Insect Structure and Classification

INSECT HEAD

Insects and other arthropods are built up on a segmental plan and their characteristic feature is a hard, jointed exoskeleton. The cuticle, which forms the exoskeleton, is continuous over the whole of the outside of the body and consists of a series of hard plates, the **sclerites**, joined to each other by flexible membranes which are also cuticular. Sometimes the sclerites are articulated together so as to give precise movement of one on the next. Each segment of the body primitively has a dorsal sclerite, the tergum, joined to a ventral sclerite, the sternum, by lateral membranous areas, the pleura. Arising from the sternopleural region on each side is a jointed appendage.

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

Head. First anterior tagma formed by the fusion of six segments namely preantennary, antennary, and intercalary, mandibular, maxillary and labial segments, the last three segments are often called the **gnathal segments** because their appendages form the mouthparts of the insect.

Orientation:

The orientation of the head with respect to the rest of the body varies (Fig. 1.1). The hypognathous condition, with the mouthparts in a continuous series with the legs, is probably primitive. This orientation occurs most commonly in phytophagous species living in open habitats. In the prognathous condition the mouthparts point forwards and this is found in predaceous species that actively pursue their prey, and in larvae, particularly of Coleoptera, which use their mandibles in burrowing. In Hemiptera, the elongate proboscis slopes backwards between the forelegs. This is the opisthorhynchous condition. The mouthparts enclose a cavity, the pre-oral cavity, with the mouth at its inner end (Fig. 1.2).

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**.

The head capsule (cranium) is formed by the union of number of sclerites or cuticular plates which are joined together by means of cuticular lines or ridges known as **sutures**. These sutures provide mechanical support to the cranial wall. In an adult insect that preserves the hypognathous condition of the head, the head capsule is formed by the union of the following **sclerites** (Fig.1.3):

1. Epicraniun is the upper part of the head extending from vertex to occipital suture.
2. Occiput is an inverted "U" shaped structure representing the area between the epicranium and post occiput.
3. Post occiput it is the extreme posterior part of the insect head that remains before the neck region.

4- Vertex is the apex or dorsal region of the head between the compound eyes for insects with a hypognathous or opisthognathous head. The vertex is the area in which ocelli are usually located.
5- Frons is that part of the head immediately ventrad of the vertex. In most insects the frons is limited ventrally by the frontoclypeal suture (epistomal suture), a transverse suture located below the antennal sockets. As its name implies, the suture separates the dorsal frons from the ventral clypeus.
6- Clypeus is a sclerite between the face and labrum, dorsally the clypeus is separated from the face or frons by the frontoclypeal suture in primitive insects, laterally, the clypeogenal suture demarcates the clypeus, and ventrally the clypeus is separated from the labrum by the clypeolabral suture.
7- Labrum is small sclerite that forms the upper lip of the mouth cavity; it is freely attached or suspended from the lower margin of the clypeus.
8- Gena is the area extending from below the compound eyes to just above the mandibles.
9- Occular sclerites are cuticular ring like structures present around each compound. A pair of compound eyes is located on the lateral or dorsolateral walls of the cranium,and usually three ocelli occur between them on the facial or dorsal area,two of the ocelli are symmetrically placed laterad of the midline, the third is median and ventral or anterior to the others.
10- Antennal sclerites form the basis for the antennae and present around the scape.

The common **sutures** present in head are:

1- Epicranial suture: It is an inverted 'Y' shaped suture distributed above the facial region extending up to the epicranial part of the head. It consists of two arms called frontal suture occupying the frons and stem called as coronal suture. This epicranial suture is also known as line of weakness or ecdysial suture because the exuvial membrane splits along this suture during the process of ecdysis.
2- Occipital suture: It is 'U' shaped or horseshoe shaped suture between epicranium and occiput.
3- Post occipital suture: This suture lies on the extreme posterior part of the cranium where it closely surrounds the foramen magnum dorsally and laterally (The posterior surface of the head is occupied by the opening from the head into the neck; usually a large aperture termed the occipital foramen). It is the only real suture in insect head. Posterior end of the head is marked by the post occipital suture to which the sclerites are attached. As this suture separates the head from the neck, hence named as real suture.
4- Clypeolabral suture: It is the suture present between clypeus and labrum.
5- Clypeofrontal suture or epistomal suture: The suture present between clypeus and frons
6- Genal suture: It is the sutures present on the lateral side of the head i.e. gena
7- Occular suture: It is circular suture present around each compound eye.
8- Antennal suture: It is a marginal depressed ring around the antennal socket.

The part of the pre-oral cavity enclosed by the proximal part of the hypo pharynx and the clypeus is known as the cibarium. Between the hypopharynx and the labium is a smaller cavity known as the salivarium, into which the salivary duct opens

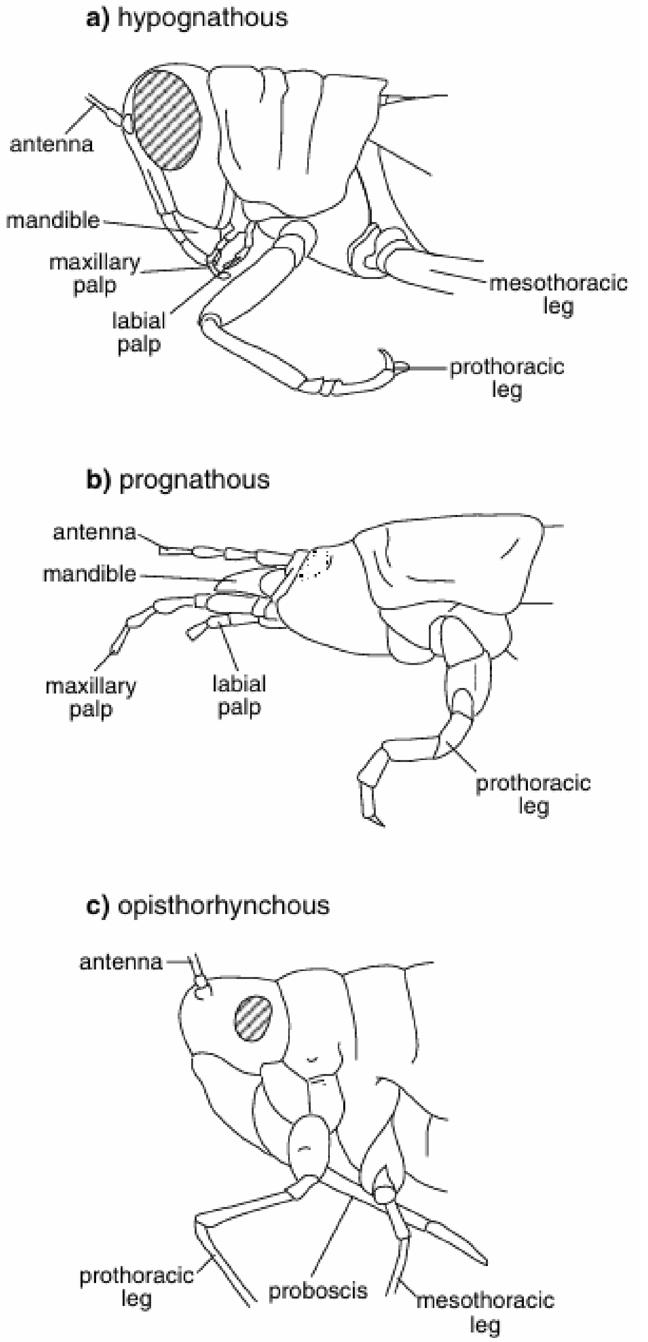


Fig. 1.1. Orientation of the head. **(a)** Hypognathous – mouthparts ventral, in a continuous series with the legs (grasshopper). **(b)** Prognathous – mouthparts in an anterior position (beetle larva). **(c)** Opisthorhynchous – sucking mouthparts with the proboscis extending back between the front legs (aphid).

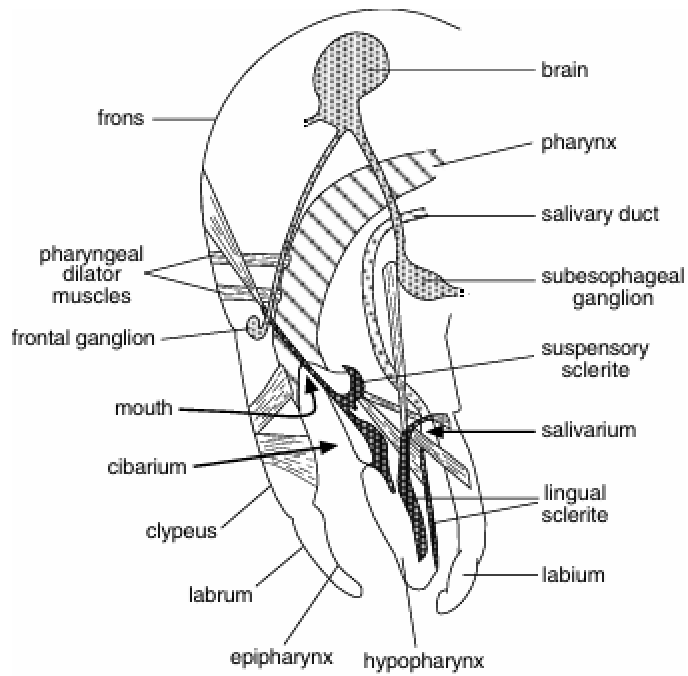


Fig. 1.2. Pre-oral cavity and some musculature. Diagrammatic vertical section through the head of an insect with biting and chewing mouthparts. Sclerites associated with the hypopharynx are black with white spots. Muscles attached to these sclerites move the hypopharynx (after Snodgrass, 1947).

Rigidity: The head is a continuously sclerotized capsule with no outward appearance of segmentation, but it is marked by a number of grooves. Most of these grooves are sulci (singu lar: sulcus), marking lines along which the cuticle is inflected to give increased rigidity. The term suture should be retained for grooves marking the line of fusion of two formerly distinct plates. The groove which ends between the points of attachment of maxillae and labium at the back of the head is generally believed to represent the line of fusion of the maxillary and labial segments and it is therefore known as the postoccipital suture. Since the sulci are functional mechanical developments to resist the various strains imposed on the head capsule, they are variable in position in different species and any one of them may be completely absent. However, the needs for strengthening the head wall are similar in the majority of insects, so some of the sulci are fairly constant in occur rence and position (Fig. 1.3). The most constant is the epistomal (frontoclypeal) sulcus, which acts as a brace between the anterior mandibular articulations. At each end of this sulcus is a pit, the anterior tentorial pit, which marks the position of a deep invagination to form the anterior arm of the **tentorium**. The lateral margins of the head above the mandibular articulations are strengthened by a horizontal inflexion indicated externally by the **subgenal sulcus**. This sulcus is generally a continuation of the **epistomal sulcus** to the postoccipital suture. The part of the subgenal sulcus above the mandible is called the **pleurostomal sulcus**, the part behind the mandible is the **hypo stomal sulcus**. Another commonly occurring groove is the circumocular sulcus, which strengthens the rim of the eye and may develop into a deep flange protecting the inner side of the eye. Sometimes this sulcus is connected to the subgenal sulcus by a vertical **subocular sulcus**; the inflexions associated with these sulci act as a brace against the pull of the muscles associated with feeding. The circum antennal ridge, marked by a sulcus externally, strengthens the head at the point of insertion of the antenna, while running across the back of the head, behind the compound eyes, is the **occipital sulcus**. The areas of the head defined by the sulci are given names for descriptive purposes, but they do not represent primitive sclerites.

Since the sulci are variable in position, so too are the areas which they delimit. The front of the head, the **frontoclypeal area**, is divided by the epistomal sulcus into the frons above and the clypeus below (Fig. 1.3).

It is common to regard the arms of the ecdysial cleavage line as delimiting the frons dorsally, but this is not necessarily so.

From the frons, muscles run to the pharynx, the labrum and the hypopharynx; from the clypeus arise the dilators of the cibarium. The two groups of muscles are always separated by the frontal ganglion and its connectives to the brain (Fig. 1.2). Dorsally the frons continues into the vertex and posteriorly this is separated from the occiput by the **occipital sulcus**. The occiput is divided from the post occiput behind it by the **postoccipital suture**, while at the back of the head, where it joins the neck, is an opening, the occipital foramen, through which the alimentary canal, nerve cord and some muscles pass into the thorax. The lateral area of the head beneath the eyes is called the gena, from which the subgena is cut off below by the **subgenal sulcus**, and the postgena behind by the occipital sulcus. The region of the subgena above the mandible is called the **pleurostoma** and that part behind the mandible is the **hypostoma.** In hypognathous insects with a thick neck, the posterior ventral part of the head capsule is membranous. The postmentum of the labium is contiguous with this membrane, articulating with the subgena on either side. The hypostomal sulci bend upwards posteriorly and are continuous with the postoccipital suture (Fig.

1.4a). In insects with a narrow neck, permitting greater mobility of the head, and in prognathous insects, the cuticle of the head below the occipital foramen is sclerotized. This region has different origins. In Diptera, the hypostomata of the two sides meet in the midline below the occipital foramen to form a hypostomal bridge which is continuous with the postocciput (Fig. 1.4b). In other cases, Hymenoptera and the water bugs Notonecta and Naucoris, a similar bridge is formed by the postgenae, but the bridge is separated from the postocciput by the postoccipital suture (Fig. 1.4c). Where the head is held in the prog nathous position, the lower ends of the postocciput fuse and extend forwards to form a median ventral plate, the gula (Fig. 1.4d), which may be a continuous sclerotization with the labium. Often the gula is reduced to a narrow strip by enlargement of the postgenae and sometimes the post genae meet in the midline, so that the gula is obliterated. The median ventral suture which is thus formed at the point of contact of the postgenae is called the gular suture.

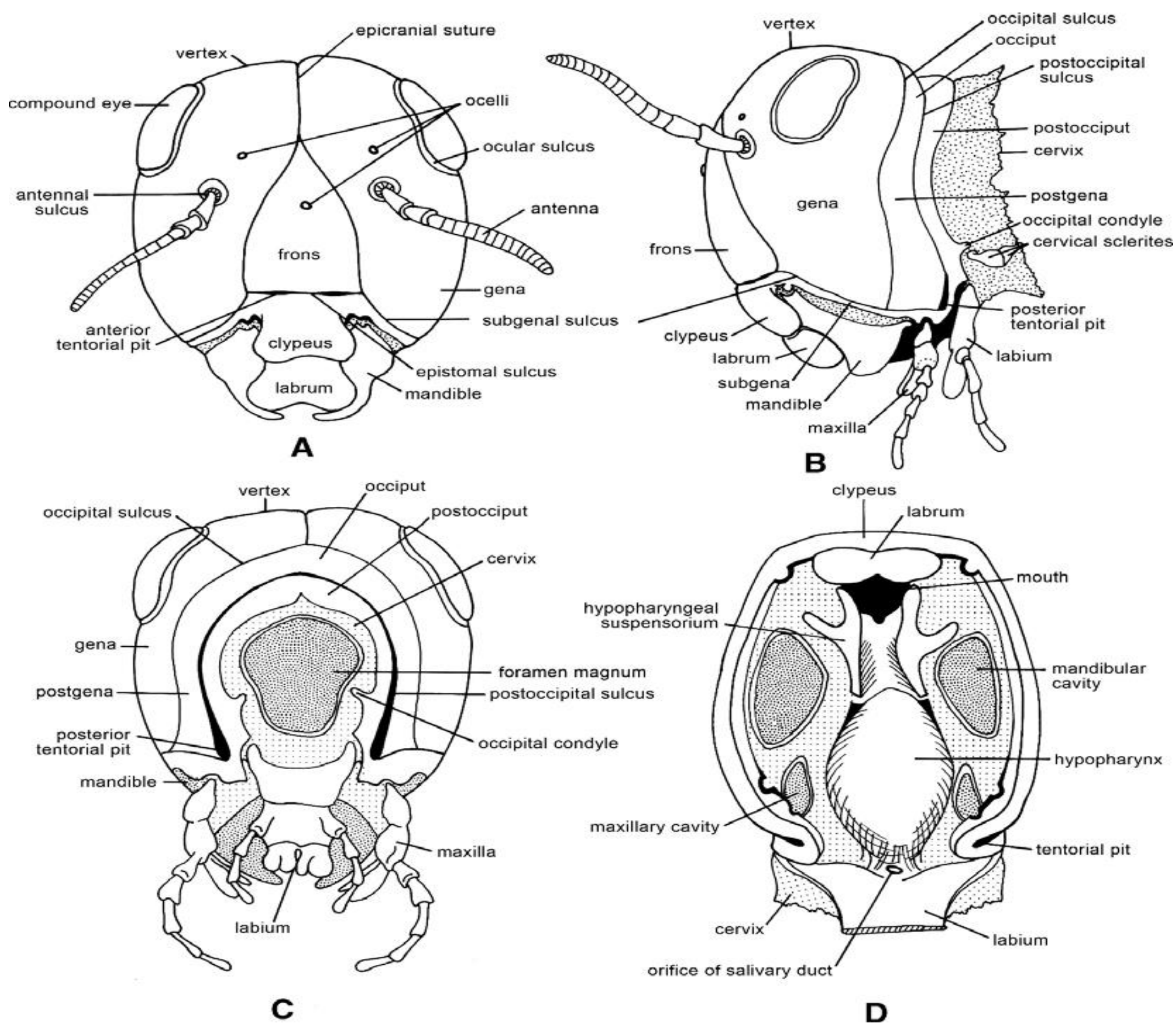
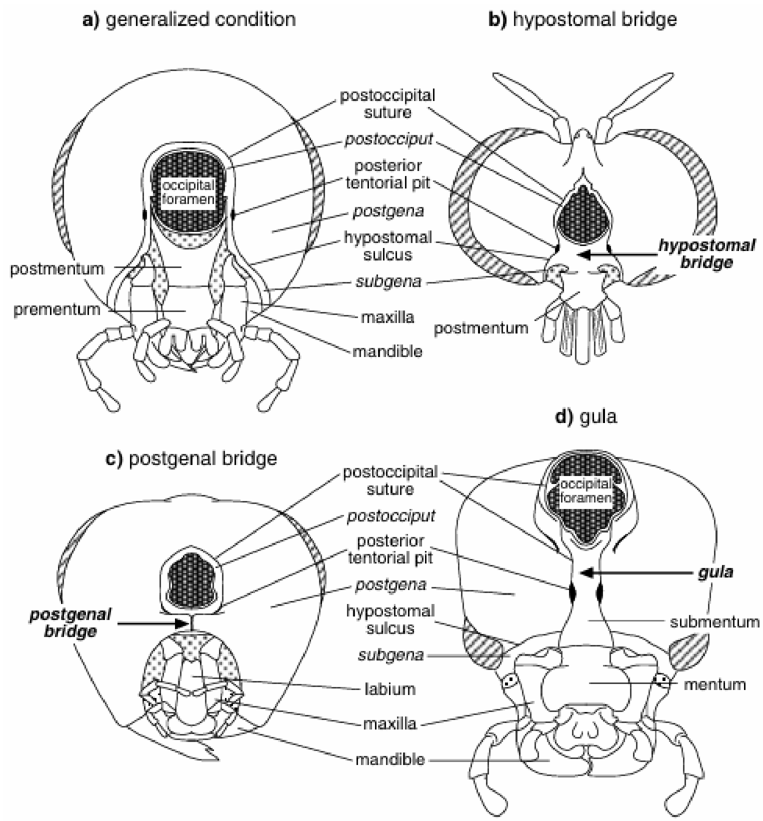


Fig.1.3. Structure of the typical pterygotan head.(A) Anterior; (B) lateral; (C) posterior; and (D) ventral View.

Fig. 1.4. Sclerotization at the back of the head. Notice the position of the bridge below the occipital foramen with reference to the posterior tentorial pit. Membranous areas stippled, compound eyes cross-hatched. The names of areas defined by sulci are italicized (after Snodgrass, 1960). (a) Generalized condition, no ventral sclerotization; (b) hypostomal bridge (*Deromyia*, Diptera); (c) postgenal bridge (*Vespula*, Hymenoptera); (d) gular bridge formed from the postoccipital sclerites (*Epicauta*, Coleoptera).



In all insects, the rigidity of the head is increased by four deep cuticular invaginations, known as **Apodemes**, which usually meet internally to form a brace for the head and for the attachment of muscles. The structure formed by these invaginations is called **the Tentorium** (Fig. 1.5). Its two anterior arms arise from the anterior tentorial pits and two posterior arms arise from pits at the end of postoccipital suture and they unit to form abridge known as the tentorial bridge. The **tentorium** strengthens the head for chewing, provides attachment points for muscles, and also supports and protects brain and foregut.

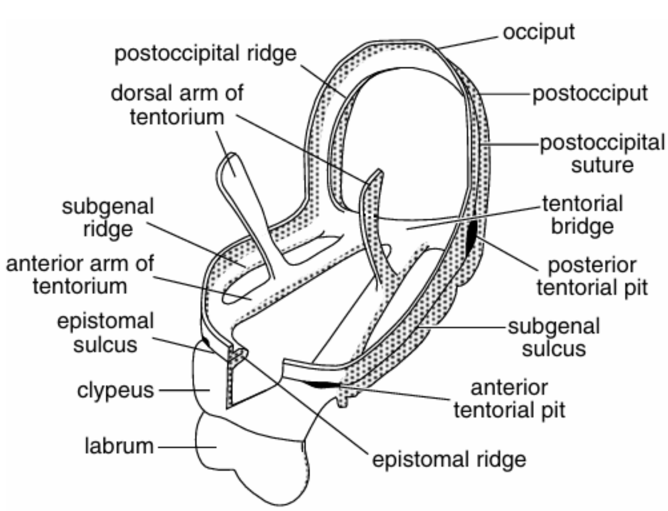


Fig. 1.5. Tentorium. Cutaway of the head capsule to show the tentorium and its relationship with the grooves and ridges of the head (after Snodgrass, 1935).

Molting: Immature insects nearly always have a line along the dorsal midline of the head dividing into two lines on the face so as to form an **inverted Y** (Fig. 1.3). There is no groove or ridge along this line, and it is simply a line of weakness, continuous with that on the thorax, along which the cuticle splits when the insect molts. It is therefore called the **ecdysial cleavage line**, but has commonly been termed the **epicranial suture**. The anterior arms of this line are very variable in their development and position and, in Apterygota, they are reduced or absent. The ecdysial cleavage line may persist in the adult insect and sometimes the cranium is inflected along this line to form a true sulcus. Other ecdysial lines may be present on the ventral surface of the head of larval insects.

NECK The neck or cervix is a membranous region which gives freedom of movement to the head. It extends from the post occiput at the back of the head to the prothorax, and possibly represents the posterior part of the labial segment together with the anterior part of the prothoracic segment.

ANTENNAE

Antennae All insects possess a pair of antennae, but they may be greatly reduced, especially in larval forms. Amongst the non-insectan Hexapoda, Collembola and Diplura have antennae, but Protura do not.

Antennal structure: The antenna consists of a basal scape, a pedicel and a flagellum. The scape is inserted into a membranous region of the head wall and pivoted on a single marginal point, the antennifer (Fig. 1.8a), so it is free to move in all directions. Frequently the flagellum is divided into a number of similar annuli joined to each other by membranes so that the flagellum as a whole is flexible. The term segmented should be avoided with reference to the flagellum of insects since the annuli are not regarded as equivalent to leg segments. The antennae of insects are moved by levator and depressor muscles arising on the anterior tentorial arms and inserted into the scape, and by flexor and extensor muscles arising in the scape and inserted into the pedicel (Fig. 1.7a). There are no muscles in the flagellum, and the nerve which traverses the flagellum is purely sensory. This is the **annulated type** of antenna. In Collembola and Diplura the mus culature at the base of the antenna is similar to that in insects, but, in addition, there is an intrinsic musculature in each unit of the flagellum (Fig. 1.7b), and, consequently, these units are regarded as true segments. The number of annuli is very variable between species. Adult Odonata, for example, have five or fewer annuli while adult Periplaneta have over 150, increasing from about 48 in the first stage larva. The form of the antenna varies considerably depending on its precise function (Fig. 1.8). Sometimes the modification produces an increase in surface area allowing a large number of sensilla to be accommodated on the antenna (Fig. 1.9) and, in the case of the plumose antennae of some male moths, enabling them to sample a large volume of air. Sexual dimorphism in the antennae is common, those of the male often being more complex than those of the female. This often occurs where the male is attracted to or recognizes the female by her scent. Conversely, in chalcids scent plays an important part in host-finding by the female and in this case the female's antennae are more specialized than the male's. The antennae of larval hemimetabolous insects are similar to those of the adult, but with fewer annuli. The number increases at each molt (see Fig. 15.10). In Periplaneta, for example, there are only 48 annuli in the first stage larva compared with over 150 in the adult. The antennae of larval holometabolous insects are usually considerably different from those of the adult. The larval antennae of Neuroptera and Megaloptera have a number of annuli, but in larval Coleoptera and Lepidoptera the antennae are reduced to three simple segments. In some larval Diptera and Hymenoptera the antennae are very small and may be no more than swellings of the head wall.

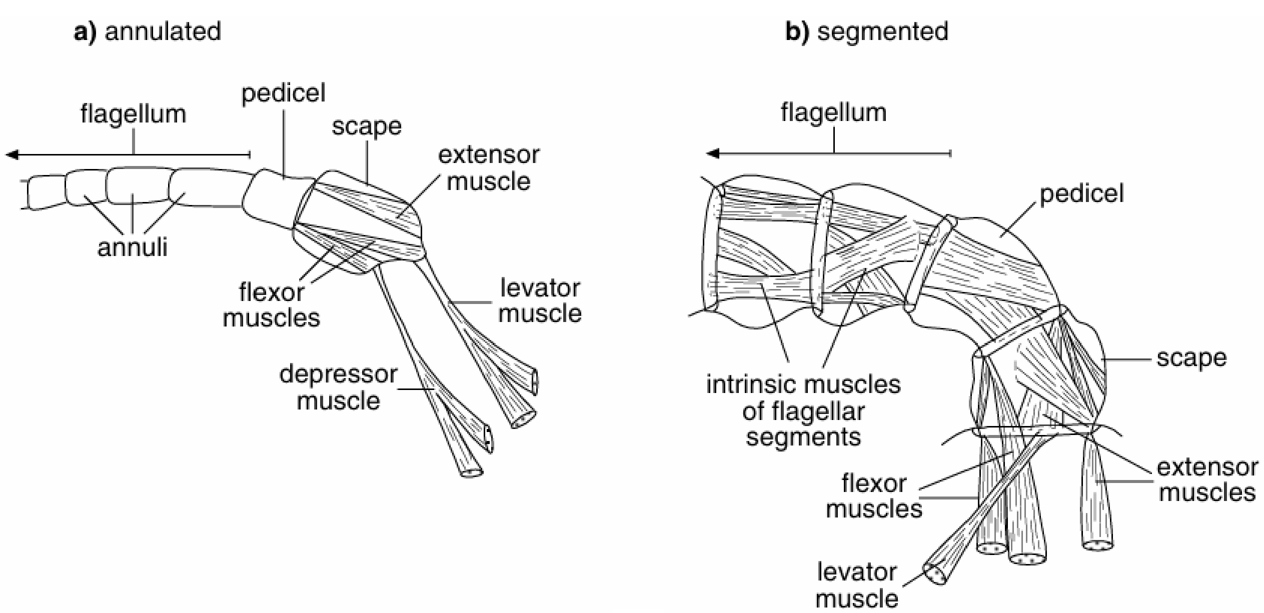


Fig. 1.7. Antenna. Proximal region showing the musculature. **(a)** Typical insect annulated antenna. There are no muscles in the flagellum (*Locusta*, Orthoptera). **(b)** Segmented antenna of a non-insect hexapod (*Japyx*, Diplura) (after Imms, 1940).

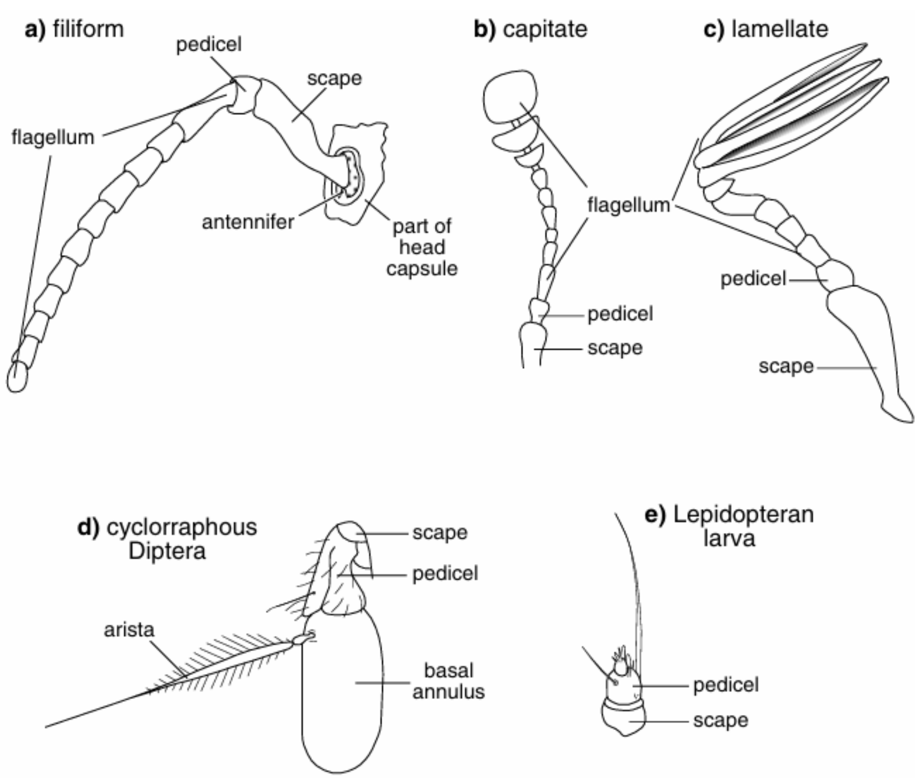


Fig. 1.8. Antennae. Different forms occurring in different insects. Not all to same scale.

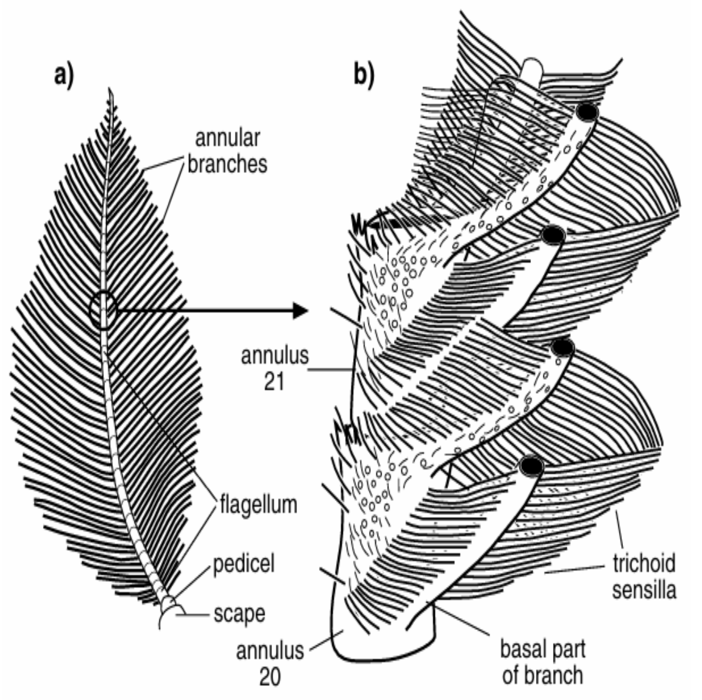


Fig. 1.9. Antenna. Plumose form providing space for large numbers of sensilla (male of the moth *Telea polyphemus*) (after Boeckh, Kaissling & Schneider, 1960). **(a)** The whole antenna seen from above. Two slender branches arise on opposite sides of each annulus. **(b)** Detail of two annuli from the side showing the bases of the branches and arrangement of long trichoid olfactory sensilla along the branches.

Functions of antennae:

The antennae function primarily as sense organs and they are the primary olfactory receptors of all insects. They also have a tactile function by virtue of the large number of mechanosensitive sensilla that are often present.

Very long antennae, such as occur in the cockroach, are possibly associated with their use as feelers. Johnston's organ is important in the regulation of airspeed in flying insects and in some insects, male mosquitoes, female Drosophila and worker honeybees, for example, it is concerned in the perception of near-field sounds. Sometimes the antennae have other functions.

The adult water beetle Hydrophilus submerges with a film of air over its ventral surface which it renews at intervals when it comes to the surface. At the water surface the body is inclined to one side and a funnel of air, connecting the ventral air bubble to the outside air, appears between the head, the pro thorax and the distal annuli of the antenna, which is held along the side of the head. The four terminal annuli of the antenna are enlarged and are clothed with hydrofuge hairs which facilitate the formation of the air funnel.

In the newly hatched larva of Hydrophilus the antennae assist the mandibles in masticating the prey. This is facilitated by a number of sharp spines on the inside of the antennae.

In fleas and Collembola the antennae are used in mating. Male fleas use the antennae to clasp the female from below and the inner surfaces bear large numbers of adhesive discs. These discs, about 5 m in diameter, are set on stalks above the general surface of the cuticle and within each one there is a gland, presumably secreting an adhesive material. Species with sessile or semi-sessile females lack these organs). In many Collembola the males have prehensile antennae with which they hold on to the antennae of the female and, in Sminthurides aquaticus, the male may be carried about by the female, holding on to her antennae, for several days.

INSECT MOUTHPARTS

The mouthparts are the organs concerned with feeding, comprising the unpaired labrum in front, a median hypo pharynx behind the mouth, a pair of mandibles and maxillae laterally, and a labium forming the lower lip. In Collembola, Diplura and Protura the mouthparts lie in a cavity of the head produced by the genae, which extend ventrally as oral folds and meet in the ventral midline below the mouthparts (Fig. 2.1). This is the **entognathous condition**. In the Insecta the mouthparts are not enclosed in this way, but are external to the head, the **ectognathous condition.**

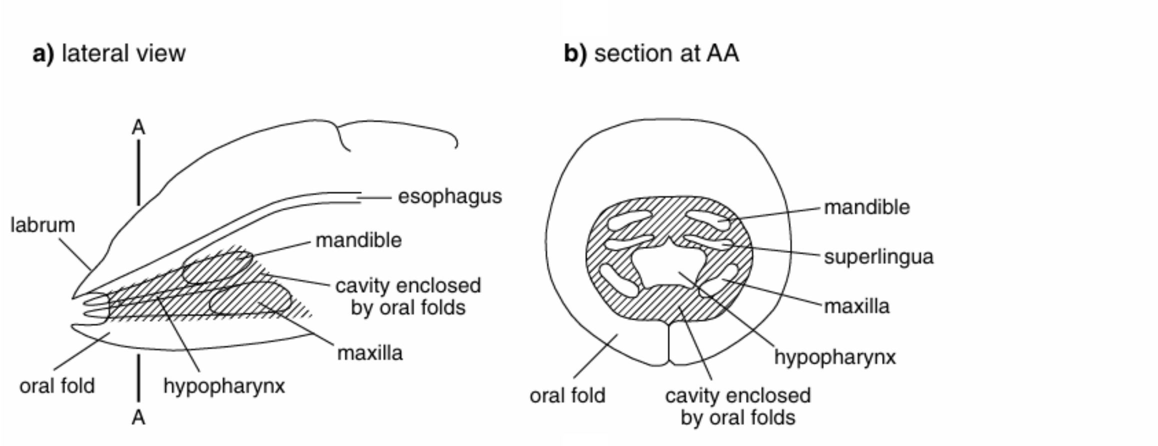


Fig. 2.1. Entognathous mouthparts (modified after Denis, 1949). **(a)** Lateral view showing the mouthparts within the cavity formed by the oral folds. The extent of the cavity is indicated by hatching. **(b)** Transverse section at AA in **(a)**.

Ectognathous mouthparts: The form of the mouthparts is related to diet, but two basic types can be recognized: one adapted for biting and chewing solid food, and the other adapted for sucking up fluids.These are the organs primarily concerned with the uptake of food. Typical mouthpart of an insect consists of the following parts. (1) Labrum (upper lip) (2) A pair of mandibles (3) A pair of maxillae (4) Labium (lower lip) (5) Hypopharynx (tongue).

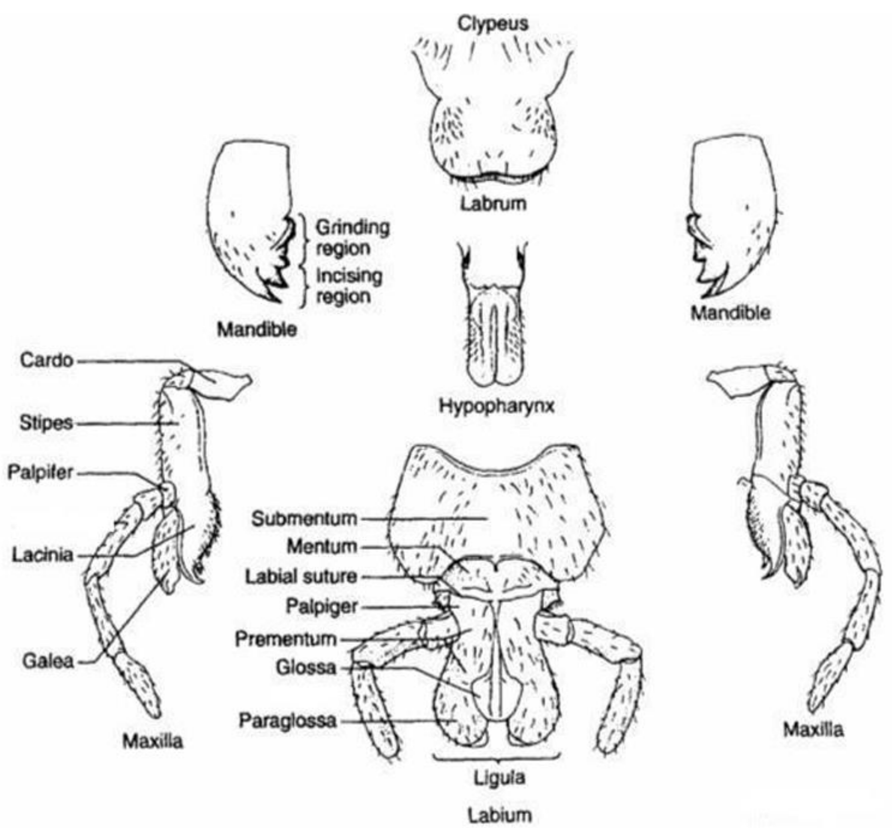


Fig.1 Biting and chewing type of mouthparts.

Insect mouthparts divided into two groups:-

1-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.

2-Haustellate or Suctorial mouthparts are primarily used for sucking liquids and can be broken down into two subgroups:

a-Piercing-sucking mouthparts **b-**non piercing-sucking mouthparts

Biting mouthparts

Labrum. The labrum is a broad lobe suspended from the clypeus in front of the mouth and forming the upper lip (Figs. 1.2, 2.2a). On its inner side it is membranous and may be produced into a median lobe, the epipharynx, bearing some sensilla. The labrum is raised away from the mandibles by two muscles arising in the head and inserted medially into the anterior margin of the labrum. It is closed against the mandibles in part by two muscles arising in the head and inserted on the posterior lateral margins on two small sclerites, the tormae, and, at least in some insects, by a resilin spring in the cuticle at the junction of the labrum with the clypeus. Differential use of the muscles can produce a lateral rocking movement of the labrum.

Mandibles. In the entognathous groups and the Archaeognatha, the mandibles are relatively long and slender and have only a single point of articulation with the head capsule (Fig. 2.3). The mandible is rotated about its articulation by anterior and posterior muscles arising on the head capsule and on the anterior tentorial arms. The principal adductor muscles are transverse and ventral, those of the two sides uniting in a median tendon.

In Thysanura and the Pterygota, the mandibles are articulated with the cranium at two points, having a second, more anterior articulation with the subgena in addition to the original posterior one (Figs. 1.3, 2.2b). These mandibles are usually short and strongly sclerotized and the cuticle of the cusps is often hardened by the presence of zinc or manganese. These cusps may become worn down during feeding, but the distribution of the harder areas of cuticle promotes self-sharpening.

The original anterior and posterior rotator muscles of Apterygota have become abductors and adductors in the Pterygota, the adductor often becoming very powerful.

Maxillae. The maxillae occupy a lateral position, one on each side of the head behind the mandibles.The proximal part of the maxilla consists of a basal cardo, which has a single articulation with the head, and a flat plate, the stipes, hinged to the cardo (Fig. 2.2c). Both cardo and stipes are loosely joined to the head by a membrane so they are capable of movement. Distally on the stipes are two lobes an inner lacinea and an outer galea, one or both of which may be absent. More laterally on the stipes is a jointed, leg-like palp made up of a number of segments; in Orthoptera there are five. Anterior and posterior rotator muscles are inserted on the cardo, and ventral adductor muscles arising on the tentorium are inserted on both cardo and stipes. Arising in the stipes are flexor muscles of lacinea and galea and another lacineal flexor arises in the cranium, but neither lacinea nor galea has an extensor muscle. The palp has levator and depressor muscles arising in the stipes and each segment of the palp has a single muscle causing flexing of the next segment.

Labium. It is known as lower lip and is also called as second maxillae.The labium is similar in structure to the maxillae, but with the appendages of the two sides fused in the midline so that they form a median plate (Fig. 2.2d). The basal part of the labium, equivalent to the maxillary cardines and possibly including a part of the sternum of the labial segment, is called the postmentum. This may be subdivided into a proximal submentum and a distal mentum. Distal to the postmentum, and equivalent to the fused maxillary stipites, is the prementum. The prementum closes the pre-oral cavity from behind. Terminally it bears four lobes, two inner glossae and two outer paraglossae, which are collectively known as the **ligula**. One or both pairs of lobes may be absent or they may be fused to form a single median process. A palp arises from each side of the prementum, often being three-segmented. The musculature corresponds with that of the maxillae, but there are no muscles to the postmentum.

Muscles corresponding with the ventral adductors run from the tentorium to the front and back of the prementum; glossae and paraglossae have flexor muscles, but no extensors, and the palp has levator and depressor muscles arising in the prementum. The segments of the palp each have flexor and extensor muscles. In addition, there are other muscles with no equivalent in the maxillae. Two pairs arising in the prementum converge onto the wall of the salivarium at the junction of labium with hypopharynx (Fig. 1.2). A pair of muscles opposing these arises in the hypopharynx and the combined effect of them all may be to regulate the flow of saliva or to move the prementum. Finally, a pair of muscles arising in the postmentum and inserted into the prementum serves to retract or flex the prementum.

Hypopharynx. The hypopharynx is a median lobe immediately behind the mouth (Fig. 1.2). The salivary duct usually opens behind it, between it and the labium. Most of the hypopharynx is membranous, but the adoral face is sclerotized distally, and proximally contains a pair of suspensory sclerites which extend upwards to end in the lateral wall of the stomodeum. Muscles arising on the frons are inserted into these sclerites, which distally are hinged to a pair of lingual sclerites. These, in turn, have inserted into them antagonistic pairs of muscles arising on the tentorium and labium. The various muscles serve to swing the hypopharynx forwards and back; in the cockroach there are two more muscles running across the hypopharynx, which dilate the salivary orifice and expand the salivarium.

In Apterygota, larval Ephemeroptera and Dermaptera there are two lateral lobes of the hypopharynx called the superlinguae.

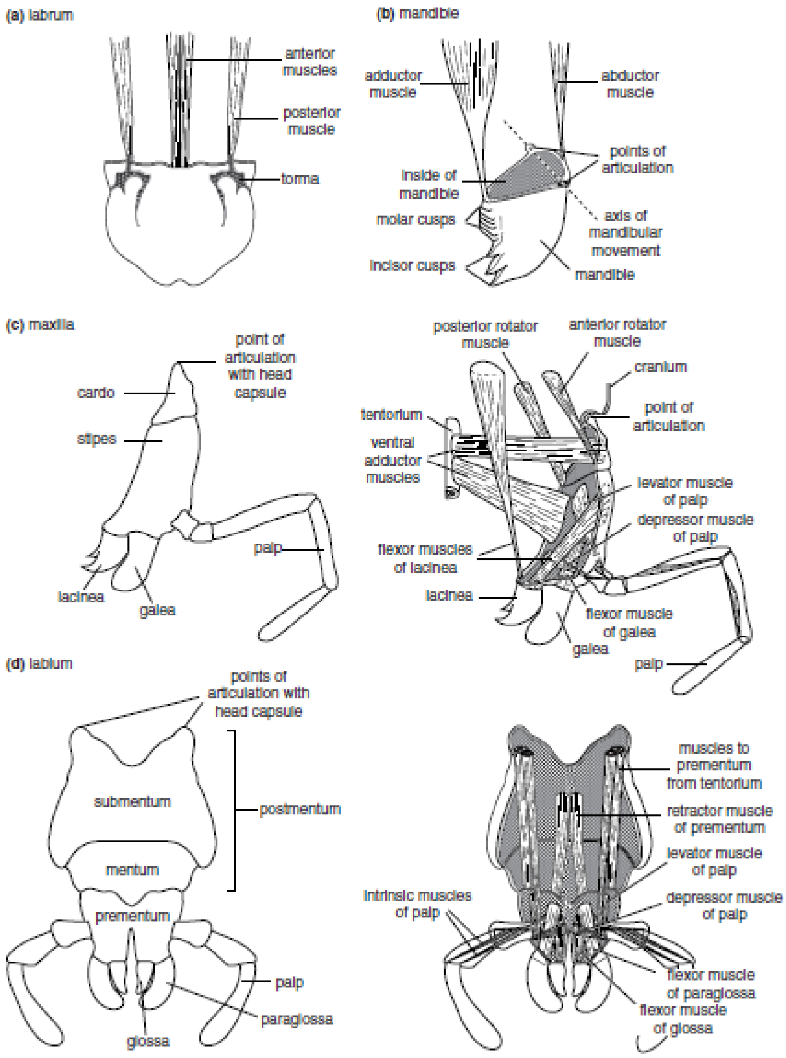


Figure 2.2 Biting and chewing mouthparts of a pterygote insect. Surfaces normally in contact with the hemocoel, the inside of the cuticle, are shaded (after Snodgrass, 1935, 1944). (a) Labrum seen from the posterior, epipharyngeal surface. (b) Mandible – notice the dicondylic articulation. (c) Maxilla from the outside (left) and inside (right). (d) Labium from the outside (left) and inside (right).

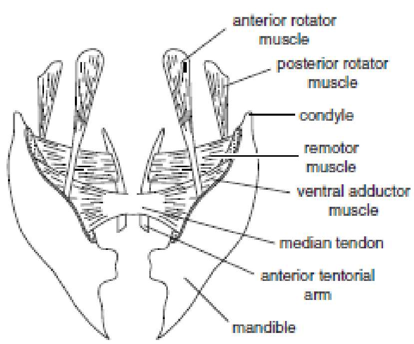


Figure 2.3 Monocondylic mandibles as found in Archaeognatha and non-insecta hexapods. Not all muscles are shown (after Snodgrass, 1935).

Variation in form of mouthparts

The form of the mouthparts varies greatly between species. The biting surface of the mandible is often differentiated into a more distal incisor region and a proximal molar region whose development varies with diet. The mandibles of carnivorous insects are armed with strong shearing cusps; in grasshoppers feeding on vegetation other than grasses, there is a series of sharp pointed cusps, while in grass-feeding species the incisor cusps are chiseledged and the molar area has flattened ridges for grinding.

In species that do not feed as adults, the mouthparts may be greatly reduced. The mandibles of adult Ephemeroptera, for example, are vestigial or absent altogether and the maxillae and labium are also greatly reduced, being represented mainly by the palps.

The greatest divergence from the basic form occurs in the larvae of holometabolous insects. While larval Lepidoptera and Coleoptera usually have well-developed biting and chewing mouthparts, larval Diptera and Hymenoptera show some extreme modifications and reductions. Mosquito larvae, for example, have brushes of hairs on the mandibles and maxillae which are especially long in some species where they serve to filter particulate material, including food, from the water. The larvae of cyclorrhaphous flies exhibit extreme reduction of the head. The principal structures are a pair of heavily sclerotized mouthhooks with which the larva rasps at its food; sensory papillae probably represent the palps. Amongst Hymenoptera, larval Symphyta have well-developed mouthparts, similar to caterpillars, but in some parasitic species the mandibles are represented only by simple spines, and other mouthparts are not differentiated into separate sclerites.

Sucking mouthparts.

The mouthparts of insects which feed on fluids are modified in various ways to form a tube through which liquid can be drawn into the mouth and usually another through which saliva passes. The muscles of the cibarium or pharynx are strongly developed to form a pump. In Hemiptera and many Diptera, which feed on fluids within plants or animals, some components of the mouthparts are modified for piercing, and the elongate structures are called **stylets**. The combined tubular structures are referred to as the proboscis, although specialized terminology is used in some groups.

In Hemiptera, mandibles, maxillae and labium are all elongate structures, while the labrum is relatively short. The food canal is formed by the opposed maxillae which are held together by a system of tongues and grooves (Figs. 2.4a, 2.8a). These allow the stylets to slide freely on each other, while maintaining the integrity of the food canal. The maxillae also contain the salivary canal. On either side of the maxillae are the mandibular stylets. These are the principal piercing structures and they are often barbed at the tip. When the insect is not feeding, the slender maxillary and mandibular stylets are held within a groove down the anterior side of the labium. The hemipteran labium is known as the rostrum. It is usually segmented, allowing it to fold as the stylets penetrate the host. There are no palps.

Since the Hemiptera are hemimetabolous, the larvae and adults have similar feeding habits and both have sucking mouthparts.

Thysanoptera are also fluid feeders as larvae and adults. Their stylets are normally held in the cone-shaped lower part of the head formed by the clypeus, the labrum and labium. Only the left mandible is present. It is used to penetrate plant cells. The maxillary stylets are held together to form the food canal. There is no salivary canal; the salivary duct opens into the front of the esophagus .

The adult Diptera exhibit a great variety of modifications of the mouthparts, but in all of them the food canal is formed between the apposed labrum and labium and the salivary canal runs through the hypopharynx (Fig. 2.4e,f). The mandibles and maxillae are styliform in species that suck the blood of vertebrates, but are generally lacking in other species, including the bloodsucking Cyclorrhapha. Where they are present, they are the piercing organs; in blood-sucking Cyclorrhapha toothlike structures at the tip of the labium penetrate the host tissues by a rasping action. Similar prestomal teeth occur in other Cyclorrhapha, including the house fly, *Musca*.

In many species, the tip of the labium is expanded to form a lobe, the **labellum** which, in Brachycera, is traversed by a series of grooves known as pseudotracheae because they are held open by cuticular ribs giving them a superficial similarity to tracheae. The pseudotracheae converge centrally on the distal end of the food canal. Diptera have maxillary palps, but no labial palps.

The food canal of fleas is formed between an extension of the epipharynx and the maxillary stylets (Fig. 2.4b). A salivary canal extends along the inside of each maxilla which also form the piercing organs. Both maxillary and labial palps are present.

The proboscis of adult Lepidoptera is formed from the galeae held together by a system of cuticular hooks ventrally and a series of plates dorsally (Fig. 2.4c). Since most Lepidoptera are nectar feeders, they do not require piercing mechanisms and the rest of the mouthparts, apart from the labial palps, are reduced or absent. There is no salivary canal although adult Lepidoptera do have salivary glands.

Adults of most Hymenoptera have biting and chewing mouthparts, but the bees are nectar-feeders and are described as lapping the nectar. This is achieved by an elongation and flattening of the galeae and labial palps which surround the fused glossae (Fig. 2.4d). The space outside the glossal tongue forms the food canal. The salivary canal is in the posterior folds of the tongue.

Larval Neuroptera and some predaceous larval Coleoptera that digest their prey extra-orally have a food canal in each of the mandibles. These function in a similar way to those of biting and chewing insects, but they are sickle-shaped. In larval Neuroptera, a groove on the inside of each mandible is converted to a tube by the juxtaposition of a slender lacinea (Fig. 2.5a).

A similar groove is present in the mandibles of some larval Dytiscidae, but instead of being closed by the lacinea the lips of the groove almost join to form a tube (Fig. 2.5b). Larval Lampyridae have a tube running through each mandible and opening by a hole near the tip and another near the base within the cibarial cavity (Fig. 2.5c). Associated with the production of a tube for feeding is the development of a pump for drawing up the fluids and a salivary pump for injecting saliva (see Fig. 3.15). Often the feeding pump is developed from the cibarium, which by elongation and flattening of the galeae and labial palps which surround the fused glossae (Fig. 2.4d). The space outside the glossal tongue forms the food canal. The salivary canal is in the posterior folds of the tongue.

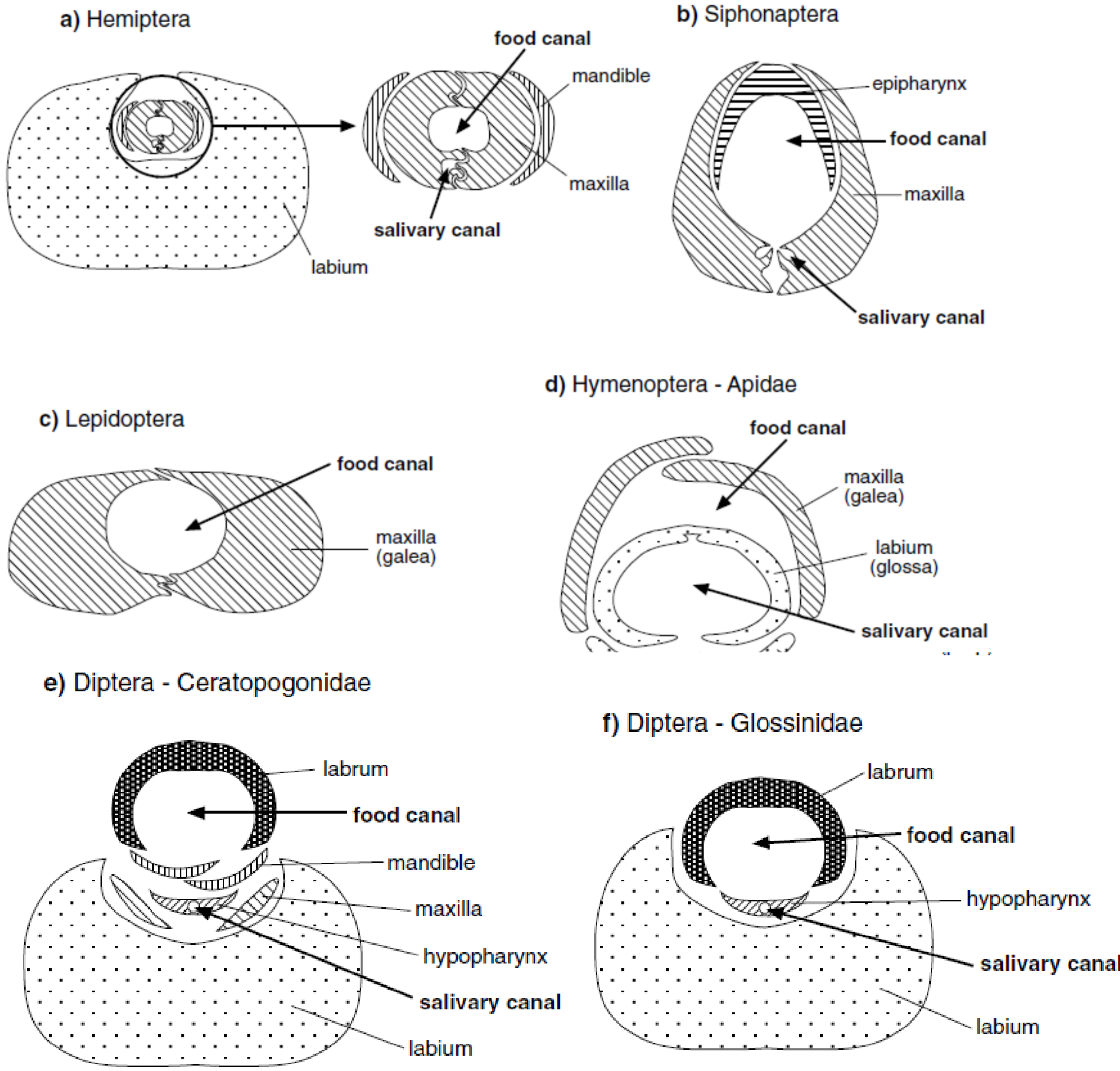


Fig. 2.4. Sucking mouthparts. Diagrammatic cross-sections of the proboscis showing the principal structures used to form tubes for delivery of saliva and intake of food. Homologous structures are indicated with the same shading in all the diagrams. In some cases the structures contain an extension of the hemocoel; this is not shown. (a) Hemiptera (bugs) (compare Fig. 2.8a); (b) Siphonaptera (fleas); (c) Lepidoptera (butterflies and moths); (d) Hymenoptera, Apidae (bees); (e) Diptera, Ceratopogonidae (biting midges); (f) Diptera, Glossinidae (tsetse flies).

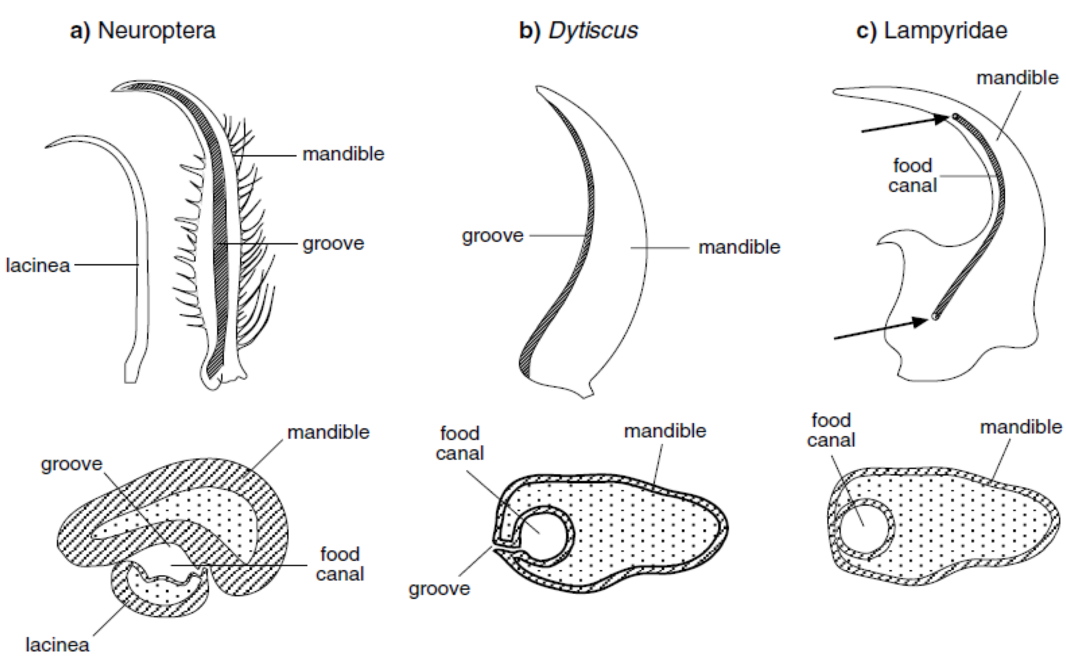


Fig. 2.5. Sucking mouthparts of larval holometabolous insects. (a) An antlion (Neuroptera); (b) *Dytiscus* larva (Coleoptera, Dytiscidae); (c) a firefly larva (Coleoptera, Lampyridae). Arrows show the positions at which the food canal opens to the

Mouthparts modification.

1.Chewing and lapping type ex. Honey bees
2.Sucking or siphponing type ex. butter fly
3.Piercing and sucking type Plant ex. Bugs and Mosquitoes
4.Rasping and sucking type ex.Thrips
5.Sponging type ex.Adult Houseflies
6.Cutting-lapping type ex. horse fly
7.Cutting-sucking type ex.stable fly

Modification in predaceous insect mouthparts.

1.predaceous with sucking type (larva of ant lion)
2.predaceous with biting (Naids of Dragonflies)

Chewing and lapping type of Mouthparts.

The mouthparts of bees are of a chewing and lapping type. Lapping is a mode of feeding in which liquid or semi-liquid food adhering to “tongue”, is transferred from substrate to mouth. In the honey bee, Apis mellifera, the elongate and fused labial glossae form a hairy tongue, which is surrounded by the maxillary galeae and the labial palps to form a tubular proboscis containing a food canal (Fig. 1). In feeding, the tongue is dipped into the nectar or honey, which adheres to the hairs, and then is retracted so that adhering liquid is carried into the space between the galeae and labial palps. Glossae is provided with long hairs and a small spoon shaped lobe, called flabellumat its apex. The maxillary laciniae and palps are rudimentary and the paraglossae embrace the base of the tongue, the mandibles are dumbbell shaped, non-trophic and industrial in function, have a variety of functions, including the manipulation of wax and plant resins for nest construction, the feeding of larvae and the queen, fighting, and the removal of nest debris including dead bees.

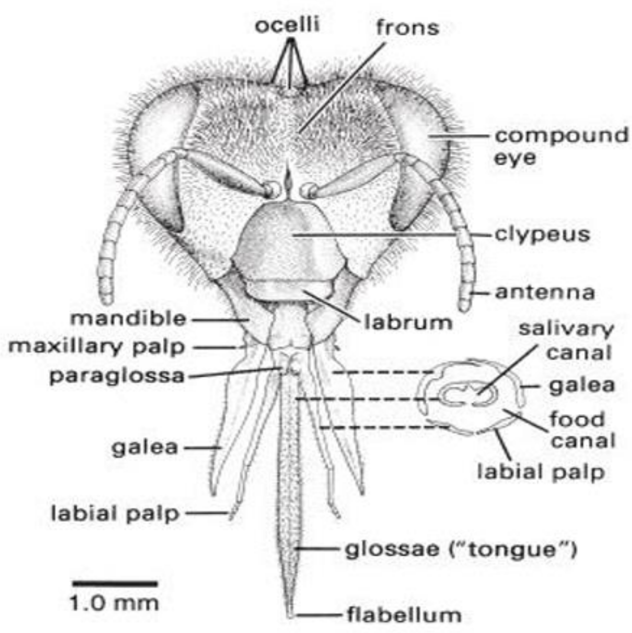


Fig.1.Chewing and lapping type of mouthparts

Siphoning type of Mouth parts eg. Butterflies.

These are specially modified for taking nectar from the flowers. The galea of maxilla form into a slender, hollow, tubular structure which remains as an elongated coiled proboscis underneath the head during non-feeding (Fig. 2). Mandibles are totally absent. The labrum and maxilla palpi are reduced. Labium is modified in to a small basal plate possessing a 3 segmented labial palpi. The food channel is formed by the fusion of both the galea.

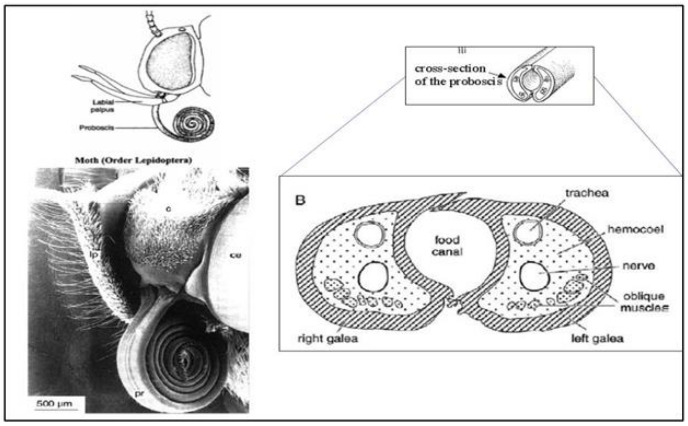


Figure 2. Sucking type of mouth Parts.

Piercing and sucking type e.g plant bugs, mosquitoes.

They are mainly adopted for piercing the tissues and sucking either plant sapor the nectar or blood from the host. Mouth parts are represented by rostrum/beak which is a modification of Labium It acts as a pouch for protecting the mandibular and maxillary stylets.Mandibles and maxillae are modified in to sharp needle like stylets (Fig. 3).The mandibular stylets form the outer pair and possess serrated margins at their tip. The maxillary stylets forms the inner pair having smooth curved tips and combine together enclosing a food channel. Labrum is modified into a small flap like structure at the base of rostrum. Insects with these types of mouthparts pierce the tissues with the mandibular stylets and suck the contents (sap/ blood / nectar) through cibarium with the action of pharyngeal and cibarial muscles.

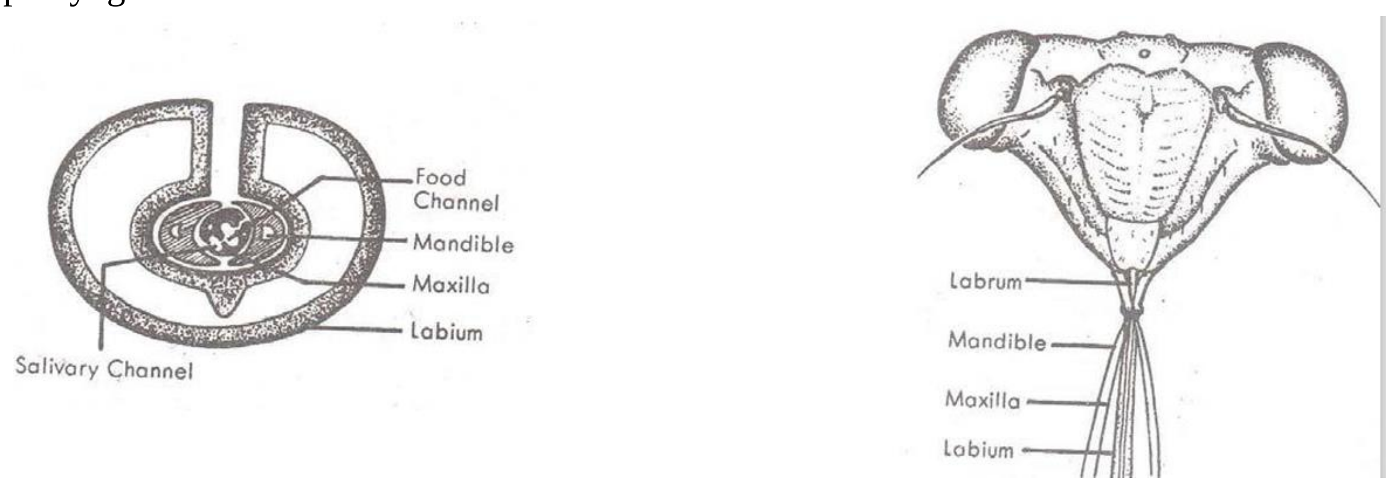


Figure 3. Piercing and sucking mouthparts (plant bug)

Piercing and sucking mouthparts in Mosquitoes (female) it consist of six stylet (fig.4).Labrum epipharynx (enclosing the food canal); Hypopharynx (containing the salivary duct).Paired mandibles (with acute apex);Paired maxillae (with toothed apex)Labium (ensheaths the peirsingstylets but do not penetrate the feeding puncture) Blood is taken into the food canal by suction (suction is provided by cibarial pump) .

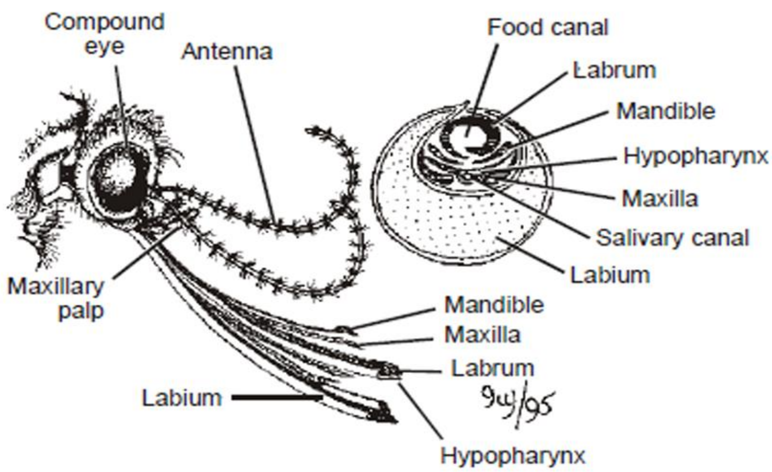


Figure 4. Piercing and sucking mouthparts in Mosquitoes (female)

Sponging type of Mouth Partseg.Housefly.

These mouthparts are represented by proboscis formed from the labium. The proboscis is divided into a basal rostrum, middle haustellum and a distal labellum.The labellum is a sponge like structure. It is traversed by a number of narrow transverse channels called pseudotrachea which converge at one point in the centre of the labellum. From this point, the food enters in to food channel which is formed by the labrum- epipharynx and hypopharynx. Mandibles are absent (reduced) maxillary palpi are 1-3 segmented (Fig. 5). During feeding, the proboscis is pressed over the food material. The pseudo trachea gets filled with the food material by the capillary action.

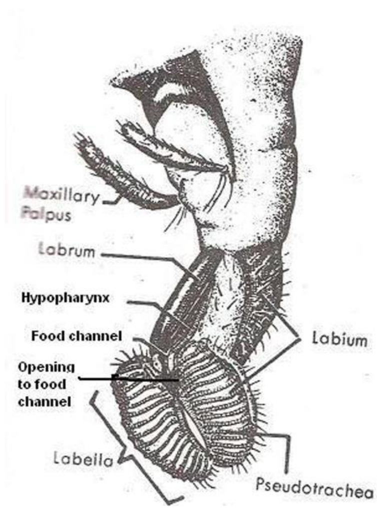


Figure 5. Sponging type of mouthparts (house fly)

Cutting and sucking mouthparts eg stable fly and tsetse fly. Is regard as asecondary modification of sponging type, the labium is the most prominent mouthpart, is selender, and stiff with the labellum reduced in size and provided at tip with rasping denticles; the mandible is missing and the palps are all that remain of the maxillae (Figure 6).the labrum and hypopharynx are partly enclosed by the labium so that the combined appendages form the piercing organ.

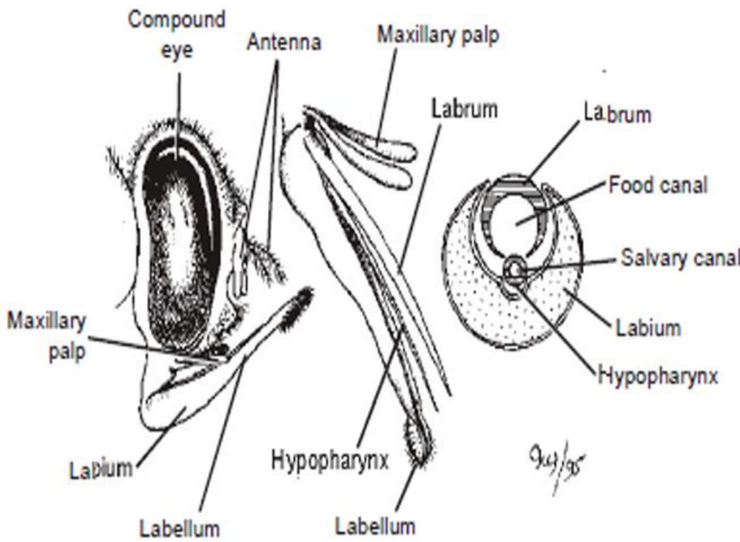


Figure 6.Cutting and sucking mouthparts of stable fly.

Cutting and lappiingeg. Horse fly Horse flies, Tabanus spp., and deer flies, Crysops spp.

All theancestral mouthparts are present, but highly modified and divided in two main functional components (Figure 7). The cutting blades are formed from the mandibles and the lacinea of the maxilla. They open and close much like a pair of scissors as they cut through the skin. It is the combined action of the paired mandibles and maxillae that makes the bite of these two flies so painful. The hypopharynx is elongated and has a central salivary canal that releases saliva into the blood that pools in a wound. The apex of the labium is greatly enlarged in two lobes (labellum), the under surfaces of thelobes are traversed by fine groove calledpseudotrachea.

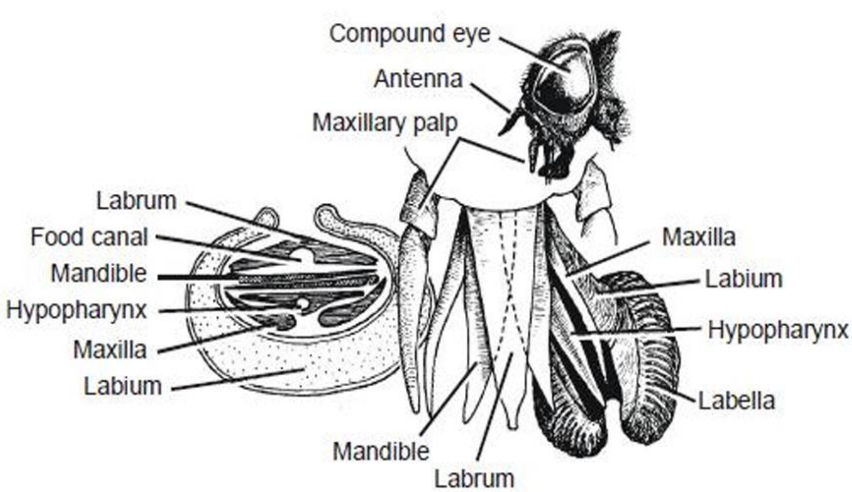


Figure 7. Cutting and lapping mouthparts of horse fly(female).