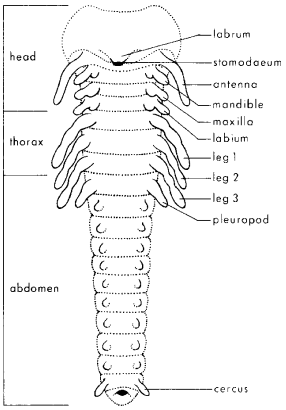


ENTOMOLOGY 322
LAB 12
Head Capsule

The insect head is a complex structure formed through the fusion of multiple, serially-arranged body segments. Primitively in arthropods, each body segment was characterized by the possession of certain features (some of which are inherited from annelid-like ancestors): (1) one pair of jointed legs, (2) one pair of nerve ganglia, and (3) the presence of paired coelomic sacs (at least early in embryonic development). The composite nature of the insect head is clear from a variety of morphological and developmental evidence, including the structural homology of the mouthparts to legs (Fig. 12.1), the presence of multiple pairs of ganglia in the head, the presence of multiple pairs of coelomic sacs in the heads of insect embryos, and, more recently, patterns of gene expression in *Drosophila* embryonic development. While the composite nature of the insect head is not in dispute, there continues to be considerable debate about both the number of head segements and the specific homologies of the head segments among the major classes of Arthropoda. In this lab we will first examine head morphology in a generalized insect, the cricket, and later take a broad overview of head and mouthpart diversity.

1.

Obtain a freshly killed or preserved cricket, *Acheta domestica* (Orthoptera: Gryllidae). Note that, as in the myriopods, the head is a continuously sclerotized capsule with no outward appearance of segmentation, but is marked by a number of grooves. Almost all of these groves are sulci (singular, sulcus) and mark the position of internal phragmata (or costae) that function to provide bracing and points of attachment for muscles, rather than sutures marking the boundary between segments. One possible exception is the postoccipital suture, which is generally believed to be the line of fusion of the maxillary and labial segments.

First, remove the cricket's head and pin the head "face down" so that you can clearly view the posterior surface of the head capsule. The large openning in the back of the head, through which the gut and muscle tissue pass into

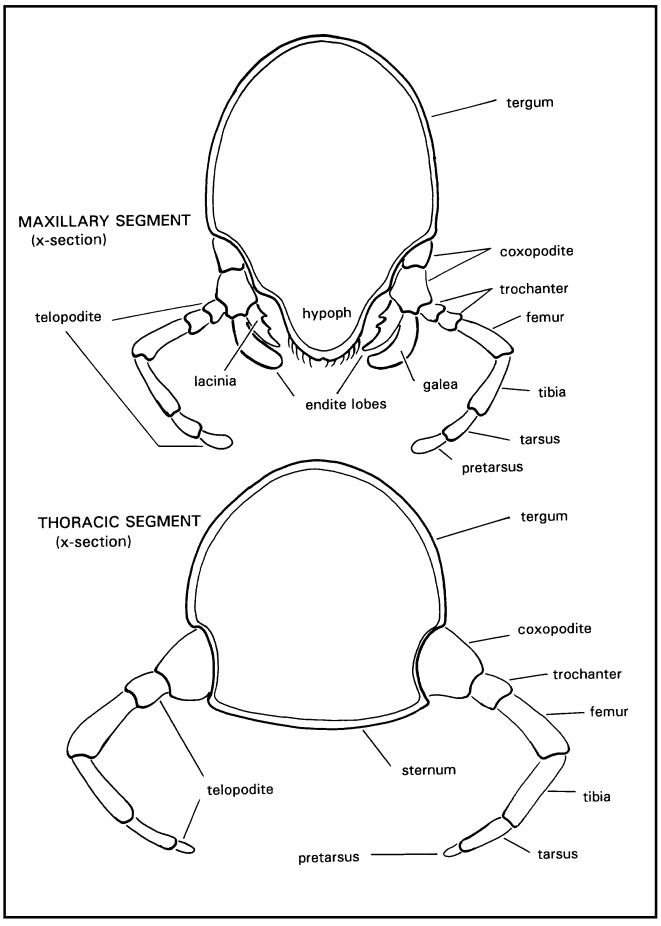


Figure 12.1 Comparison of maxillary and thoracic segments (G.W. Byers)

the thorax, is the occipital foramen (For in Fig. 12.2B). Encircling the occipital foramen is a very faint suture called the postoccipital suture (pos in Fig. 12.2B). Follow the postoccipital suture downward, around the occipital foramen, and locate the paired posterior tentorial pits (pt in Fig. 12.2B). The posterior tentorial pits mark the point where the posterior arms of the tentorium intersect with the outer wall of the head capsule. The easiest way to locate the posterior tentorial pits is to look on the back of the head just above the point where the narrow lateral arms of the submentum (base of the labium) meet the head. The very narrow area between the postoccipital suture and the occipital foramen is the postocciput (Poc in Fig. 12.2B).

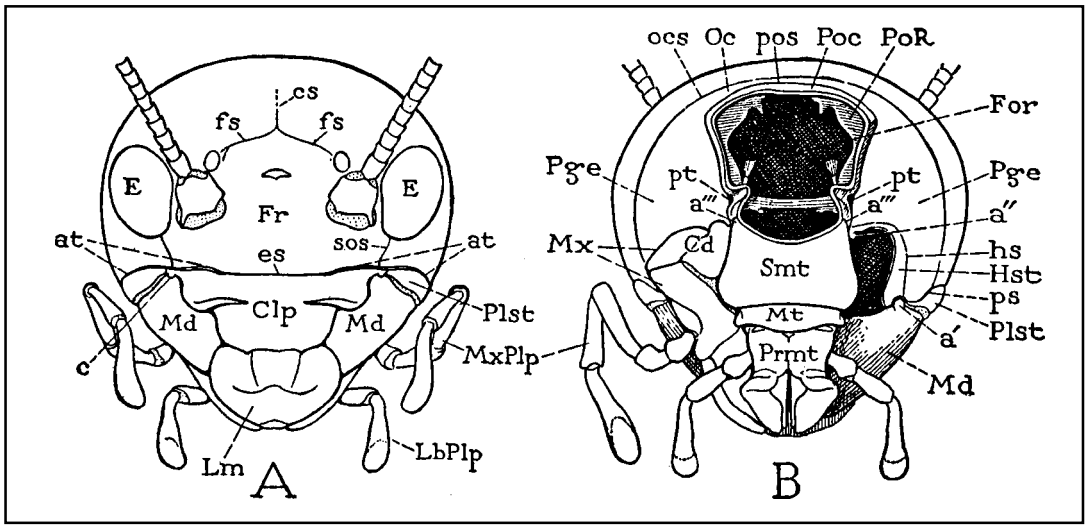


Figure 12.2 (Snodgrass, 1935)

Laterad of the postocciput is a broad, flat area. Where this flat part of the back of the head intersects the side of the head, there is a discrete ridge or carina, called the occipital sulcus (ocs in Fig. 12.2B). The back of the head, between the postoccipital suture and occipital carina, is called the occipital arch, or occiput (Oc in Fig. 12.2B). Not all insects have a distict occipital carina, but the term occiput is still generally used to refer to the back of the head, laterad of the very narrow postocciput. A more precise usage restricts the term occiput to the dorsal part of the occipital arch, and refers to the lateroventral parts as the postgena (Pge in Fig. 12.2B).

Before continuing our survey of the head sutures we need to remove some of the mouthparts so this is a convenient time to identify mouthpart morphology. Beneath the occipital foramen is the last pair of head appendages, the labium. Immediately below the occipital foramen there is a broad rectangular sclerite, the submentum (Smt in Fig. 12.2B). Further distad is the mentum (Mt in Fig. 12.2B), a thinner, transverse, rectangular sclerite. Together the submentum and the mentum comprise the postmentum. The prementum (Prmt in Fig. 12.2B) is the large sclerite (divided medially by a groove) which bears the lateral labial palpi, the the broad, lobe-like paraglossae, and the slender, medial, acutely pointed glossae. Once you have identified all these structures of the labium, remove the labium.

Beneath the labium is the median, soft hypopharynx (Hphy in Fig. 12.3 and 12.4). Note that there are two paired openings on the posterior surface of the hypopharynx which are the openings of the salivary ducts. The space formed between the posterior surface of the hypopharynx and the anterior surface of the labium is the salivarium (Slv in Fig. 12.4). The salivarium is the region into which secretions of the salivary (or labial) glands are released.

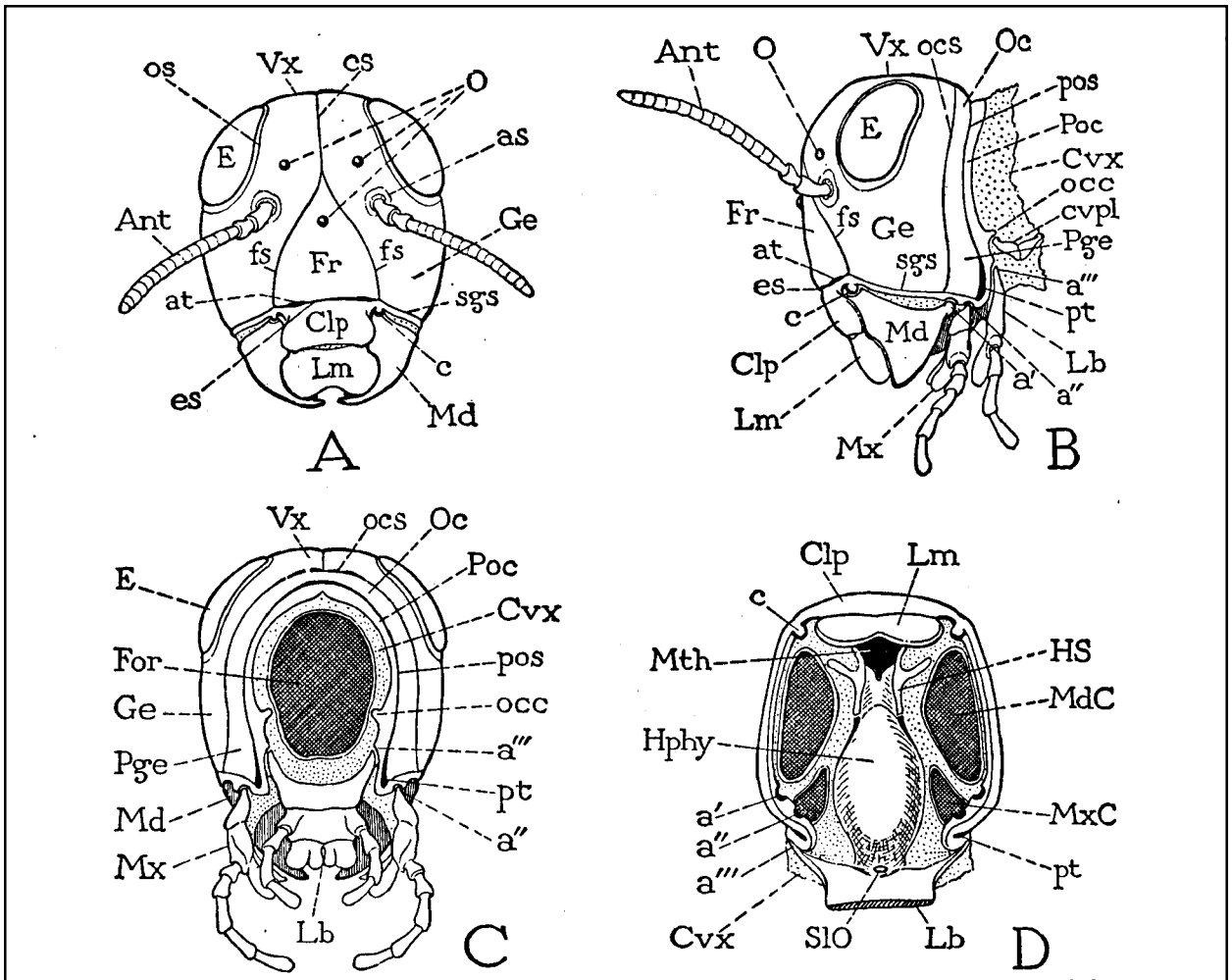


FIG. 56.—Typical structure of the head of a pterygote insect, showing potential sutures and intersutural areas. A, anterior. B, lateral. C, posterior. D, ventral, appendages removed. *a′*, *a″*, *a‴*, primary cranial articulations of mandible, maxilla, and labium; *Ant*, antenna; *as*, antennal suture; *at*, anterior tentorial pit; *c*, secondary anterior articulation of mandible; *Clp*, clypeus; *cs*, coronal suture; *cvpl*, cervical plates; *Cvx*, neck (cervix); *E*, compound eye; *es*, epistomal suture; *For*, foramen magnum; *Fr*, frons; *fs*, frontal suture; *Ge*, gena; *Hphy*, hypopharynx; *HS*, hypopharyngeal suspensorium; *Lb*, labium; *Lm*, labrum; *Md*, mandible; *MdC*, mandibular cavity; *Mx*, maxilla; *MxC*, maxillary cavity; *O*, ocelli; *Oc*, occiput; *occ*, occipital condyle; *ocs*, occipital suture; *os*, ocular suture; *Pge*, postgena; *Poc*, postocciput; *pos*, postoccipital suture; *SlO*, orifice of salivary duct; *sgs*, subgenal suture; *Vx*, vertex.

Figure 12.3 (Snodgrass, 1935)

To either side of the hypopharynx are the paired maxillae (Mx in Fig. 12.2B). Note the monocondylic articulation of the cardo (Cd in Fig. 12.2B) with the head capsule. The cardo articulates with the more distal stipes along a thin, membranous line. Move the stipes dorsally and ventrally to see how the cardo and the stipes articulate with each other and the head capsule. Distally, the stipes bears the 5-segmented maxillary palpus, the sharply pointed lacinia, and the lobe-like galea. Now carefully remove the maxilla from **one side** of the head.

With the maxilla removed you will see the large and heavily sclerotized mandible (Md in Fig. 12.2B). Note the posterior mandibular articulation, a ball and socket structure on the lower margin of the head capsule. Note the discrete suture that extends upward from the posterior mandibular articulation and extends to the posterior tentorial pit (which you located earlier). This suture is the hypostomal sulcus (hs in Fig. 12.2B) and dilineates a region called the hypostoma (Hst in Fig. 12.2B), which is where the maxilla attaches to the head.

Once you are satisfied that you have identified the above structures, remove the pins from the head and remount the head in lateral view.

In lateral view (Fig. 12.3B) note the large compound eye and the antennal base. Note also, that you can see the anterior mandibular articulation. (How does it differ from the posterior mandibular articulation?) Unlike the maxilla, the cricket mandible is dicondylic (a derived condition unique to the mandibles of many insects). The suture running along the side of the head above the base of the mandible is the pleurostomal sulcus (ps in Fig. 12.2B). The small region between the pleurostomal sulcus and the upper margin of the mandible is the pleurostoma (Plst in Fig. 12.2B). The region above the pleurostomal sulcus (beneath and behind the eye) is the gena (Ge in Fig. 12.3B). The pleurostomal and hypostomal sulci together comprise the subgenal sulcus (sgs in Fig. 12.3B), which runs from the posterior tentorial pit to the anterior tentorial pit.

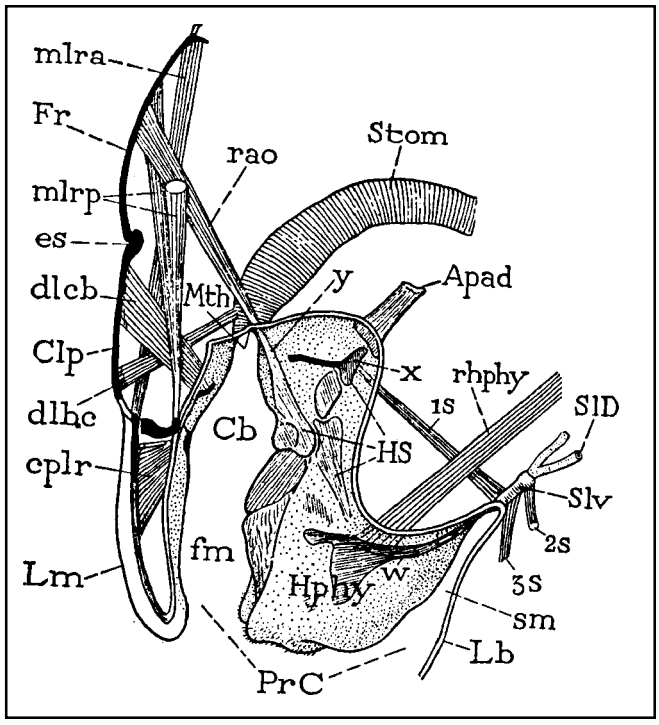


Figure 12.4 (Snodgrass, 1935)

Carefully remove the mandible from the head (noting its dicondylic articulation as you do so). With the mandible removed there is a large cavity, bounded anteriorly by posterior faces of the clypeus and labrum (collectively, the posterior wall of these two sclerites is the epipharynx), laterally by the other mandible, and posteriorly by the hypopharynx. This cavity is the cibarium (Cb in Fig. 12.4). The mouth (Mth in Fig. 12.4), which is the anterior opening of the digestive tract, lies at the top of the cibarium. It should be clear in this view that the large tongue-like hypopharynx separates the salivarium (posterior) from the cibarium (anterior).

Now remount your cricket head "face up" (Fig. 12.2A). On the front of the head, locate the epistomal (or frontoclypeal) sulcus (es in Fig. 12.2A), which is a continuation of the subgenal sulcus. The epistomal sulcus extends between two points just above the anterior articulation of each mandible. At each end of this sulcus is an anterior tentorial pit (at in Fig. 12.2A), marking the point where the cuticle invaginates to form one of the anterior arms of the tentorium (AT in Fig. 12.5). In most insects, the epistomal sulcus, subgenal sulcus, and postoccipital suture mark the postion of a continuous internal ridge, or costa, that provides a brace for the bottom and back of the head capsule (see Fig. 12.5: ER, SgR and PoR). Where the subgenal sulcus meets the postoccipital suture there are usually posterior tentorial pits marking the points where the posterior arms of the tentorium (TB in Fig. 12.5) intersect with the outer wall of the head capsule.

Note the clearly dilineated, rectangular sclerite below the epistomal sulcus. This sclerite is the clypeus (Clp in Fig. 12.2A), and below it is another rectangular flap, the labrum (Lm in Fig. 12.2A). The front of the head capsule, above the epistomal sulcus, is the frons (Fr in Fig. 12.2A). Sometimes there is a vertical sulcus, the subocular sulcus (sos in Fig. 12.2A), extending from the anterior tentorial pits to the compound eyes. Perhaps you will be able to discern a faint suggestion of this sulcus on your cricket. In crickets the clypeus bears two lateral sutures which do not meet medially. These sutures are not present in other insects.

Notice that at the top of the head, close to the compound eyes (also called the vertex [Vx in Fig. 12.3), there is a median line which extends downward and then branches into two lines extending ventro-laterally toward the compound eyes. This is the coronal suture (cs in Fig. 12.3) and marks the line along which the head capsule splits at molting in nymphal crickets (=ecdysial cleavage line).

Check the demonstration of the cleared cricket head to see the the tentorium. Identify the anterior and posterior arms of the tentorium (refer to Fig. 12.5).

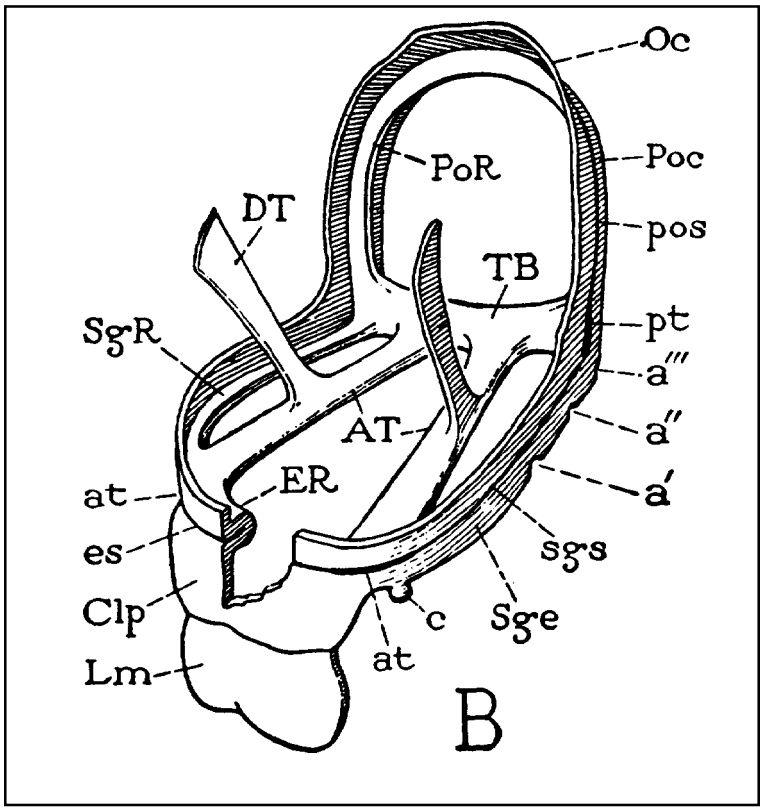


Figure 12.5 (Snodgrass, 1935)

2.

Examine the demonstration of the ventral region of the head of a bombardier beetle (Coleoptera: Carabidae), an example of a prognathous head (Fig. 12.6). The cricket and most members of the orthoptera have a hypognathous head, in which the mouthparts are directed downward.

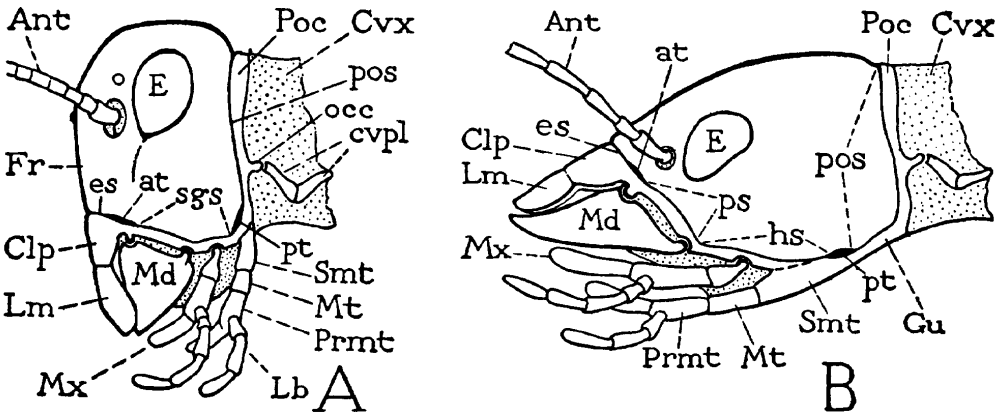


FIG. 66.—Diagrams illustrating the hypognathous (A) and prognathous (B) types of head structure.

Figure 12.6 (Snodgrass, 1935)

In many insects with prognathous heads, the cervical region between the occipital foramen and the labium becomes sclerotized to form a median ventral plate, the gula (Gu in Fig. 12.7B). Note its proximal position with respect to the posterior tentorial pits. Compare this to the cricket, and notice that the head posterior to the mandibles and compound eyes (i.e., the postgena) is greatly enlarged and the mouthparts extend anteriad rather than ventrad.

Now examine the gula on the head of a staphylinid beetle larva. Here the gula is so greatly narrowed that it appears as a single median line (Fig. 12.7D).

3.

Examine the demonstration showing the back of the head of a paper wasp (Hymenoptera: Vespidae) (Fig. 12.8). Although the wasps head is hypognathous, like that of the cricket, the ventral and posterior portions of the head capsule are different. First, note that the maxillae and labium are fused to form a labio-maxillary complex (or proboscis) that can be folded into a pocket called the proboscidial fossa in the posteroventral part of the head. This fossa is separated from the occipital foramen by a sclerotized bridge derived from the mesal extensions of the postgena (PGe in Fig. 12.8B); thus the bridge is called a postgenal bridge. You may or may not be able to discern a very faint median line bisecting the postgenal bridge, and may wonder how to tell a postgenal bridge from a greatly narrowed gula such as that you saw on the staphylinid beetle larva (previous section). Note that on the beetle, the median line runs between the posterior tentorial pits and the occipital foramen; whereas on the wasp the posterior tentorial pits are very close to the occipital foramen, and the postgenal bridge, with its faint median line, is distal to the posterior tentorial pits and occipital foramen.

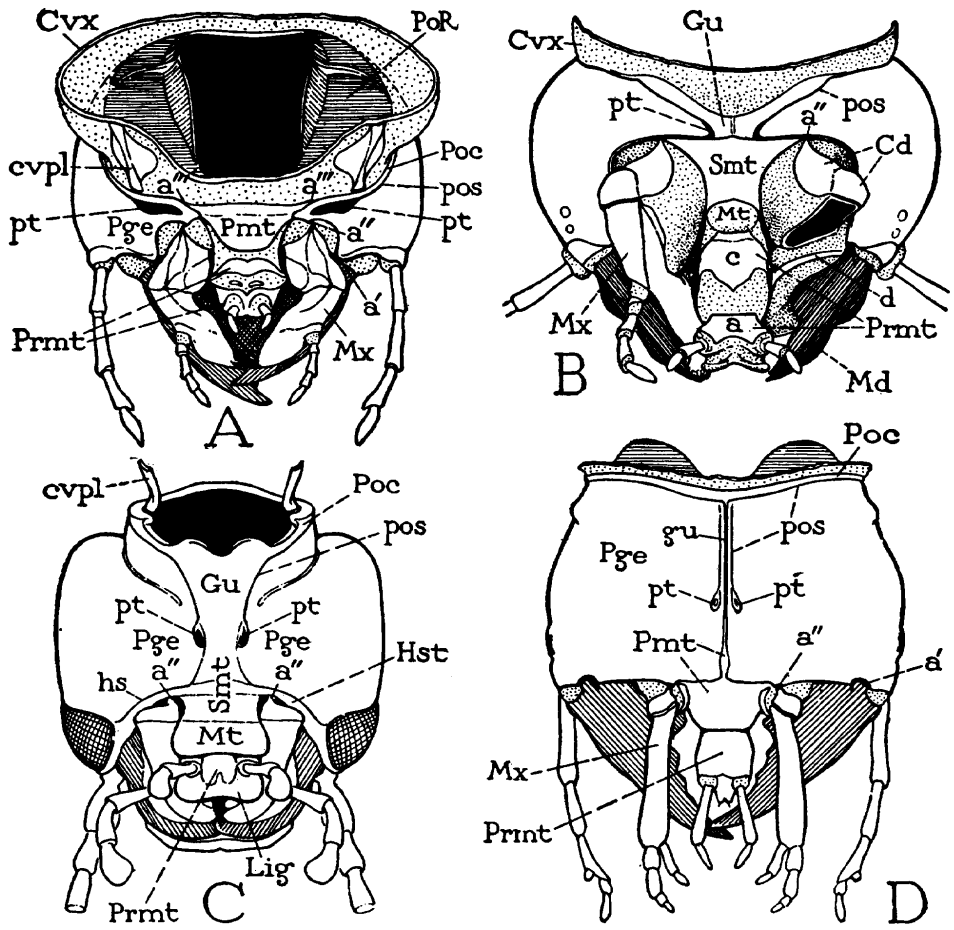


FIG. 67.—Heads of Coleoptera showing evolution of the gula. A, *Popillia japonica* larva; gula absent. B, *Silpha* larva; short gula (*Gu*) proximal to posterior tentorial pits (*pt*). C, *Epicauta* adult; gula typically developed. D, *Scarites* larva; gula obliterated, the gular area (*gu*) reduced to a median "suture."

Figure 12.7 (Snodgrass, 1935)

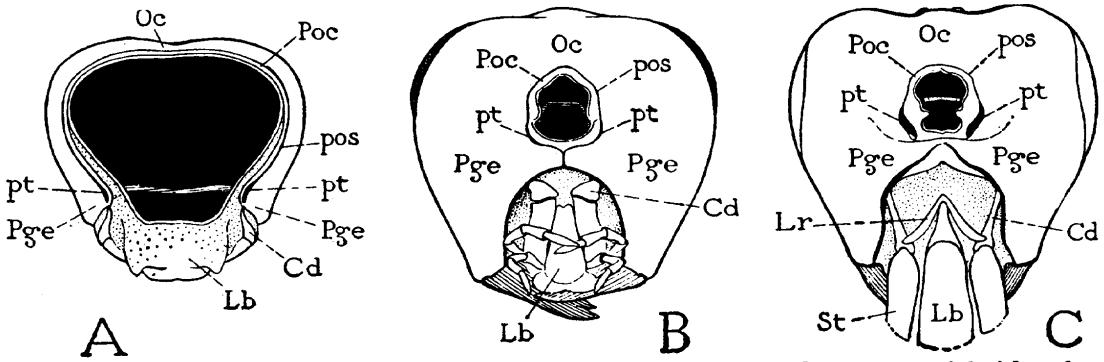
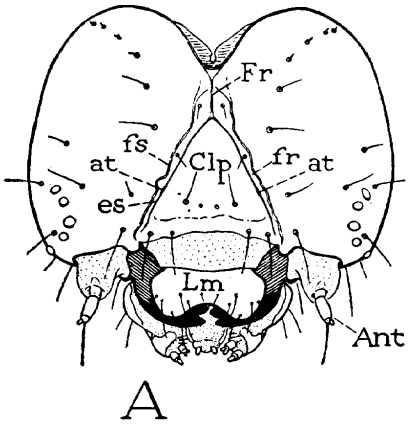


FIG. 65.—Heads of Hymenoptera, showing evolution of the hypostomal bridge formed by united median lobes of the postgenal regions. A, larva of *Vespa*. B, adult of *Vespa*. C, adult of *Apis mellifica*.

Figure 12.8 (Snodgrass, 1935)

4.

Examine the demonstration of the head of a caterpillar (Lepidoptera: Arctiidae) (Fig. 12.9). Unlike adult linsects, larvae must be able to free themselves from the solidly fused head capsule when they molt. The caterpillar's head capsule splits in half along the dorsal midline. The suture marking this fusion line is called an ecdysial cleavage line. Like other larvae of holometabolous insects, caterpillars do not have compound eyes, although a cluster of visual organs, stemmata, are situated posterolaterally on each side of the head. They lie just above the antennae, which are much lower on the head than in most adult insects with hypognathous heads.



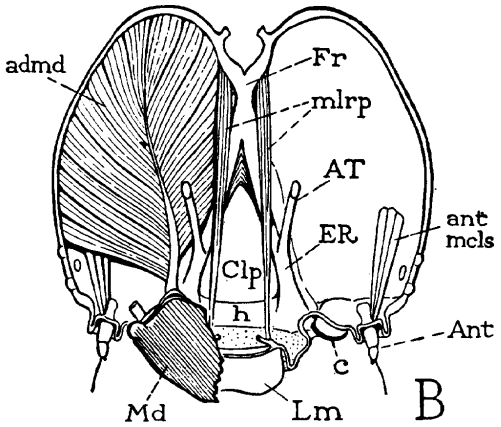


FIG. 64.—Head of a caterpillar. A, *Lycophotia margaritosa*, anterior view. B, *Prionoxystus robiniae*, interior of the head from behind, showing invaginated frons (*Fr*) on which the labral muscles (*mlrp*) are attached.

Figure 12.9 (Snodgrass, 1935)