

flagellum (except the distal ones) have thick whorls of long hair on them, e.g., male mosquitoes.

7. **Pilose** (sparsely hairy)(Fig. 18G): The segments of flagellum (except the distal ones) have very thin whorls of short hair on them, e.g., female mosquitoes.

8. **Clavate** (club-shaped)(Fig. 18H): The segments of flagellum gradually broaden towards apex, e.g., butterflies, antlions, trogossitid beetles and some darkling beetles.

9. **Capitate** (knob-like or head-like)(Fig. 18I): One or a few terminal segments of flagellum are suddenly thickened to form a head-like structure, e.g., red flour beetle, powderpost beetles, nitidulid beetles and amblyceran biting lice.

10. **Lamellate** (Leaf-like)(Fig. 18J): The terminal segments of flagellum are expanded into long, broad leaf-like plates on one side, e.g., rutelid beetles, rhinoceros beetles and dungrollers.

11. **Flabellate** (tongue-like): It has some resemblance to the lamellate antenna. But in this type one or more segments of flagellum are produced into long, thick, tongue-like processes slightly broadening towards apices, e.g., male stylopids and sandalid beetles.

12. **Geniculate** (elbow-like)(Fig. 18K): In this antenna the scape is very long and forms a sharp bend with the remaining segments like a flexed arm, e.g., weevils, honeybees, chalcid wasps and stag beetles.

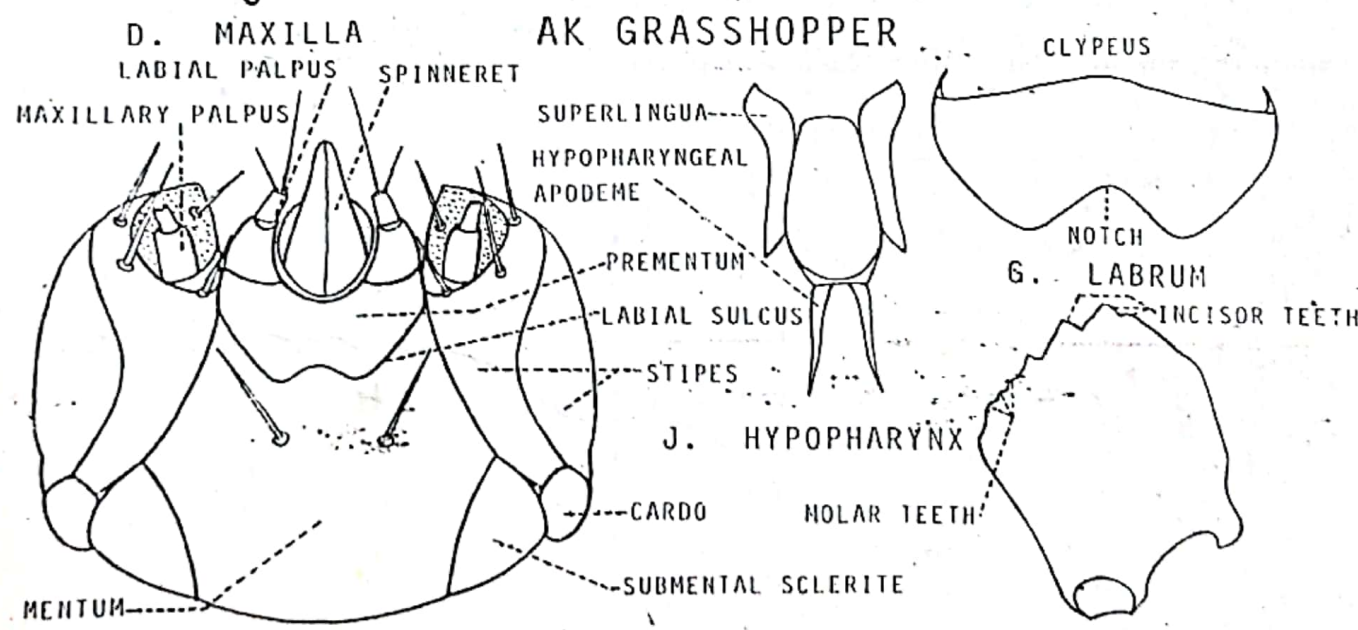
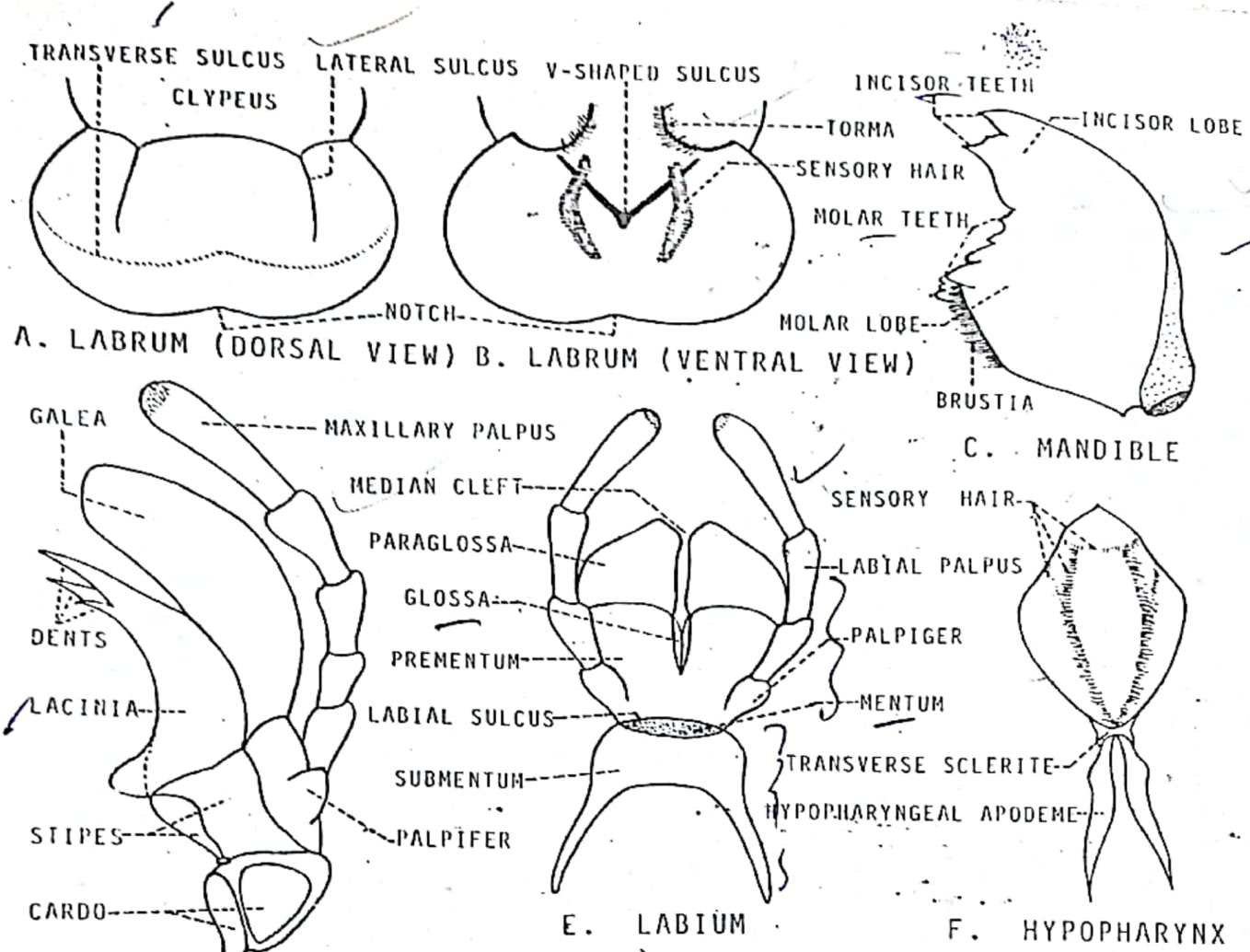
13. **Aristate** (arista-like)(Fig. 18L): The scape is very small while the pedicel is large and triangular. The first segment of flagellum is greatly enlarged, where as the remaining segments are modified into a large hairy bristle, the arista, which is attached to the first segment on the dorsum of its base, e.g., house flies, fruit flies, syrphid flies, etc.

14. **Stylate** (styliform or setiform)(Fig. 18M): The flagellum forms a long, unsegmented, terminal hair, e.g., mango hoppers (leafhoppers), planthoppers, cicadas, robber flies, delphacid bugs and mayflies.

15. **Ensiform** (sword-like)(Fig. 18N): The segments of flagellum are thin, flattened and gradually taper towards apex like a leaf-blade or a sword, e.g., green grasshoppers (*Acrida* sp.).

B. Mouthparts: These are the organs of feeding which typically consist of the following five parts:

1. Labrum (upper lip)
2. A pair of mandibles (upper jaws)
3. A pair of maxillae (lower jaws)
4. Labium (lower lip)
5. Hypopharynx (tongue or lingua)



AK GRASSHOPPER
 SILKWORM LARVA
 FIG. 19. CHEWING TYPE OF MOUTHPARTS

These parts are greatly modified in different insects due to their different methods of feeding. Hence, there are many types or modifications of mouthparts. They are generally classified into chewing (mandibulate) and sucking (haustellate) types. Insects with chewing mouthparts cut and chew or masticate the food with hard mandibles. But those with sucking mouthparts have a somewhat elongated beak or proboscis to suck the liquid food. They have further many types. The mouthparts are often classified as ectognathous and entognathous. In the former case, the mouthparts are not hidden within the head, e.g., bristletails, grasshoppers, bugs, butterflies, etc. In the latter case, the mouthparts are hidden within the head such as doubletails, telsontails and springtails.

I. Chewing or biting type: Under this type, you will dissect out the mouthparts of the following two insects and compare them.

1. Ak grasshopper (*Poekilocerus pictus*): Dissect out the mouthparts in the following order and place them on a slide.

Labrum (Fig. 19A, B): It is a broad flap-like sclerite attached to the clypeus and capable of up and down movement. It forms the roof of the mouth cavity. Its anterior border has a slight notch. Its upper surface has two short lateral sulci dividing its basal half into three parts. It has also an ill-defined transverse sulcus, which divides it into an anterior and a posterior part. Its lower surface is lined with a membrane, the epipharynx. There is a V-shaped sulcus in its posterior part. It has also two median curved bands of sensory hair. The posterior angles of labrum have two sickle-shaped sclerotised bars, the tormae.

Mandibles (Fig. 19C): These are paired, triangular, asymmetrical, strongly sclerotised but hollow jaws lying below the labrum. They move sideways. The biting surface of each mandible has two lobes, namely, the molar lobe and the incisor lobe. The former is near the base of the mandible and has a group of short and blunt molar teeth (dents) which form the mola or grinding area. The latter has a group of longer and acute incisor teeth (dents) which cut the food. The inner edge between the molar teeth and the base of the mandible has a row of short hair called brustia.

Maxillae (Fig. 19D): These are paired structures lying below the mandibles. They move sideways just like mandibles. Each maxilla consists of a basal sclerite, the cardo (pl. cardines) which on its apex has an other sclerite, the stipes (pl. stipites). The cardo has further two parts, an outer broad and triangular and an inner long and narrow one. Similarly the stipes has also two parts, an outer broad and rectangular and an inner long and narrow one. The stipes contains three structures on it. On its outer side is a small process called palpifer which bears on it an antenna-like 5-segmented structure, the maxillary palpus (pl. palpi). The stipes on its apex bears two lobe-like structures. The outer one is broad, elongate and called the galea while the inner one is basally broad but tapering anteriorly and known as the lacinia. The latter is strongly sclerotised and has three black pointed dents at its apex.

Note: When the two lobes on the stipes fuse and form a single structure, it is called mala.

Labium (Fig. 19E): It is a single structure lying below the maxillae. It closes the mouth from the lower side. It is divided by an ill-defined transverse labial sulcus into two main parts: the posterior one, the postmentum and the anterior one, the prementum. The postmentum is further divided into two parts: the lower very large is the submentum while the upper very small (in the

form of a narrow transverse belt) is the mentum. The prementum contains three pairs of structures on it. It bears at its apex two large triangular lobes, the paraglossae which are separated by a deep median cleft. At the base of this cleft are two small and narrow lobes, the glossae. The prementum, on either side of its base, has a small process which is fused with it and called palpiger. Each palpiger bears on it an antenna-like 3-segmented structure, the labial palpus.

Note: When the four lobes of the prementum are fused and form a single structure, it is called ligula.

Hypopharynx (Fig. 19F): When the labrum and mandibles are removed, a large median fleshy lobe, the hypopharynx is seen in the mouth cavity. It is attached to the base of the labium. The hypopharynx is broad from the middle and tapers anteriorly as well as posteriorly. Its anterior end looks like a triangular lobe. Its dorsal side bears two slightly curved longitudinal rows of sensory hair which after branching near their anterior ends merge into a transverse row. The hypopharynx has also a posterior transverse sclerite from which come out two hypopharyngeal apodemes or processes for the attachment of muscles.

2. **Silkworm Larva (*Bombyx mori*):** Dissect out the mouthparts and mount them on a slide in a drop of glycerine. Note that the larvae of butterflies and moths have the chewing type whereas their adults have the siphoning type of mouthparts. The latter will be described at the end of the mouthparts.

Labrum (Fig. 19G): It is a small sclerite which has a deep notch in the anterior border. Its base is attached to a narrow and transversely elongated clypeus. The epipharynx is not differentiated on its lower surface.

Mandibles (Fig. 19H): These are small, paired and strongly sclerotised structures lying below the labrum. The biting surface of each mandible has both the incisor and molar teeth. The former are pointed and the latter are blunt.

Maxillae (Fig. 19I): These are paired structures lying below the mandibles. They are fused with the labium on its sides. Take out the entire lobe consisting of labium and maxillae with the help of your dissecting needle. Each maxilla consists of a small basal sclerite, the cardo. It has on it a large, characteristic, longitudinally divided sclerite, the stipes which contains 2-segmented maxillary palpus on a palpifer. The galea and lacinia are fused and not differentiated.

Labium (Fig. 19I): It is present between the maxillae and closes the mouth from the lower side. It consists of three main parts; viz., submentum, mentum and prementum. The submentum comprises a pair of widely separated triangular submental sclerites present at the base of the maxillae. The mentum is very large and present between two stipites. It is separated from the prementum by a W-shaped labial sulcus. The prementum is large and carries a median process, the spinneret on its distal side. It is formed from the fusion of glossae and paraglossae. On the sides of the spinneret are two very small labial palpi, each consisting of 2 segments.

Hypopharynx (Fig. 19J): After removing the labrum and mandibles, the hypopharynx becomes visible. It is a median pad-like lobe which is attached to the base of the labium in the mouth cavity. There are two lobes on its

sides which are called superlinguae. Also note the hypopharyngeal apodemes.

II. Piercing-sucking type: e.g. red cotton bug (*Dysdercus koenigii*) (Fig. 20A): The mouthparts are greatly modified and visible only in the form of a long, slender beak or proboscis. The proboscis comes out from the front of the triangular head. It bends downwards and backwards and thus lies beneath the body between the legs when not in use. Try to straighten this structure two or three times with a dissecting needle. You will see that the labrum is automatically separated from its base. If this method is not satisfactory, lift the labrum from the base of the proboscis with a dissecting needle. Similarly lift out the needles (forming a single structure). Now separate the four hair-like needles by teasing them gently with a dissecting needle. Remove the insect head and study the structure of mouthparts as given below.

Labrum: It is a short structure, broad at base and narrowing towards apex. It is attached to the clypeus and covers the groove of the labium up to the end of its first segment. It keeps the needles in the groove of the labium by pressing them.

Mandibles: These are paired, long, hair-like needles called stylets. Their tips are slightly curved and serrated or provided with short teeth (when seen under high magnification) for piercing the plant. They form the outer pair.

Maxillae: These are also paired, long, hair-like needles called stylets. Each maxillary stylet has a double groove along its inner side (if seen under high magnification). When the two maxillae fit together, their grooves form two tubes or channels, the upper food channel or suction tube and the lower salivary channel or ejection tube. They form the inner pair.

Note: The stylets of mandibles and maxillae cling together to form a single structure, the fascicle. It lies in the groove of the labium.

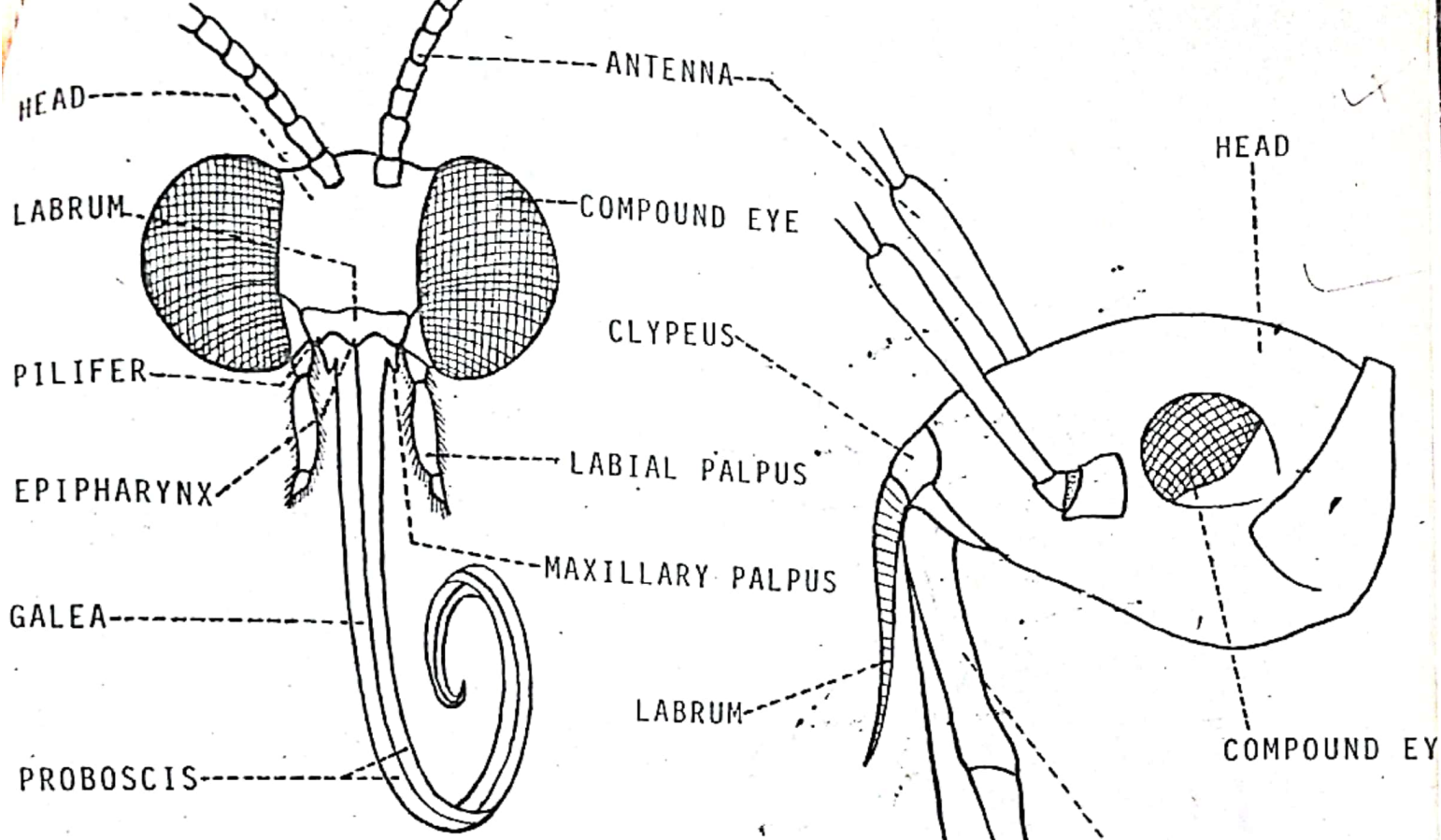
Labium: It is the principal structure which is modified to form an antenna-like 4-segmented proboscis. It has a dorsal groove like that of a knife to accommodate the fascicle. Its tip is provided with small sensory hair. It does not penetrate into the plant.

Note: The head of a weevil is prolonged anteriorly to form a beak-like structure. This beak appears to be a sucking proboscis. But actually the mouthparts are of chewing type as this beak has the chewing mandibles at its tip.

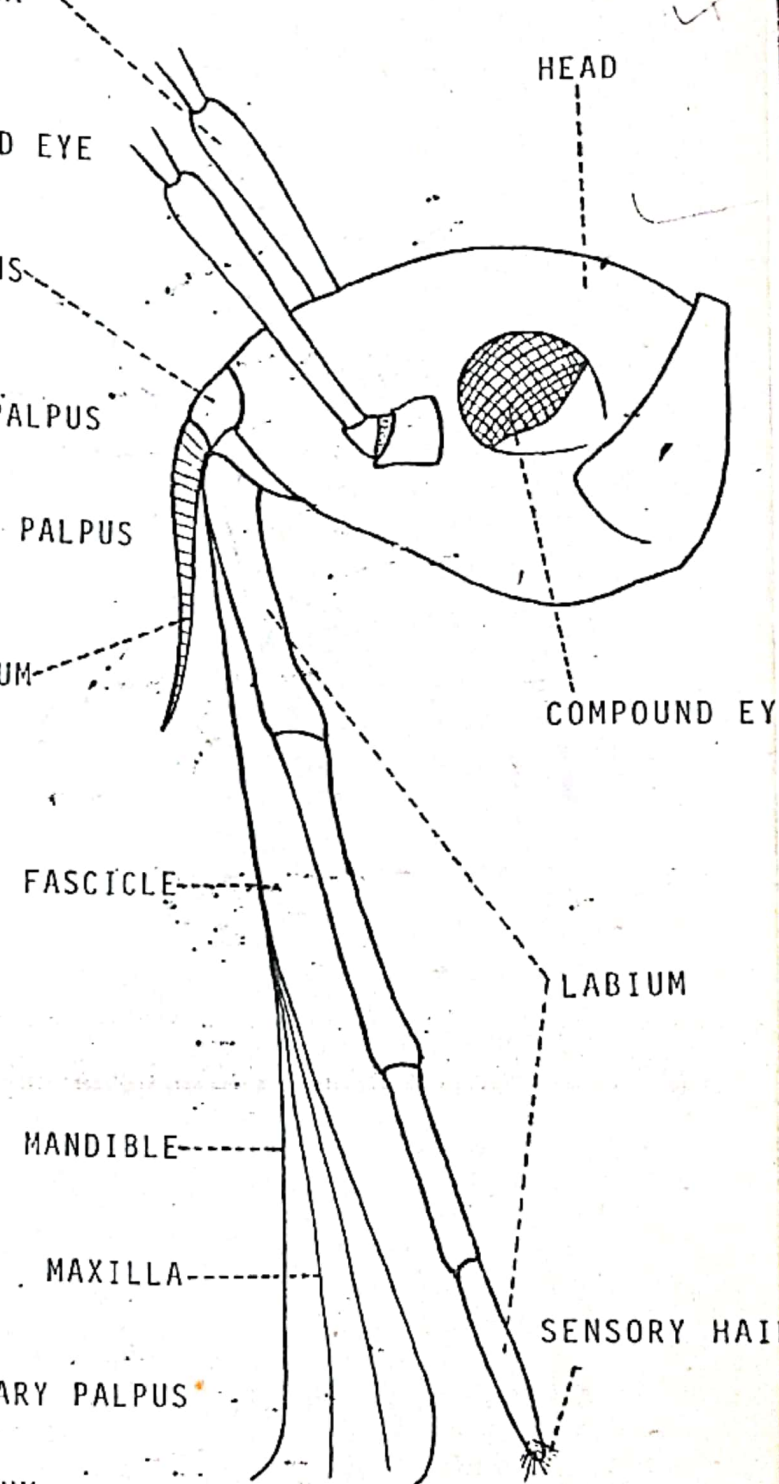
III. Sponging type: e.g. house fly (*Musca domestica*) (Fig. 20B): The mouthparts are greatly modified and visible in the form of a short, thick, elbow-shaped fleshy proboscis on the lower side of the head. Press the head with a needle and see that the proboscis is dissected out. It consists of three main parts, viz., rostrum, haustellum and labellum.

Rostrum: It is the basal cone-shaped portion of the proboscis. A pair of unsegmented, club-shaped, hairy maxillary palpi are present on its distal end.

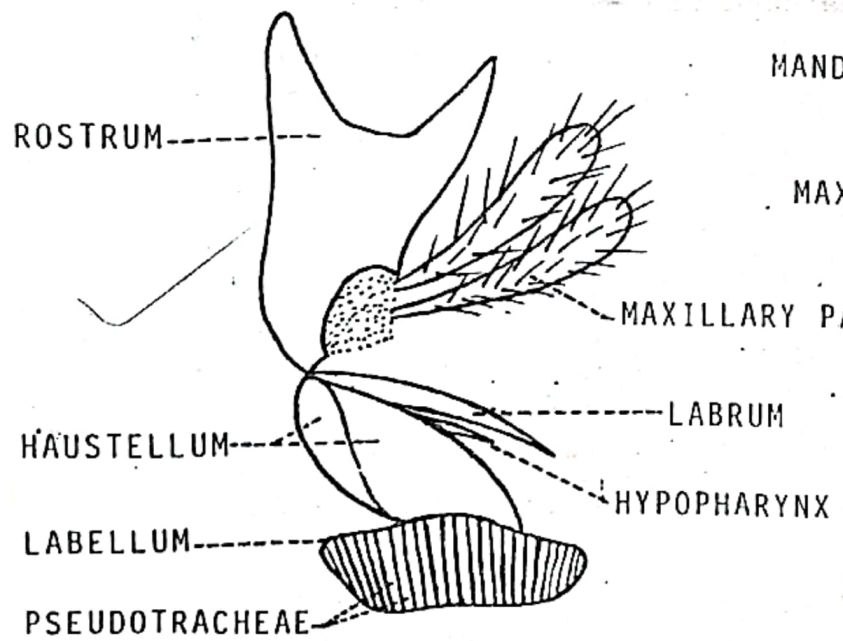
Haustellum: The part of the proboscis between maxillary palpi and labellum is called haustellum. It has a groove on its dorsal side (Fig. 20B shows the lateral view) which contains a pair of needle-like structures, the hypopharynx



C. SIPHONING TYPE
(LEMON BUTTERFLY)



A. PIERCING-SUCKING TYPE
(RED COTTON BUG)



B. SPONGING TYPE
(HOUSE FLY)

FIG. 20. SUCKING TYPE OF MOUTHPARTS

and labrum. The former lies at the bottom of the groove and forms the salivary channel because it has a canal within it. The latter is ventrally grooved and lies on the hypopharynx and thus forms the food channel by closing its groove from below by the hypopharynx. Normally these two structures are not visible outside. Press the haustellum gently, you will see that they become easily visible.

Labellum: It is the terminal portion of the proboscis which has a pair of large, sponge-like, fleshy lobes, the labella. They contain numerous fine tubes, the pseudotracheae which open outside.

IV. Siphoning type: e.g. ~~lemon butterfly~~ (*Papilio demoleus*) (Fig. 20C): The mouthparts are highly modified and visible in the form of a long but coiled proboscis below the head. It is straightened only at the time of feeding. Many parts are either absent or greatly reduced and thus not visible. Examine the KOH treated head and note that only the following parts are visible.

Labrum: It is a narrow, transverse sclerite which is provided with a median triangular lobe, the epipharynx and two prominent lateral lobes, the pilifers.

Maxillae: The galeae of the maxillae are greatly elongated to form the suctorial proboscis. They are grooved on their inner sides and hooked together to form a sucking tube. The maxillary palpi are greatly reduced and appear as small knobs.

Labium: It is represented only by the large, 3-segmented, hairy labial palpi.

V. Chewing-lapping type: e.g. honeybee (*Apis florea*) (Fig. 21): This is a combination of two types, i.e., the labrum and mandibles are similar to those of the chewing type but the labium and maxillae are greatly elongated and modified to form the lapping or licking proboscis. First locate the parts and then dissect them out by the following method. Take the head in your hand and remove the labrum and mandibles one by one with a dissecting needle. Then for dissecting out the labium and maxillae, press the head forward with a needle against some hard surface (preferably on a slide). In this way the mouthparts are taken out easily. Now study them in the following order.

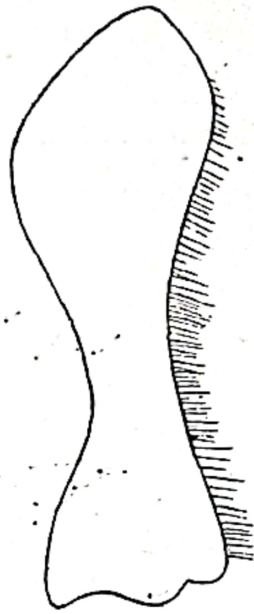
Labrum (Fig. 21A): It is a narrow, transverse flap with the anterior border slightly excavated. Its base is attached to the clypeus and its free border contains small hair.

Mandibles (Fig. 21B): These are paired, dumb-bell-shaped sclerotised structures lying on sides and partly concealed by the labrum. The outer surface is provided with long hair which gradually shorten towards anterior end. They are not used for feeding but for moulding wax into hexagonal cells in the hive.

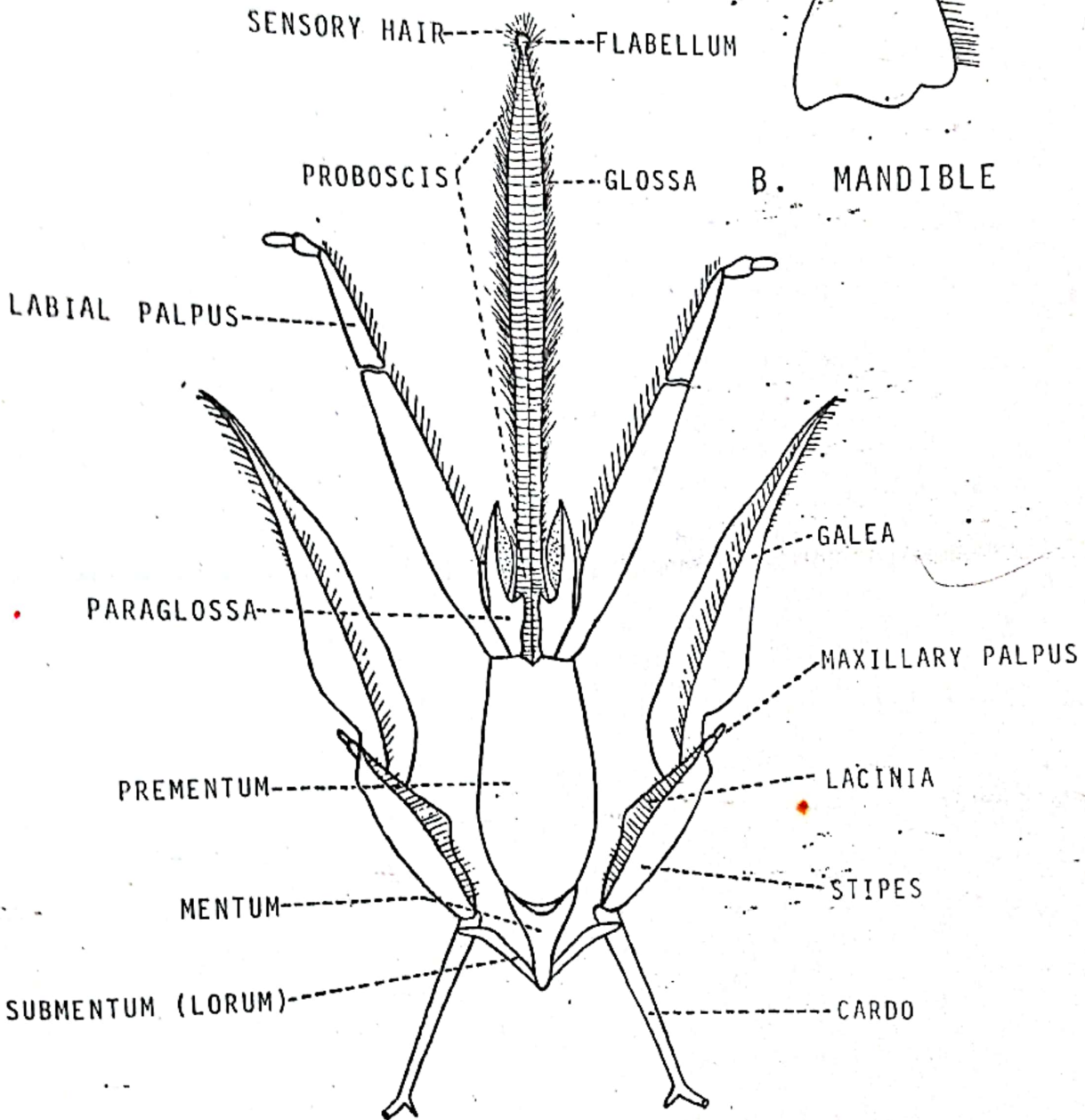
Maxillae (Fig. 21C): These are paired lateral structures lying below mandibles. Each maxilla consists of a long, narrow, basal sclerite, the cardo. It contains on it an elongate and broad sclerite, the stipes. This, in turn, bears three structures on it, i.e., a minute peg-like 2-segmented maxillary palpus on the outer side of its apex, a very large blade-like galea on the inner side of its apex and a reduced, narrow lacinia on its inner side.



A. LABRUM



B. MANDIBLE



C. MAXILLAE AND LABIUM

FIG. 21. CHEWING-LAPPING TYPE OF MOUTHPARTS (HONEYBEE)

Labium (Fig. 21C): It lies between the maxillae on the lower side of the mouth. It consists of a flexible, V-shaped, basal sclerite, the submentum (lorum). Its extremities are connected with the distal ends of the cardines. In its middle articulates a small triangular sclerite, the mentum which carries on it a large sclerotised prementum. On each side of the apex of the prementum is an elongate, 4-segmented, hairy structure, the labial palpus. Inner to the labial palpi are two small lobes, the paraglossae. Each one is apically divided into two processes, the inner very small and the outer large and spoon-shaped. Between the paraglossae lies an elongate spindle-shaped flexible proboscis which is formed by the fusion of two glossae. It has transverse ridges and long hair on it. Its apex is expanded to form a small knob-like lobe, the flabellum.

APPENDAGES OF THORAX

These consist of the wings and legs.

A. Wings: These are the membranous, paired appendages of flight which are located dorsolaterally on the thorax.

(a) Occurrence of wings: The insects have either no wings or a pair of wings (on the mesothorax) or two pairs of wings (first on the mesothorax and second on the metathorax). Examine these conditions in a silverfish (Fig. 8A), house fly (Fig. 7E) and grasshopper (Fig. 4) respectively. Note that the prothorax never bears wings.

(b) Development of wings: The wingless insects are called the apterous, with reduced wings the brachypterous and with complete wings the macropterous. The undeveloped wings of nymphs and naiads are called wing pads (Fig. 9C).

The insects which are supposed primitively wingless are known as Apteriygota, e.g., silverfish (Fig. 8A), doubletails, telson tails and springtails. The insects which are winged or secondarily wingless are called the Pterygota. It has further two types. The insects which develop their wings outside the body are called Exopterygota, e.g., grasshoppers (Fig. 8B), bugs, etc. The insects which develop their wings inside the body are known as Endopterygota, e.g., flies, wasps, moths (Fig. 9A), butterflies, beetles, etc.

(c) Wing margins and angles: Place the hind wing of an ak grasshopper (Fig. 22H) between two slides under a microscope and note the following: It is almost triangular in shape. Its anterior border is called the costal margin, outer border the apical margin and inner border the anal margin. The following three angles are also defined: the humeral angle between the costal and anal margins, the apical angle between the costal and apical margins, and the anal angle (tornus) between the anal and apical margins.

(d) Wing venation (Fig. 22A): The wings of most insects are membranous. They are supported by a framework of hollow ribs or thickened ridges, the veins. Most of these veins extend lengthwise in the wing and are called longitudinal veins. A few of them connect the longitudinal veins and are called cross veins. The arrangement of veins in a wing is called venation or neuration.

In the wings of certain insects, the areas between the longitudinal veins contain an irregular network of veins called archdictyon, e.g., dragonflies, mayflies, stoneflies and ant-lions. The wings of these insects are also called net-veined.