Entomology

- the scientific study of insects
- Insects are an incredibly successful group; about 90% of all species are insects. About 1 million species of insects are described, but the total number of species is estimated to be between 2.5 and 10 million.

Why are insects so successful on earth?

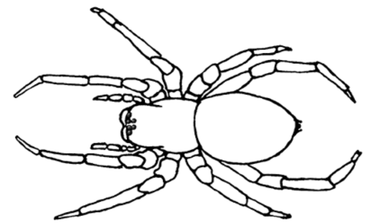
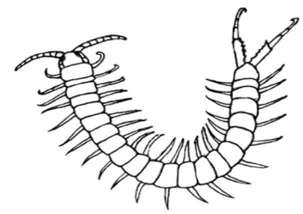
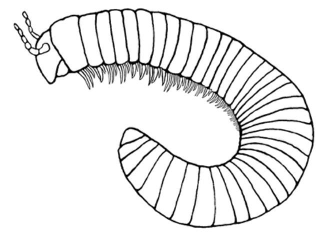
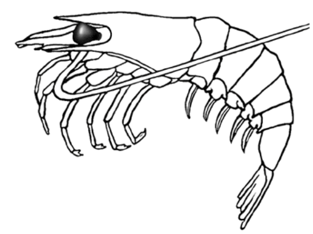
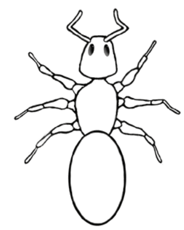
- 1- Small size.
- 2- Ability to adapt.
- 3- Ability to reproduction.
- 4- Different feeding.
- 5- Different living
- 6- Short life cycle
- 7- Covering with exoskeleton
- 8- Ability to fly

Insect Morphology

All arthropods characterize by:

- **Exoskeleton** - a hard protective covering around the outside of the body (divided by sutures into plates called **sclerites**)
- 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, mites, etc. Arachnids possess: • 2 body segments - cephalothorax and abdomen • 8 legs • 1 pair of chelicerae • no antennae	
Class Chilopoda Chilipods possess: • many body segments • 1 pair of legs per body segment • 1 pair of antennae • 1st pair of legs modified into venomous **Centipedes**	
Class Diplopoda Diplopods possess: • Many body segments • 2 pair of legs per body segment • 1 pair of antennae • **Millipedes**	
Class Crustacea (crustaceans): crabs, shrimp, etc. Crustaceans possess: • Several body segments - head, thorax and abdomen or cephalothorax and abdomen • Segments may be fused • Varied number of legs • 2 pairs of antennae	
Class Insecta (Insects); beetles, bugs, wasps, moths, flies, etc.: • 3 body segments • 6 legs • 1 pair of antennae • Diverse modifications to appendages	

The Importance of Insects to Humans, Environment & Agriculture:

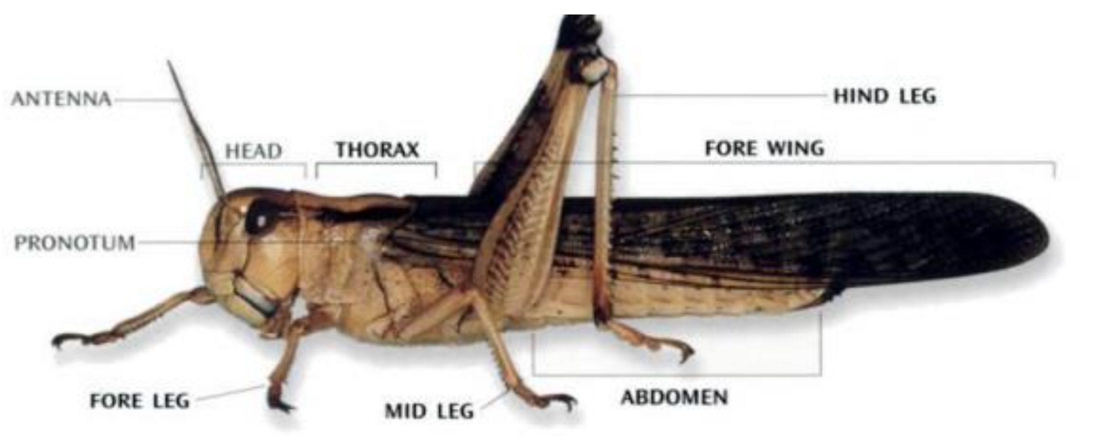
Beneficial Insects	Insect Pests
• Pollination of many flowering plants • Decomposition of organic materials • Recycling of carbon, nitrogen, and other essential nutrients • Control of populations of harmful invertebrates including other insects • Direct production of foods as honey • Manufacture of products as silk	• Damage Crops • Household Pests • Parasites • Biting and Stinging Insects • Prey on domestic animals • Eat human food, clothing & possessions • Destroy trees, wood, paper

Basic Insect Morphology: Head, thorax, abdomen

A look at the outside of an insect:

The **exoskeleton** is comprised of **sclerites**: (hardened plates)

The insect outer skeleton, the **cuticle**, is made up of two layers; the **epicuticle**, which is a thin, waxy, water-resistant outer layer and contains no chitin, and the layer under it called the **procuticle**. This is chitinous and much thicker than the epicuticle and has two layers, the outer is the **exocuticle** while the inner is the **endocuticle**.

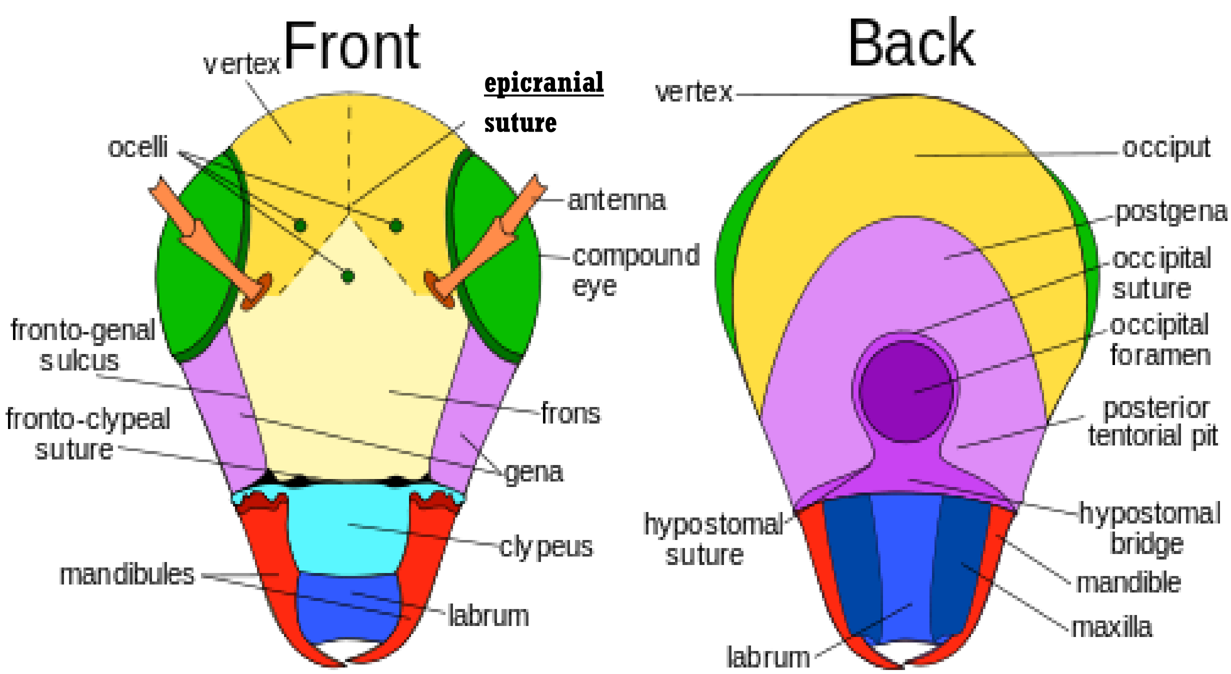


THE HEAD:

The **head** in most insects is enclosed in a hard, heavily sclerotized, exoskeletal head capsule, or **epicranium**.

In most insects, the head capsule is a sturdy compartment that houses the **brain**, a mouth opening, **mouthparts** used for ingestion of food, and major sense organs (including **antennae**, **compound eyes**, and **ocelli**). Embryological evidence suggests that the first six body segments of a primitive worm-like ancestor may have fused to form the head capsule of most present-day insects.

The surface of the head is divided into regions (**sclerites**) by a pattern of shallow grooves (**sutures**). The uppermost sclerite (dorsal surface) of the head capsule is known as the **vertex**. A **coronal suture** usually runs along the midline of the vertex and splits into two **frontal sutures** as it extends downward across the front of the head capsule these sutures involve **epicranial suture**. The triangular sclerite that lies between these frontal sutures is called the **frons**. The **epistomal suture** is a deep groove that separates the base of the frons from the **clypeus**, a rectangular sclerite on the lower front margin of the head capsule.



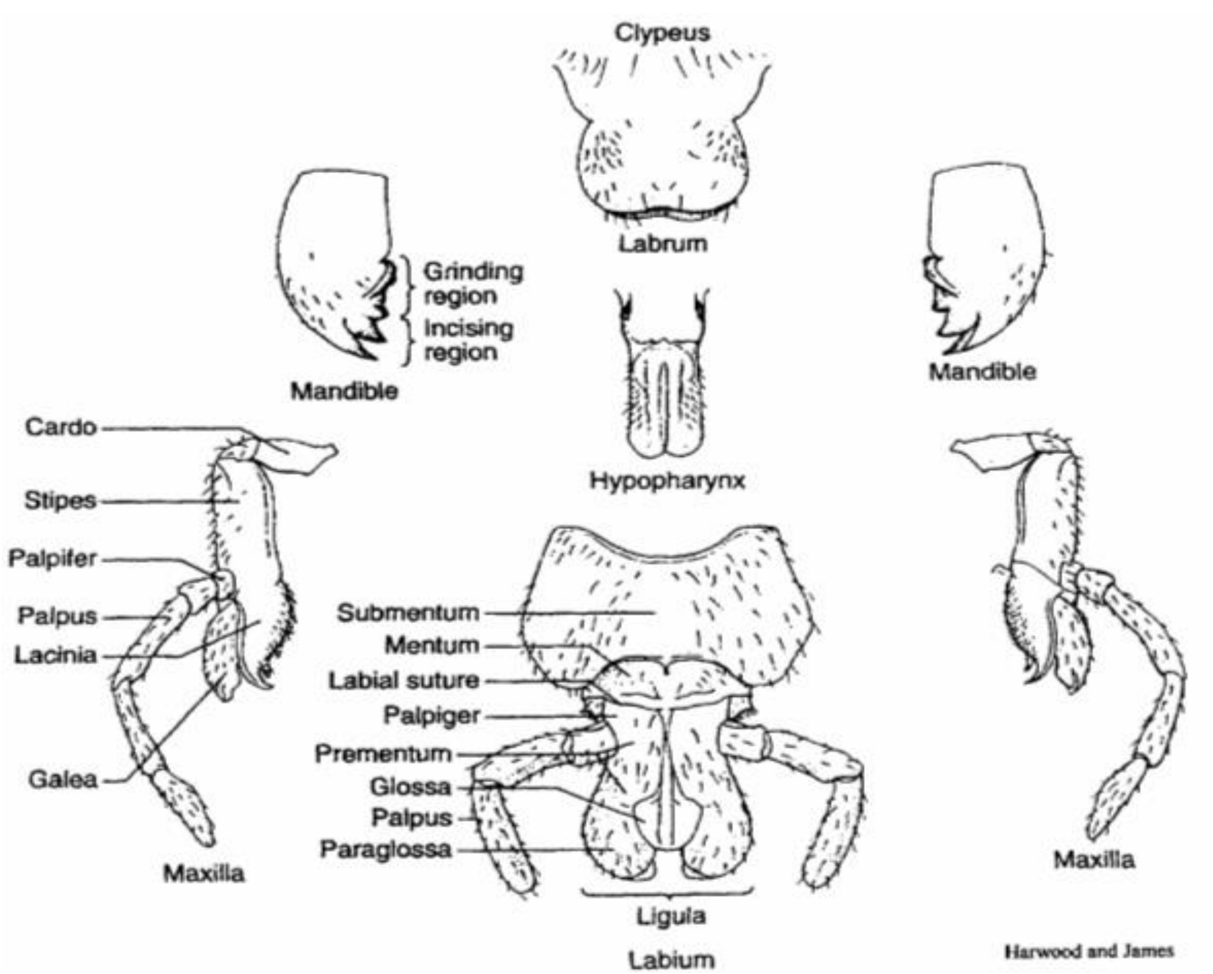
Compound eyes and ocelli:

In most insects there is one pair of large, prominent compound eyes composed of units called **ommatidia**. There may be up to 30,000 **ommatidia** in a compound eye. This type of eye gives less resolution than the vertebrate eye, but it gives acute perception of movement. When present, ocelli (either 2 or 3), detect low light or small changes in light intensity.

Mouthparts:

The 5 main mouthparts are the **(labrum, mandibles, maxillae (plural maxilla), labium and hypopharynx).** 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**.



1- **Mandibulate** (chewing) mouthparts and (Chewing- Lapping mouthparts)
2- **Haustellate** mouthparts can be further classified as piercing-sucking, sponging, and siphoning.

Mandibulate (chewing) mouthparts are used for biting and grinding solid foods. Two types: (Chewing mouthparts)

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**)

And (Chewing- Lapping mouthparts)

Examples: The mouthparts of honeybees (Family **Apidae**)

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.

1- 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.

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 is 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.

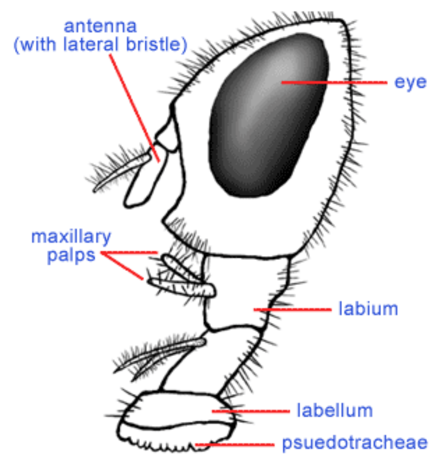
Piercing-sucking mouthparts are used to penetrate solid tissue and then suck up liquid food.

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

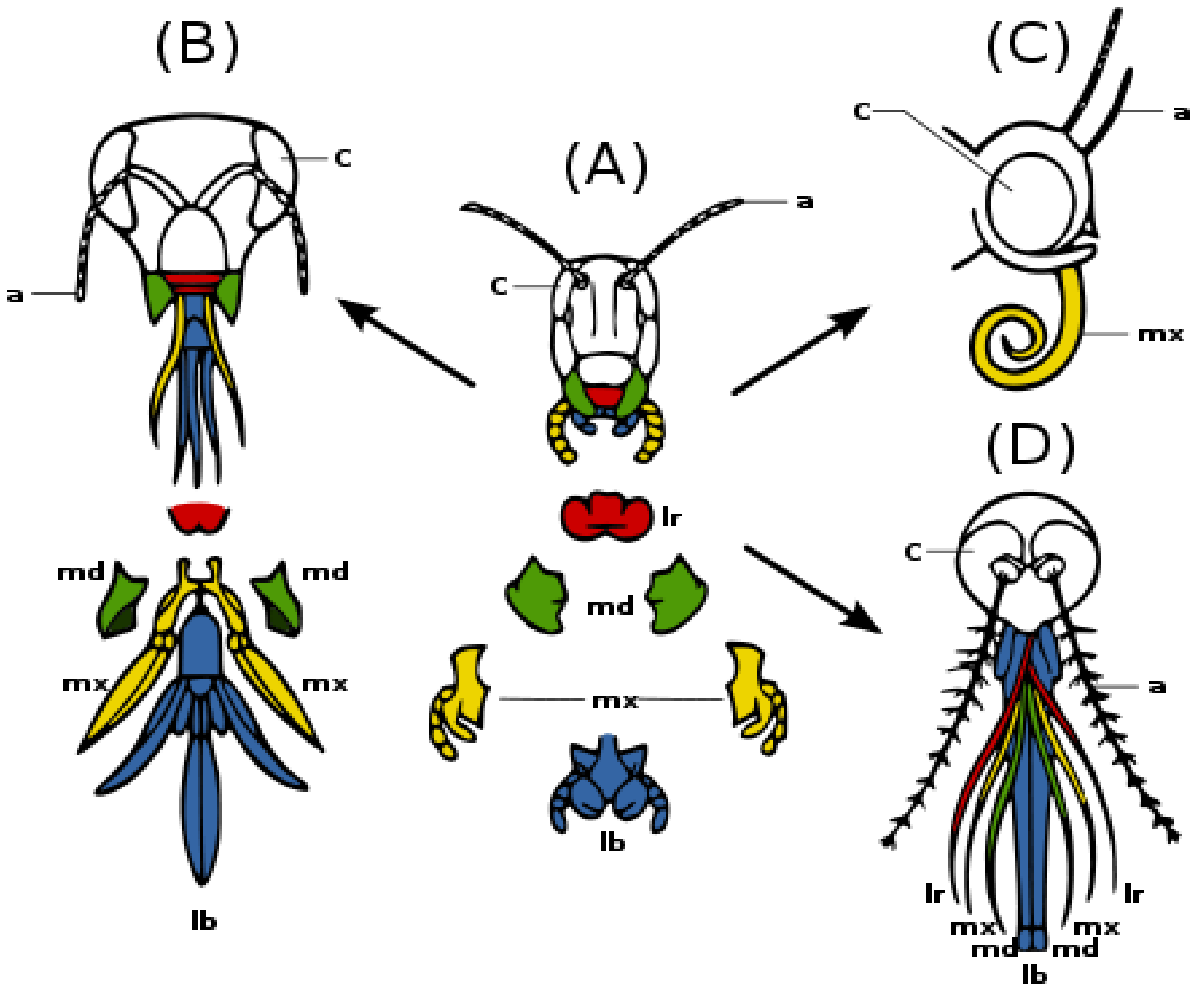
2- None Stylets

Siphoning mouthparts lack stylets and are used to suck liquids.

Examples: Butterflies, moths and skippers (order **Lepidoptera**)

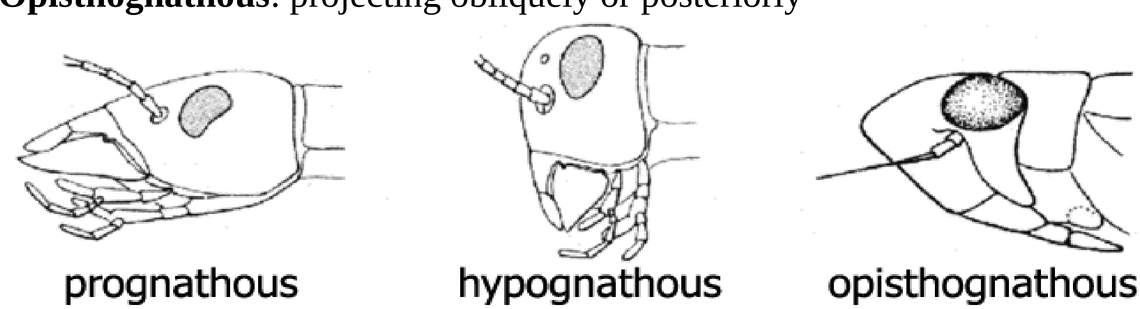


Sponging mouthparts are used to sponge and suck liquid.
Examples: House flies and blow flies (order **Diptera**).



The development of insect mouthparts from the primitive chewing mouthparts of a grasshopper in the center (A), to the chewing-lapping type (B) of a bee, the siphoning type (C) of a butterfly and the piercing-sucking type (D) of a female mosquito.
a – antennae **c** - compound eye **lb** – labium **lr** – labrum **md** – mandibles **mx** - maxillae

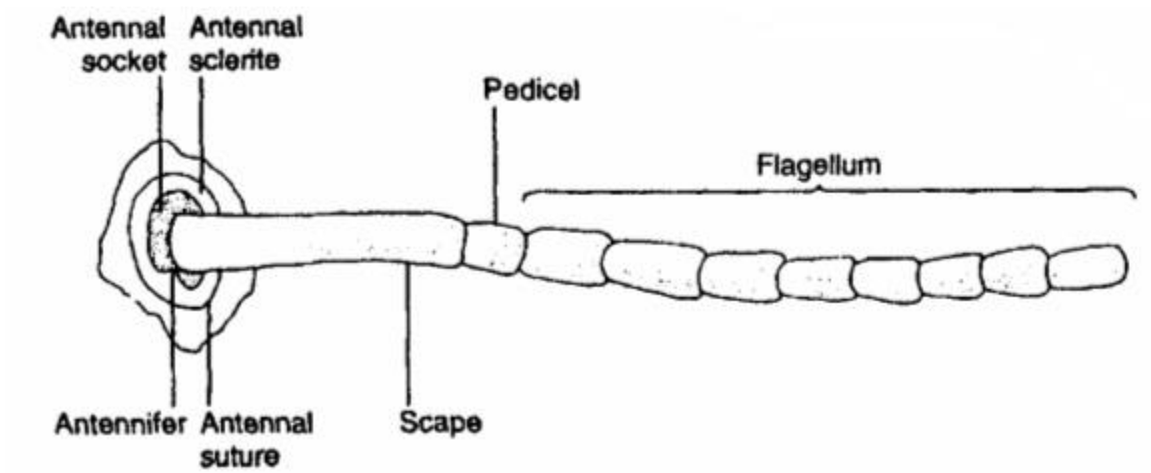
The orientation of the mouthparts on the head may differ, and they may be described as:
Prognathous: projecting forward (horizontal)
Hypognathous: projecting downward
Opisthognathous: projecting obliquely or posteriorly



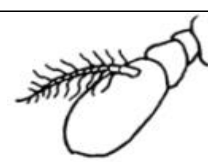
Antennae

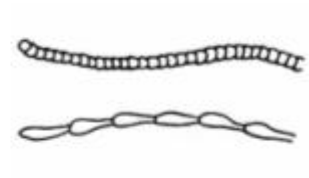
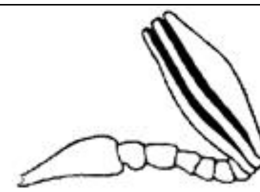
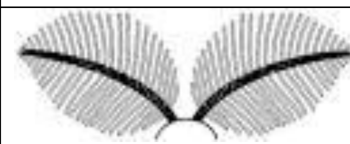
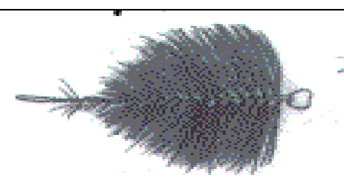
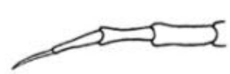
The **antennae** are a pair of sense organs located near the front of an insect's head capsule. The antennae are much more than just tactile receptors. They are usually covered with olfactory receptors that can detect odor molecules in the air (the sense of smell). Many insects also use their antennae as humidity sensors, to detect changes in the concentration of water vapor. Mosquitoes detect sounds with their antennae, and many flies use theirs to measure air speed while they are in flight. Although antennae vary widely in shape and function, all of them can be divided into three basic parts

1. **scape** -- the basal segment that articulates with the head capsule
2. **pedicel** -- the second antennal segment
3. **flagellum** -- all the remaining "segments" (individually called **flagellomeres**)



Types of Antennae:

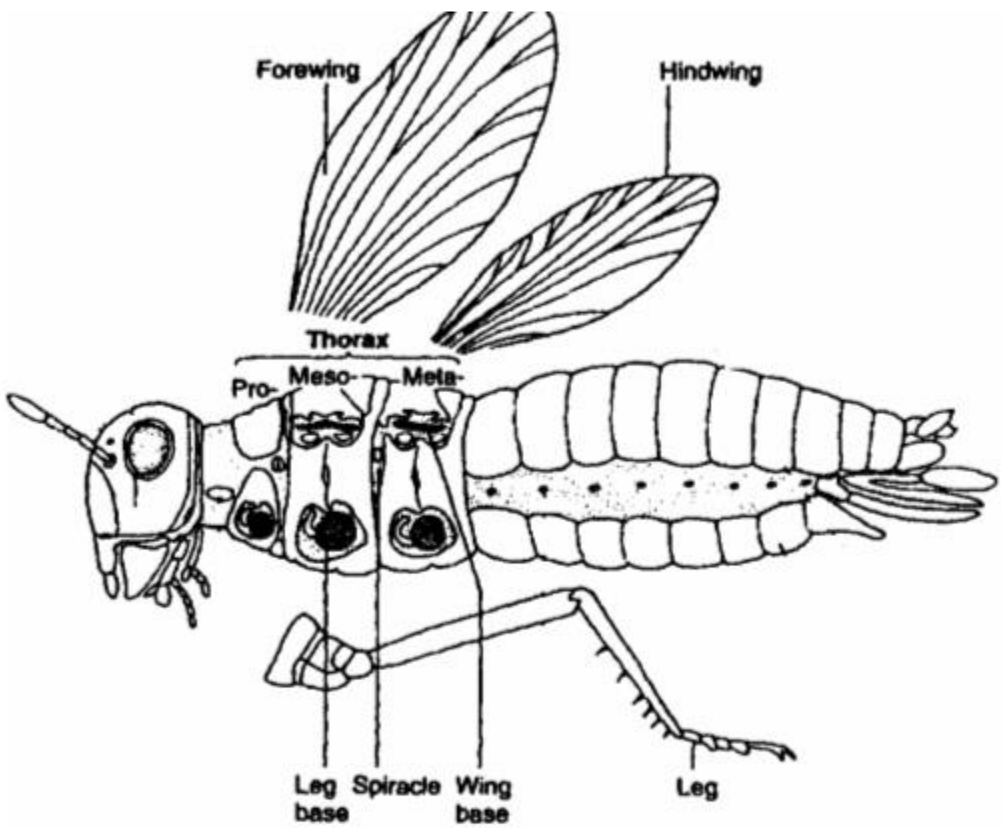
Aristate antennae are pouch-like with a lateral bristle. Examples: House and shore flies (order Diptera).	
Capitate antennae are abruptly clubbed at the end. Examples: Carrion beetles (order Coleoptera). Adult carrion beetles.	
Clavate antennae are gradually clubbed at the end. Examples: Butterflies (order Lepidoptera).	

Filiform antennae have a thread-like shape. Examples: Ground and long-horned beetles (order Coleoptera).	
Geniculate antennae are hinged or bent like an elbow. Examples: Bees and ants (order Hymenoptera).	
Lamellate or clubbed antennae end in nested plates. Examples: Scarab beetles (order Coleoptera).	
Moniliform have a beadlike shape. Examples: Termites (order Isoptera).	
Pectinate antennae have a comb-like shape. Examples: fireflies beetles (order Coleoptera).	
Bipectinated : having two margins toothed like a comb —used especially of the antennae of certain moth (Family Lymantriidae)	
Plumose antennae have a feather-like shape. Examples: mosquitoes (order Diptera).	
Serrate antennae have a saw-toothed shape. Examples: Click beetles(order Coleoptera).	
Setaceous antennae have a bristle-like shape. Examples: Dragonflies and damselflies (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. the notum (pronotum, mesonotum, and metanotum) which may be further subdivided into an anterior alinotum (which divided to prescutum, scutum and scutellum) and a posterior postnotum. The ventral sclerite of each segment is the sternum (prosternum, mesosternum, and metasternum).The side of each segment is called the pleuron -- it is usually divided by a pleural suture into at least two **sclerites**:; an anterior **episternum** and a posterior **epimeron**.

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



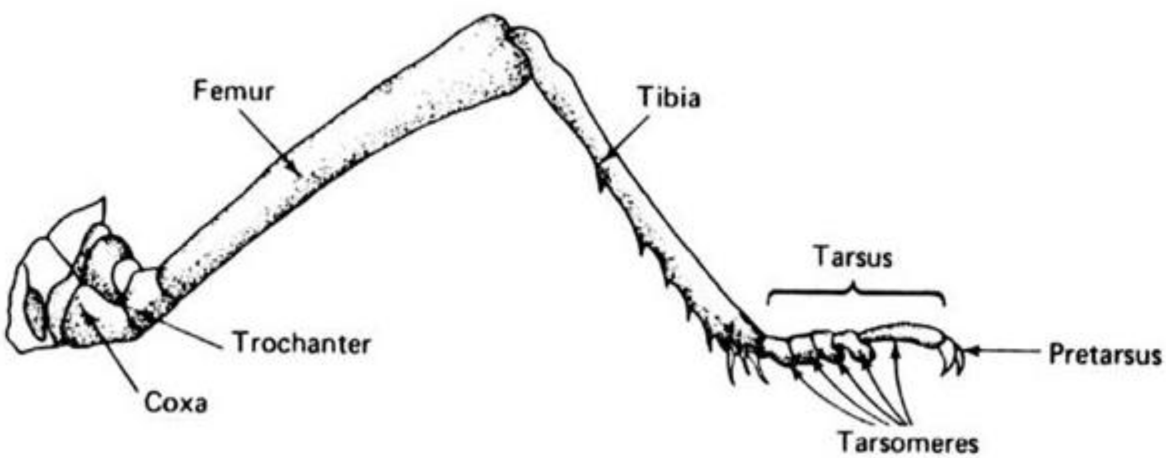
Legs

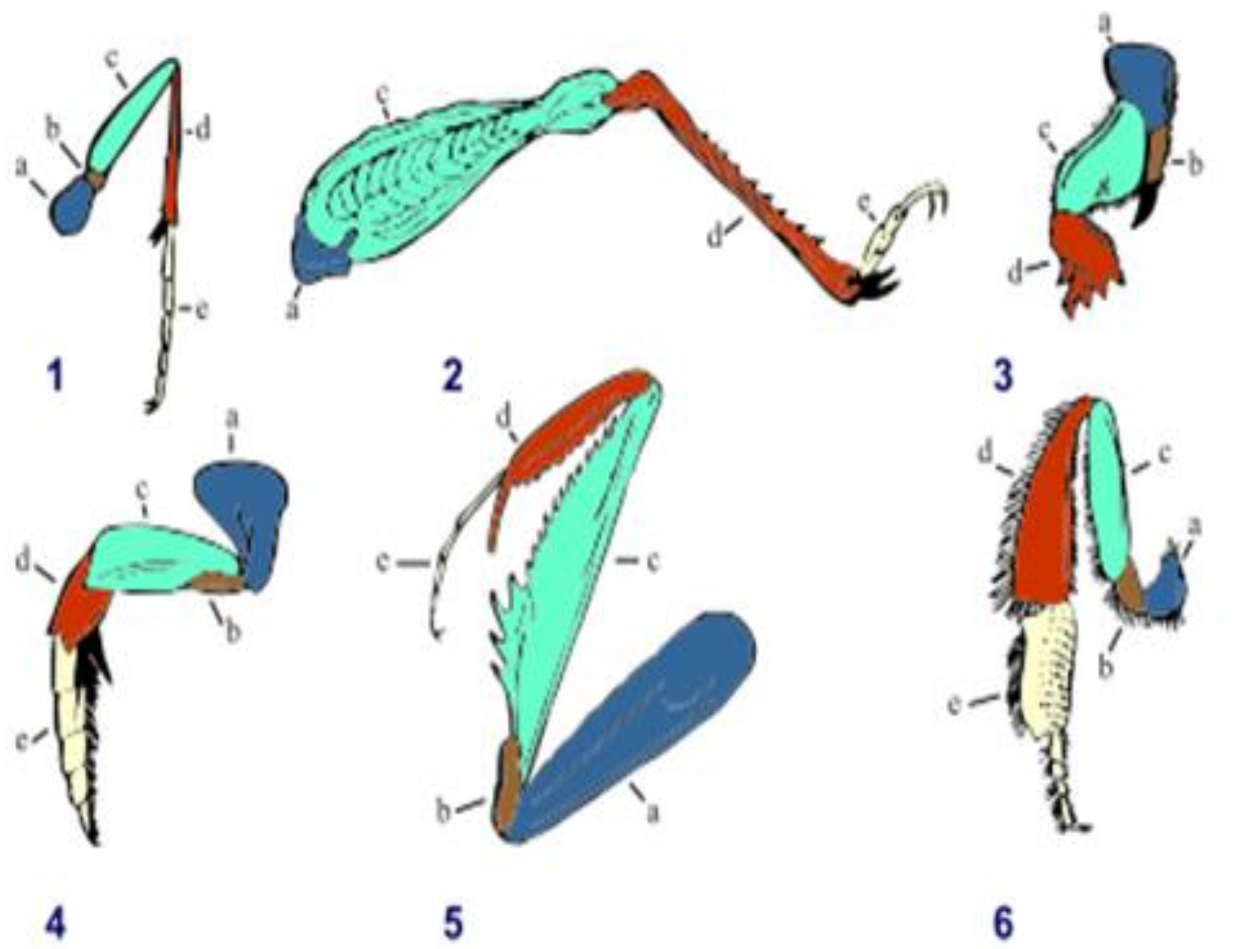
Most insects have three pairs of walking legs -- one pair on each thoracic segment. Each leg contains five structural components (segments) that articulate with one another by means of hinge joints:

1.Coxa **2.Trochanter** **3.Femur** **4.Tibia** **5.Tarsus**

The term **pretarsus** refers to the terminal segment of the tarsus and any other structures attached to it, including:

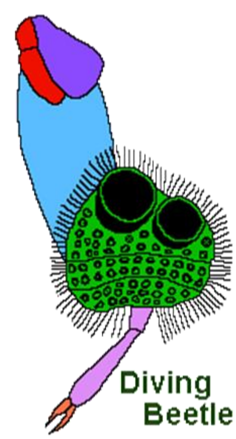
ungues -- a pair of claws
arolium -- a lobe or adhesive pad between the claws
empodium -- a large bristle (or lobe) between the claws
pulvilli -- a pair of adhesive pads





part of leg: a. coxa, b. trochanter, c. femur, d. tibia, e. tarsus

1. **Running** (or walking)(**Cursorial):** legs are modified for running(ground beetle)
2. **Jumping** (**Saltatorial**) : hind legs adapted for jumping (locust)
3. **Digging** (**Fossorial**): fore legs are modified for digging (mole cricket)
4. **Swimming** (**Natorial**): legs are modified for swimming (diving beetle) (Family Dytiscidae)
5. **Grasping** (**Raptorial**): fore legs modified for grasping. Catching prey (Mantidae))
6. **Collecting**: Leg (hind legs of worker honeybee).
7. **Cleaning:** first leg of worker honeybee).
8. **Clinging** (**Scansorial**) legs are claw-like and modified for climbing (**Lice**)
9. **Mating** legs Fore leg of the male great diving beetle (Family **Dytiscidae**)

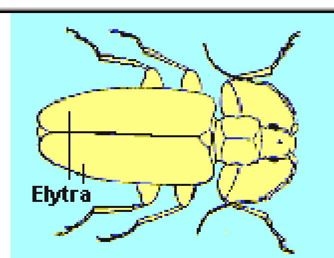
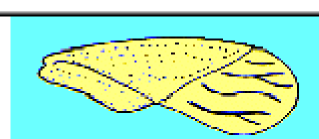


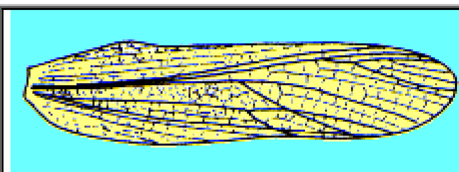
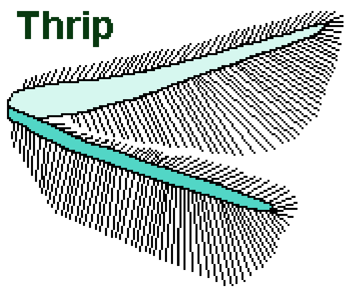
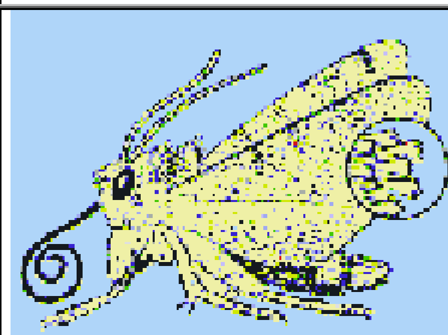
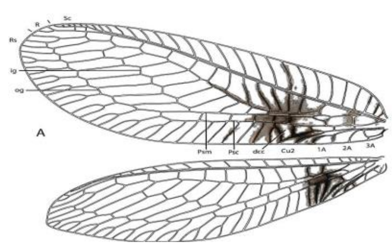
Wings

Insects are the only invertebrates that can fly. Their wings develop as evaginations of the exoskeleton during morphogenesis but they become fully functional only during the adult stage of an insect's life cycle. The wings may be membranous, leathery, heavily sclerotized, fringed with long hairs, or covered with scales. Most insects have two pairs of wings -- one pair on the mesothorax and one pair on the metathorax (never on the prothorax). Wings serve not only as

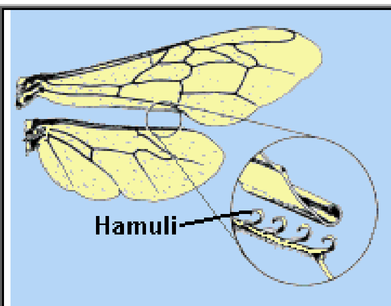
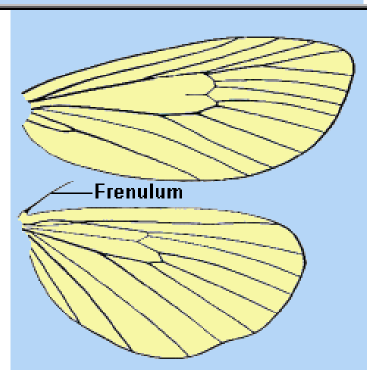
1- organs of flight, but also may be adapted variously as:
2- protective covers (Coleoptera and Dermaptera),
3- thermal collectors (Lepidoptera),
4- gyroscopic stabilizers (Diptera),
5- sound producers (Orthoptera),
In most cases, a characteristic network of veins runs throughout the wing tissue. These veins are extensions of the body's circulatory system. They are filled with hemolymph and contain a tracheal tube and a nerve. In membranous wings, the veins provide strength and support during flight. Wing shape, texture, and venation are quite distinctive among the insect taxa and therefore highly useful as aides for identification.

Wing adaptations and modifications:

Characteristic	Appearance	Order(s)
membranous: are characterized by having thin, unscleritized (meaning not leathery or hard) membranes between the veins of the wings		**House flies; Mosquitoes (Order: Diptera**
Elytra -- hard, sclerotized front wings that serve as protective covers for membranous hind wings		**Coleoptera**
Hemelytra -- front wings that are leathery or parchment-like at the base and membranous near the tip		**Hemiptera**

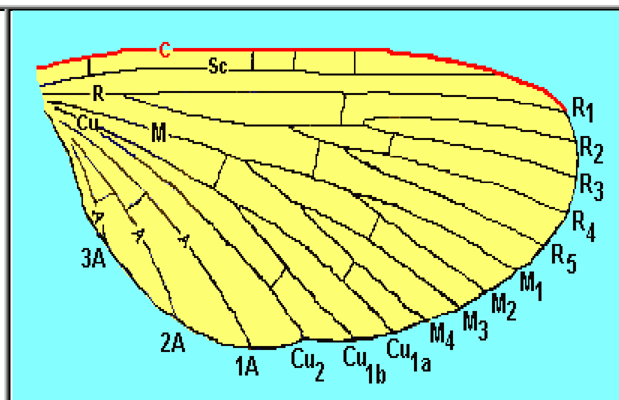
Tegmina -- front wings that are completely leathery in texture		**Orthoptera, Blattodea,** and **Mantodea**
Halteres -- small, club-like hind wings that serve as gyroscopic stabilizers during flight		**Diptera**
Hairy wings -- slender front and hind wings with long fringes of hair		**Thysanoptera**
Scaly wings -- front and hind wings covered with flattened setae (scales)		**Lepidoptera**
Lance-wings: characterized by a wide coastal field in their wing venation, which includes the cross-veins.		**Neuroptera** **F. Chrysopidae**

Coupling mechanism in insects wings

Hamuli -- tiny hooks on hind wing that hold front and hind wings together		**Hymenoptera**
Frenulum -- Bristle near base of hind wing that holds front and hind wings together		**Lepidoptera**

Wing Venation:

The **archedictyon** is the name given to a hypothetical scheme of wing venation proposed for the very first winged insect. These veins (and their branches) are named according to a system devised by John Comstock and George Needham -- the Comstock-Needham System:

Costa (C) -- the leading edge of the wing Subcosta (Sc) -- second longitudinal vein (behind the costa), typically unbranched Radius (R) -- third longitudinal vein, one to five branches reach the wing margin Media (M) -- fourth longitudinal vein, one to four branches reach the wing margin Cubitus (Cu) -- fifth longitudinal vein, one to three branches reach the wing margin Anal veins (A1, A2, A3) -- unbranched veins behind the cubitus	

Names of cross veins are based on their position relative to longitudinal veins:

c-sc cross veins run between the costa and subcosta
r cross veins run between adjacent branches of the radius
r-m cross veins run between the radius and media
m-cu cross veins run between the media and cubitus

Insect Abdomen:

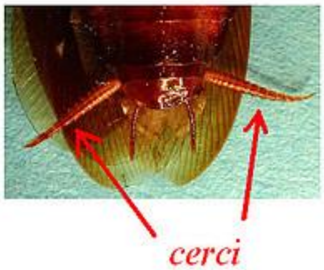
Insect abdomen is the third functional region of insect body. It is located behind the thorax and contains 6-10 segments. There are various types of appendages arise from the abdomen. The abdomen subdivided into:

- **pregenital segments**: which include the first seven segments in female or first eight segments in male and be free from appendages in the adult phase
- **Genital segments**: Include the ninth segment in male and carrying genital appendages. In females, paired appendages of the eighth and ninth abdominal segment fit together to form an egg-laying mechanism called the ovipositor
- **Postgenital segments**: Include the tenth and eleventh segment. carrying the two appendages anal cerci.

Appendages found on the abdomen.

1- Cerci

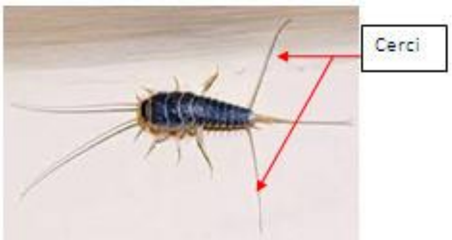
Located close to anus.



Order: Orthoptera: simple and not jointed cerci

Order: Dermaptera: Sclerotized, forceps like cerci (**Pincers).**

Order: Thysanura: Long filamentous cerci



2- Styles:

Can be seen in Cockroach, It is regarded as the vestige of the walking limb.

3- Median caudal filament:

This is a thread like projection arising from center of the last abdominal segment between the cerci.

4- Abdominal Prolegs:

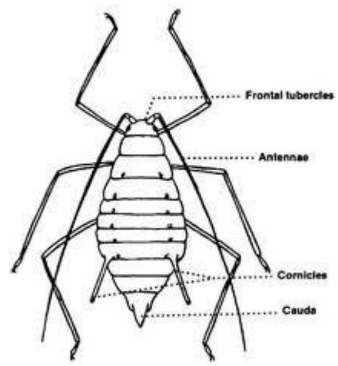
Can be seen in Lepidopera.

5- Abdominal Gills:

These are respiratory organs and found in naiad of some aquatic insects.

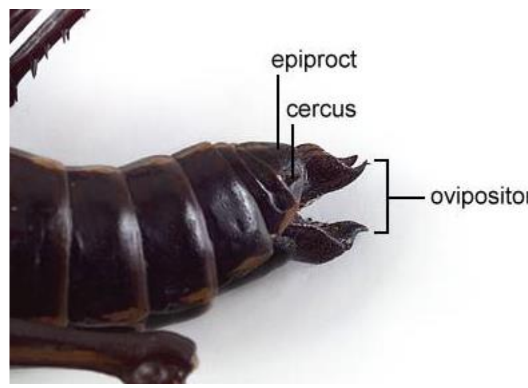
6- Cornicles:

These are located dorsally on the abdomen as paired secretory structures.



7- Female External Genitalia:

Ovipositors are used for oviposition and it is formed by the modification of 8-9 abdominal segments. E.x. Orders: Orthoptera, Thysanoptera and some Hymenoptera insects contain true ovipositors.



The ovipositor is modified sometime as a poison injecting sting (Wasps, bees..etc)

8- Male External genitalia:

Modification of 9th abdominal segment makes the copulatory organ of males which is consist of aedeagus and pair of lateral claspers to grasp and hold the abdomen of the female during mating.