ENTOMOLOGY 322 LAB 25
Central Nervous System

In the seventeenth century it was believed that the internal anatomy of insects was undifferentiated tissue: “insects have no bowels, nor fat, nor bones, nor spines, but a nature between flesh and nerve” (Jonston, 1633). It remains surprising to many people today that insects actually have complex internal organs and tissues, but what is perhaps the most difficult for people to believe is that insects have a brain and a complex central nervous system. In this lab we will consider the insect brain and central nervous system.

The insect brain, like the insect head, is a complex organ that has formed through the fusion of, primitively, independent ganglia. You will remember from the first lab that the annelid central nervous system is composed of paired ganglia (or nerve cell clusters) in each segment of the body arranged serially along the ventral nerve cord. This is the primitive condition in arthropods, but in the course of arthropod evolution the independent ganglia of the head segments have fused to form the brain (Fig. 25.1). Exactly how many pairs of ganglia have fused to form the brain remains a question (see Rempel, 1975 for a comprehensive review of the alternative theories). Refer to Table 13.1 for the hypothesis that was developed by Rempel, and the one we shall follow here.

What advantages might a concentration of nerve ganglia into the head (a brain) have for insects?

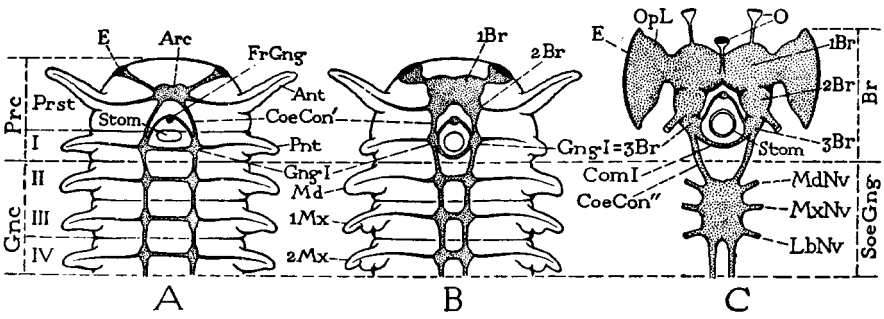

FIG. 245.—Diagrams illustrating the theoretical evolution of the insect brain from the archicerebrum and the first postoral ganglia, and the formation of the suboesophageal ganglion from the ganglia of the gnathal segments. *Ant*, antenna; *Arc*, archicerebrum; *Br*, definitive brain; *1Br*, protocerebrum; *2Br*, deutocerebrum; *3Br*, tritocerebrum; *CoeCon′*, *CoeCon″*, primitive and definitive circumoesophageal connectives; *ComI*, commissure of ganglia of first somite; *FrGng*, frontal ganglion; *Gnc*, gnathocephalon; *GngI*, ganglion of first somite; *OpL*, optic lobe; *Pnt*, postantenna (second antenna); *Prc*, procephalon; *Prst*, prostomium; *SoeGng*, suboesophageal ganglion; *Stom*, stomodaeum.

Figure 25.1 (Snodgrass 1935. p. 475)

1.

Examine the demonstration of the ventral nerve cord of a caterpillar (Lepidoptera). As is typical of holometabolous insect larvae, the nerve cord consists primarily of separate ganglia, with little fusion between segments. Note that the paired ganglia within each segment are joined transversely by a commissure, and ganglia in neighboring segments are joined longitudinally by paired connectives. The last abdominal ganglion (VIII Gng in Fig. 25.2) is a fused structure, consisting of components of the last four segments. Peripheral nerves extend from the ganglia.

2.

Examine the demonstration of the ventral nerve cord of the milkweed bug *Oncopeltus*. Note that the nerve cord ganglia have become reduced by fusion. There are no separate abdominal ganglia. The thoraco-abdominal ganglion located in the thorax innervates the abdomen as well as the meso- and metathorax (Fig. 25.3).

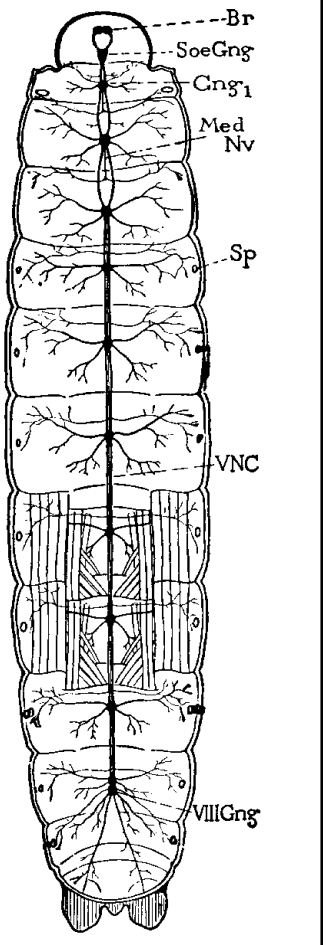

FIG. 246.—Ventral nervous system and brain of a caterpillar, *Malacosoma americana*.

Figure 25.2 (Snodgrass 1935. p. 476)

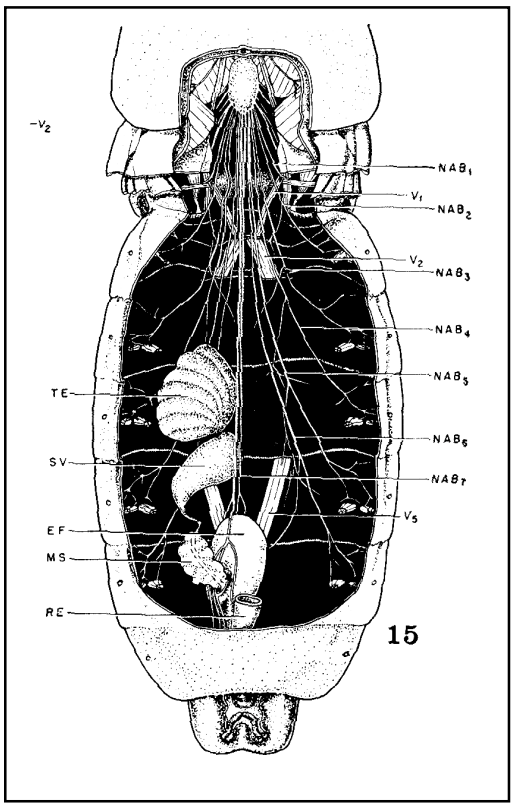

Figure 25.3 (Johannson, A.S., 1957, The nervous system of the milkweed bug, *Oncopeltus fasciatus*.Trans. Ent. Soc. Am. 83:119-183)

3.

Examine the demonstration dissection of a dorsal view of the brain of the male bumblebee, *Bombus*. Locate the protocerebrum (1Br in Fig. 25.4) with the optic lobes (Opl in Fig. 25.4) leading to the compound eyes (E in Fig. 25.4), where a few ommatidia are separated. Note the pigmented dorsal ocelli (O in Fig. 25.4), minus the corneal lenses, which were removed in the dissection. Note also the deutocerebrum (2Br in Fig. 25.4) with the antennal nerves (AntNv in Fig. 25.4), leading to the bases of the antennae. (The deutocerebrum is not clearly separated from the protocerebrum in external view.)

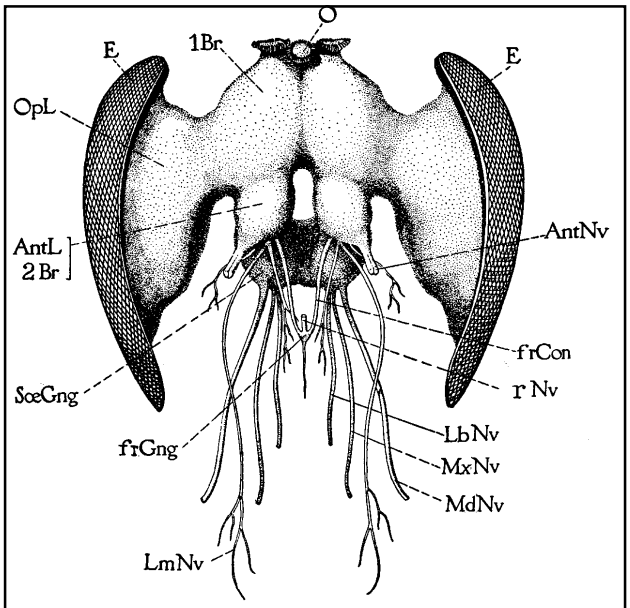

Fig. 93. Brain and suboesophageal ganglion of worker and principal head nerves, anterior.
For explanation of abbreviations see pages 278–279.

Figure 25.4 (Snodgrass. 1956. p. 255)

4.

Examine the demonstration of a dorso-lateral view of the cephalic nervous system of a cricket (Gryllidae). Locate the brain, with the optic lobes (OpL in Fig. 25.5) leading to the protocerebrum (1Br in Fig. 25.5) and the antennal nerves leading to the deutocerebrum (2Br in Fig. 25.5), and the labral nerves (LmNv in Fig. 25.5) leading to the tritocerebrum (3Br in Fig. 25.5). The association of the labral nerves with the tritocerebrum is a secondary modification of the brain. The tritocerebrum is the ganglion thought to correspond to the intercalary segment (which is absent in adult insects), and the labrum is, primitively, the appendage corresponding to the protocerebrum (Table 13.1). From the tritocerebrum, the circumesophageal connectives (CoeCon in Fig. 25.5) go around the foregut to connect to the subesophageal ganglion (SoeGng in Fig. 25.5). This ganglion itself represents the fusion of three (primitively separate) ganglia, the mandibular, maxillary and labial ganglia (Table 13.1).

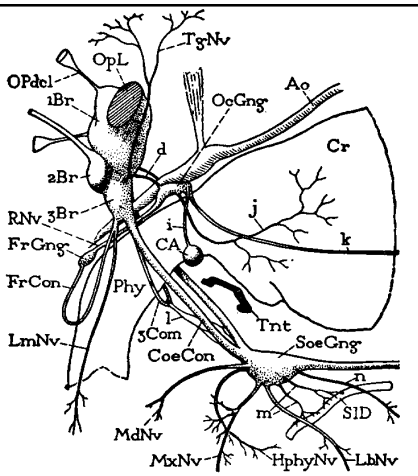

FIG. 249.—Head nervous system of *Dissosteira carolina*, lateral view. *Ao*, aorta; *1Br*, protocerebrum; *2Br*, deutocerebrum; *3Br*, tritocerebrum; *CA*, corpus allatum; *CoeCon*, circumoesophageal connective; *3Com*, tritocerebral commissure; *Cr*, crop; *FrCon*, frontal ganglion connective; *FrGng*, frontal ganglion; *HphyNv*, hypopharyngeal nerve; *LbNv*, labial nerve; *LmNv*, labral nerve; *MdNv*, mandibular nerve; *n*, cervical nerve; *OcGng*, occipital ganglion; *OPdcl*, ocellar pedicel; *OpL*, optic lobe; *Phy*, pharynx; *RNv*, recurrent nerve; *SlD*, salivary duct; *SoeGng*, suboesophageal ganglion; *TgNv*, dorsal tegumentary nerve.

Figure 25.5 (Snodgrass. 1935. p. 479)

Locate the visible parts of the stomatogastric nervous system and associated endocrine glands. On top of the esophagus, leading anteriorly from the brain, is the recurrent nerve (RNv in Fig. 25.5), which should connect to the frontal ganglion (FrGng in Fig. 25.5). Posterior to the brain on top of the foregut, locate the large corpora cardiaca on top of the small hypocerebral ganglion (or occipital ganglion; OcGng in Fig. 25.5). These would normally be covered by the aorta, whose cut stub is visible going under the brain. Nerves going through the corpora cardiaca lead to the corpora allata (CA in Fig. 25.5) on the sides of the gut. Close to each corpus allatum, find the large prothoracic gland, connected to it by a nerve.

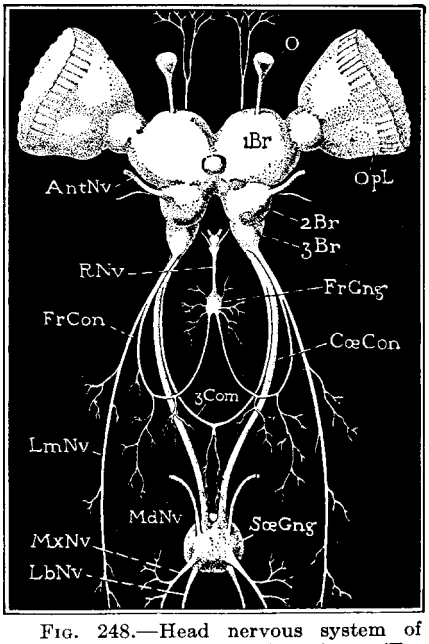

FIG. 248.—Head nervous system of *Dissosteira carolina*, anterior view. (For lettering see Fig. 249.)

Figure 25.6 (Snodgrass. 1935. p. 478)

5.

Examine the demonstration slide of the cross section of the roach head. Find the compound eye showing ommatidia cut at various angles, optic lobes, nerves from the optic lobes going into the protocerebrum proper and forming fiber tracts, and the corpora pedunculata (Cpd in Fig. 25.7). Note also the globuli (Kenyon) cells (GbII in Fig. 25.7), and the circumesophageal connectives that extend ventrally on either side of the esophagus to the subesophageal ganglion (not visible in this section).

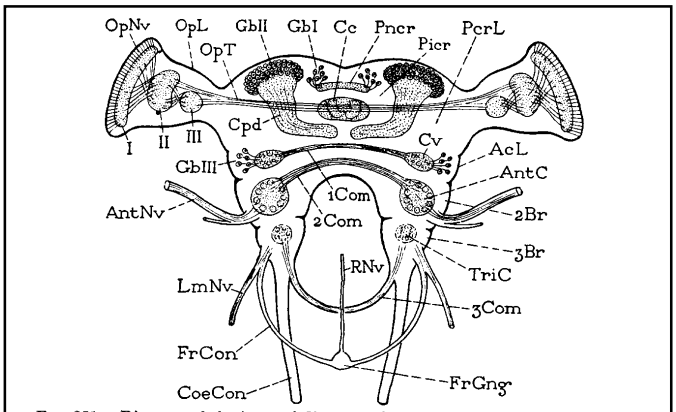

FIG. 251.—Diagram of the internal fibrous bodies and fiber tracts of the insect brain *AcL*, accessory lobe; *AntC*, antennal center; *2Br*, deutocerebrum, *3Br*, tritocerebrum; *Cc* corpus centrale; *1Com*, protocerebral commissural tract; *2Com*, deutocerebral commissura tract; *3Com*, tritocerebral commissure; *Cpd*, corpus pedunculatum; *Cv*, corpus ventrale *GbI*, *II*, *III*, three groups of globuli cells; *I*, lamina ganglionaris; *II*, medulla externa; *III* medulla interna; *OpL*, optic lobe; *OpNv*, optic nerves; *OpT*, optic tract; *PcrL*, protocerebra lobe; *Picr*, pars intercerebralis; *Pncr*, pons cerebralis; *TriC*, tritocerebral center.

Figure 25.7 (Snodgrass. 1935. p. 483)

6.

Take a preserved specimen of your insect, and make two lateral longitudinal cuts along its dorsum, from the tip of the abdomen through the prothorax. Remove the dorsum and wings. Pin the insect in a dissecting pan under alcohol and remove the gut, reproductive organs, and fat, carefully exposing the central nervous system of the thorax and abdomen. (Cut the gut in the mesothorax -- do not yank it from the head. Do not remove organs from the prothorax at this time.)

Locate the central nervous system ventral nerve cord ganglia. How many separate ganglia are there? In what way are the segmental ganglia fused intersegmentally? Can you trace some of the peripheral nerves to the segments that they innervate? Locate the paired connectives joining the ganglia intersegmentally. You may find it worthwhile to stain your preparation with acid fuchsin: drop some stain into the alcohol onto the exposed nerve cord, leave for about five minutes, and wash with 70% alcohol.

7.

With scissors or scalpel, very carefully cut off the vertex of the head, slitting to the inner margins of the compound eyes and the upper margins of the antennal sockets. Cut through the postoccipital ridge, and carefully pull off the vertex. Now very carefully remove the muscles and fat to expose the brain, optic lobes, and antennal nerves. Do not remove the foregut -- the stomatogastric system lies on its surface. Also leave the aorta intact. You may wish to cut your animal in two behind the prothorax and store the rest of it at this time. At this point you may wish to stain with acid fuchsin. You should be able to locate the following:

protocerebrum
deutocerebrum
optic lobes
antennal nerves
ocelli or ocellar nerves

Now very carefully expose the dorsal surface of the foregut behind the brain, carefully lifting the aorta. With luck, you will find parts of the stomatogastric nervous system and its associated glands right behind the brain, lying on the foregut. Try to locate the following:

corpora cardiaca
prothoracic glands
corpora allata
hypocerebral ganglion

At this point, you may wish to carefully remove one wall of the cranium laterally to the base of the mouthparts. You may cut through the compound eyes; note the individual ommatidia and the purple color of their pigment cells. Separate a portion of the cornea from the eye. What color is it? Does it have a hexagonal pattern of its own? Again, not disturbing the foregut (pharnyx), expose the brain laterally, the subesophageal ganglion, and the nerves connecting them. You may have to cut part of the tentorium to do this.

Carefully search the surface of the foregut anterior to the brain to locate the frontal ganglion, and posterior to the brain to locate the other parts of the stomatogastric nervous system. Try to locate the following:

tritocerebrum	**circumesophageal connectives**
labral nerves	**frontal ganglion**
subesophageal ganglion	**recurrent nerve**