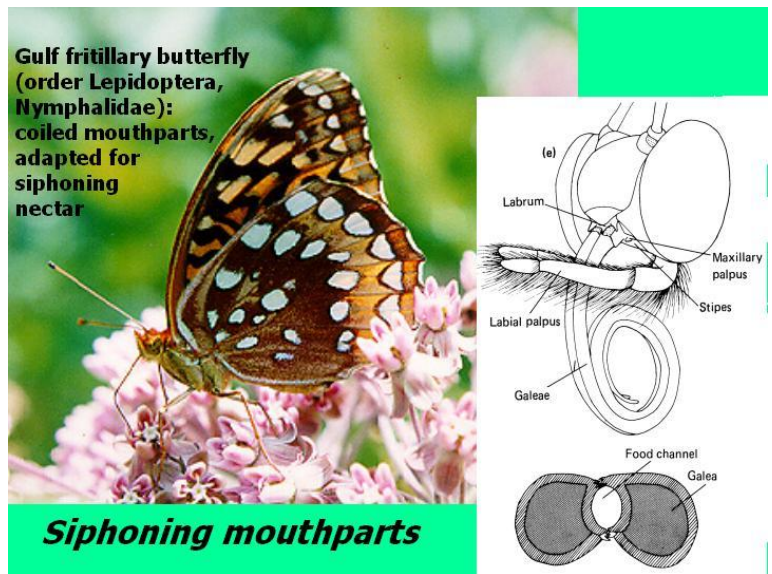
Siphoning mouthparts lack stylets and are used to suck liquids. Examples: Butterflies, moths and skippers (order Lepidoptera), bees (order Hymenoptera). Larval Lepidoptera have chewing mouthparts.



3.

### Sponging mouthparts

Sponging mouthparts are used to sponge and suck liquids. Examples: House flies and blow flies (order Diptera).



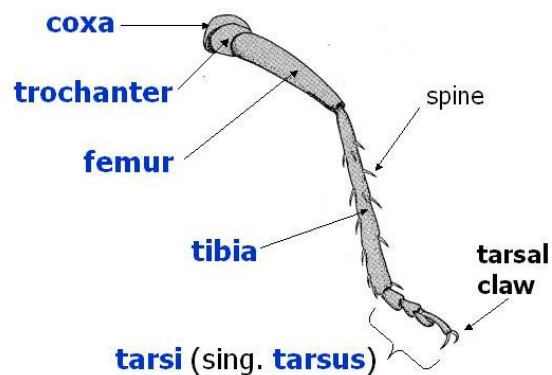
## LEGS AND THEIR MODIFICATION

### 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** (plural coxae), **trochanter**, **femur** (plural femora), **tibia** (plural tibiae), **tarsus** (plural tarsi), **pretarsus**. The femur and tibia may be modified with spines. The tarsus appears to be divided into one to five "pseudosegments" called **tarsomeres**. The term **pretarsus** refers to the terminal segment of the tarsus and any other structures attached to it, including:

- ungues -- a pair of claws
- arolium -- a lobe or adhesive pad between the claws
- empodium -- a large bristle (or lobe) between the claws
- pulvilli -- a pair of adhesive pads

Like the mouthparts and antennae, insect legs are highly modified for different functions, depending on the environment and lifestyle of an insect.



### LEG MODIFICATIONS

- Saltatorial -- jumping
- Raptorial -- seizing
- Fossorial -- digging

- Natatorial -- swimming
- Cursorial – running
- Ambulatory- walking

### 1. Ambulatory legs

Ambulatory legs are used for walking. The structure is similar to cursorial (running) legs.

Examples: Bugs (order Hemiptera), leaf beetles beetles (Corder oleoptera).



### 2. Saltatorial legs

Saltatorial hind legs adapted for jumping. These legs are characterized by an elongated femur and tibia. Examples: Grasshoppers, crickets and katydids (order Orthoptera).





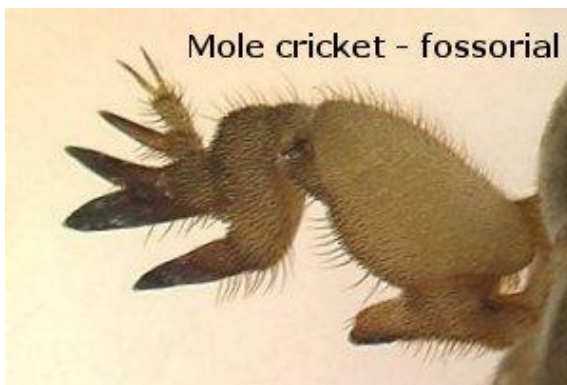
### 3. Raptorial legs

Raptorial fore legs modified for grasping (catching prey). Examples: Mantids (order Mantodea), ambush bugs, giant water bugs and water scorpions (order Hemiptera).



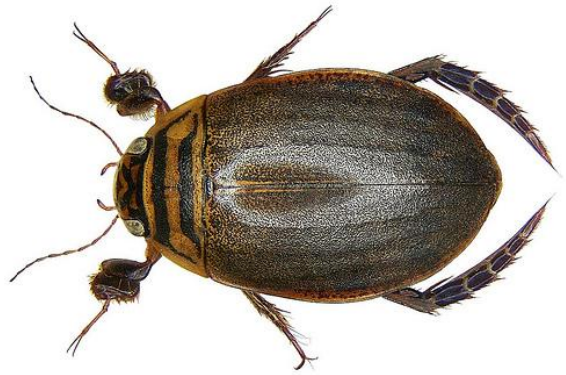
### 4. Fossorial legs

Fossorial fore legs are modified for digging. Examples: Ground dwelling insects; mole crickets (order Orthoptera) and cicada nymphs (order Hemiptera).



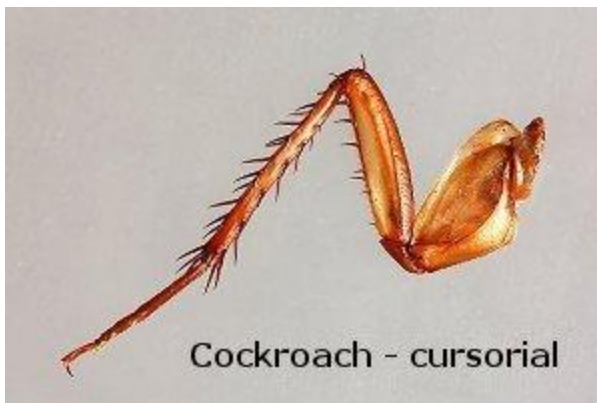
### 5. Natatorial legs

Natorial legs are modified for swimming. These legs have long setae on the tarsi. Examples: Aquatic beetes (order Coleoptera) and bugs (order Hemiptera).



## 6. Cursorial legs

**Cursorial** legs are modified for running. Note the long, thin leg segments. Examples: Cockroaches (order Blattaria), ground and tiger beetles (order Coleoptera).



## WINGS VENATION AND MODIFICATION

### WINGS VENATION

Among the invertebrate animals, only insects possess wings. Wings are present only in adult stage. Number of wings varies from two pairs to none. Certain primitive insects like silver fish and spring tail have no wings (apterous). Ecto parasites like head louse, poultry louse and flea are secondarily wingless. Wings are deciduous in ants and termites. There is only one pair of wings in the true flies. Normally two pairs of wings are present in insects and they are borne on pterothoracic segments viz., mesothorax and metathorax. Wings are moved by thoracic flight muscles attached to their bases.

Wing is flattened double layered expansion of body wall with a dorsal and ventral lamina having the same structure as the integument. Both dorsal and ventral laminae grow, meet and fuse except along certain lines. Thus a series of tracheae, nerves and blood. Wing is nourished by blood circulating through veins. Later the walls of these channels become thickened to form veins or nervures. The arrangement of veins on the wings is called venation which is extensively used in insect classification. The principal longitudinal veins arranged in order from the anterior margin are costa (C) , sub costa ( Sc), radius (R), median (M), cubitus (Cu) and anal veins (A). Small veins often found inter connecting the longitudinal veins are called cross veins. Due to the presence of longitudinal veins and cross veins, the wing surface gets divided into a number of enclosed spaces termed cells. In insects like dragon fly and damselfly, there is an opaque spot near the coastal margin of the wing called pterostigma.

### **Margins and Angles**

The wing is triangular in shape and has therefore three sides and three angles. The anterior margin strengthened by the costa is called costal margin and the lateral margin is called apical margin and the posterior margin is called anal margin. The angle by which the wing is attached to the thorax is called humeral angle. The angle between the costal and apical margins is called apical angle. The angle between apical and anal margins is called anal angle.

### **WING REGIONS**

The anterior area of the wing supported by veins is usually called remigium. The flexible posterior area is termed vannus. The two regions are separated by vannal fold. The proximal part of vannus is called jugum, when well developed is separated by a jugal fold. The area containing wing articulation sclerites, pteralia is called axilla.

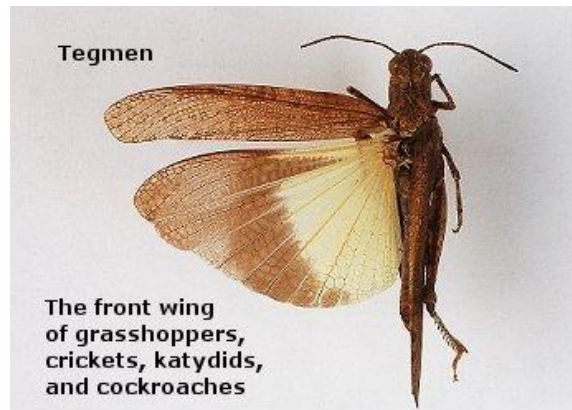
Insects have evolved many variations of the wings, and an individual insect may possess more than one type of wing. Wing venation is a commonly used taxonomic character, especially at the family and species level.

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

## **MODIFICATION**

### **1. TEGMINA**

Tegmina (singular tegmen) are the leathery forewings of insects in the orders Orthoptera, Blattaria, and Mantodea. Like the elytra on beetles and the hemelytra on bugs, the tegmina help protect the delicate hind wings. Examples: Grasshoppers, crickets and katydids (order Orthoptera), Cockroaches (order Blattaria), Mantids (order Mantodea).



### **2. ELYTRA**

**Elytra** (singular elytron)

are the hardened, heavily sclerotized forewings of beetles and are modified to protect the hind wings when at rest.

Examples: All beetles (order Coleoptera).

**Elytra are rigid (sclerotized) front wings.**

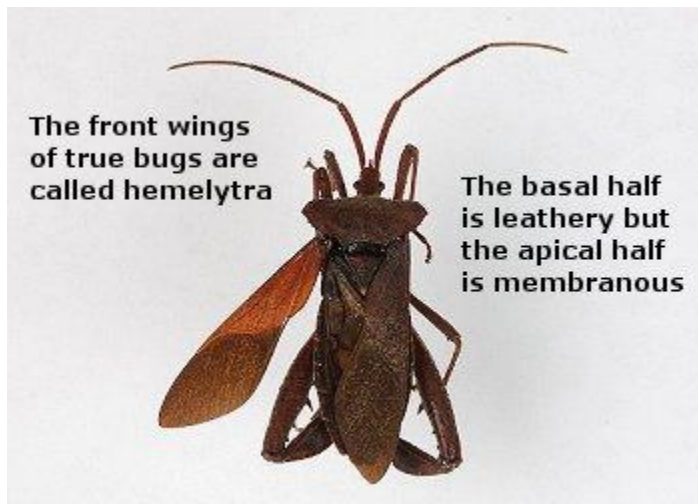


**The elytra of beetles and earwigs cover and protect membranous hind wings.**

### 3. HEMELYTRA

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, while the distal portion is membranous. Unlike elytra, hemelytra function primarily as flight wings.

Examples: Bugs (order Hemiptera).

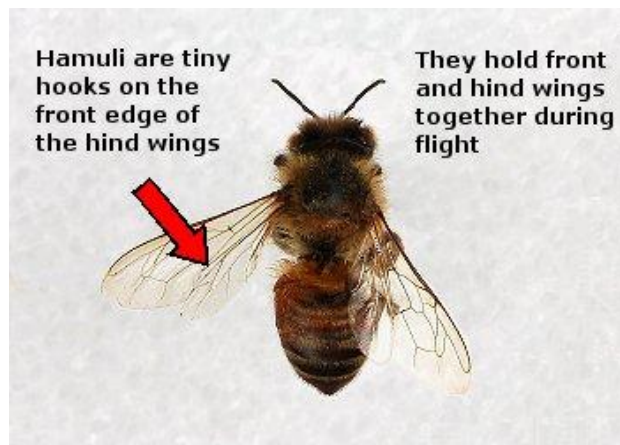


### 4. HALTERES

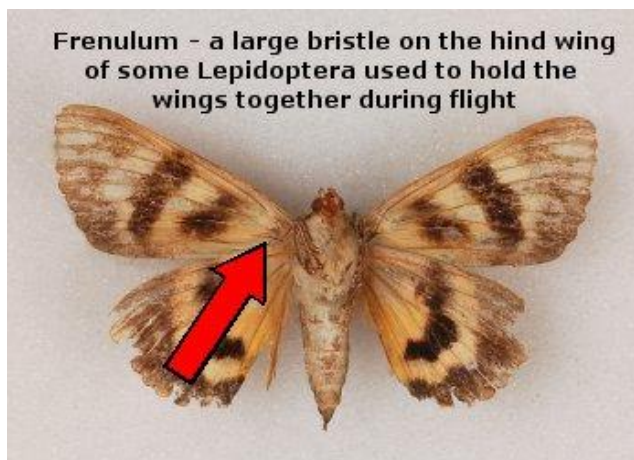
Halteres are an extreme modification among the order Diptera (true flies), in which the hind wings are reduced to mere nubs used for balance and direction during flight. Examples: All flies (order Diptera).



## 5. HAMULI



## 6. FRENULUM



## 7. MEMBRANOUS WINGS

**Membranous wings** are thin and more or less transparent, but some are darkened. Examples: Dragonflies and damselflies (order Odonata), lacewings (order Neuroptera), flies (order Diptera), bees and wasps (order Hymenoptera), termites (order Isoptera). Note the paleopterous wing conditions of the damselflies and dragonfly to the right and below and the neopterous wing conditions of the other insects.



## 8. SCALES

Some insect wings are covered with **scales**. The scales make the wings colorful. Examples: Butterflies, moths and skippers (order Lepidoptera), caddisflies (order Trichoptera).



**WING**

**COUPLING**

Higher

pterygotes have attained virtual dipterism by co ordinate wing movements. Such insects have devices for hooking fore and hind wings together so both the pairs move synchronously. By coupling the wings the insects become functionally two winged.

## TYPES OF WING COUPLING

**1. Hamulate:** A row of small hooks is present on the costal margin of the hindwing which is known as hamuli. These engage the folded posterior edge of fore wing. Eg: Bees.

**2. Amplexiform:** It is the simplest form of wing coupling. A linking structure is absent. Coupling is achieved by broad overlapping of adjacent margins. Eg: Butterflies.

**3. Frenate:** There are two sub types. Eg: Fruit sucking moth.

**(1) Male frenate:** Hindwing bears near the base of the costal margin a stout bristle called frenulum which is normally held by a curved process, retinaculum arising from the subcostal vein found on the under surface of the forewing.

**(2) Female frenate:** Hindwing bears near the base of the costal margin a group of stout bristle (frenulum) which lies beneath extended forewing and engages there in a retinaculum formed by a patch of hairs near cubitus.

**Frenate coupling - female**



**Frenate coupling - male**

