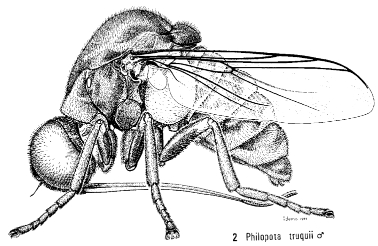


ENTOMOLOGY 322
LABS 6 & 7
External Thoracic Structure

The insect thorax is composed of three segments (prothorax, mesothorax and metathorax), which in all insects are specialized for locomotion. In apterygotes and pterygotes the thorax bears the three pairs of walking legs and their musculature. In pterygotes the meso- and metathoracic segments are highly modified and partially fused to form the primary flight motor. We shall examine the musculature of the thorax in labs 8 and 9. In these labs you will become familiar with the external morphology of the thorax.

1.

First, we will examine the thorax of a generalized pterygote insect, the lubber grasshopper (*Romalea*). While *Romalea* is a flightless insect, it exibits the generalized features of the insect pterothorax.

First, obtain a specimen. In lateral view identify the prothorax (Fig. 6.1), mesothorax and metathorax (Fig. 6.2). Note that the posterior margin of the pronotum projects posteriorly to cover much of the dorsal surface of the mesothorax. Carefully cut off the prothoracic cover and trim the wings down to about a centimeter in length (this will facilitate observation of the wing bases). In lateral view identify the suture separating the prothoracic and mesothoracic segments. This suture is membranous and

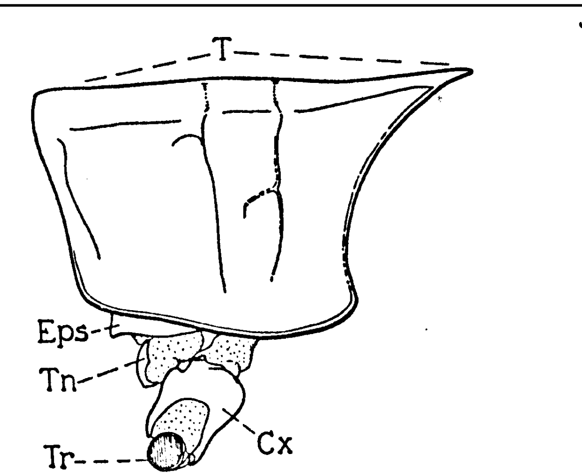


FIG. 6.—Prothorax of *Marellia remipes*, lateral view.
Cx, coxa of prothoracic leg; *Eps*, episternum; *T*, protergum; *Tn*, trochantin; *Tr*, trochanter.

Figure 6.1 Grasshopper prothorax (Carbonnell, 1959) allows the prothorax to move with respect to the mesothorax. Note that the mesothoracic spiracle (Sp2 in Fig. 6.2) is located in this suture. Next, locate the suture separating the meso- and metathoracic pleura and note that the metathoracic spiracle (Sp3 in Fig. 6.2) is located in this suture. (Given this information, where would you expect the prothoracic spiracle to be, if it were present, which it is not?) How does this suture compare to the one separating the prothorax and mesothorax? The fusion of the mesothoracic and metathoracic pleura (and sterna) into a rigid pterothorax is a common feature of insects with indirect flight musculature.

Next, identify the pleural suture (PlS in Fig. 6.2) in each segment, which run from the upper margin of the coxa to the pleural wing process (WP in Fig. 6.2). (Because the meso- and metathoracic segments are

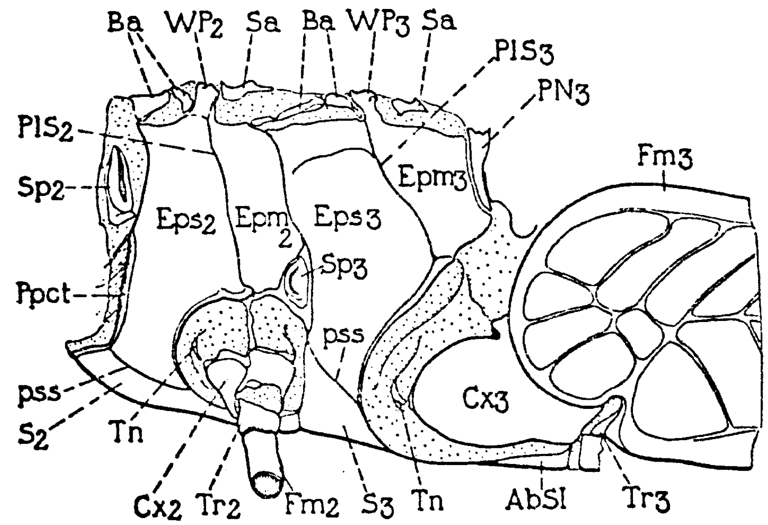


FIG. 8.—The pterothoracic pleura of *Morellia remipes.*

AbSI, first abdominal sternum; *Ba*, basalar sclerite; *Cx*, coxa; *Epm*, epimeron; *Eps*, episternum; Fm_3, base of hind femur; *PlS*, pleural suture; PN_3, lateral arm of metathoracic postnotum; *Ppct*, prepectus; *pss*, pleurosternal suture; *S*, thoracic sternum; *Sa*, subalare; Sp_2, mesothoracic spiracle; Sp_3, metathoracic spiracle; *Tn*, trochantin; *Tr*, trochanter; *WP*, pleural wing process.

Figure 6.2 Grasshopper pterothorax (Carbonnell, 1959)

equally well developed you should be able to see this structure in both.) Beneath the wing, and anterior and posterior to the pleural wing process, locate the basalare (Ba in Fig. 6.2) and subalare (Sa in Fig. 6.2). These are small but important sclerites which bear muscles internally called the direct flight muscles. The direct flight muscles connect the basalare and subalare to the coxa on the ipsilateral side and contraction of these muscles causes important wing movements during flight. (If it is available, observe the demonstration of direct flight musculature in *Romalea*.) The pleural suture divides the pleuron into an anterior episternum (Eps) and a posterior epimeron (Epm).

In dorsal view of the meso- and metathorax (Fig. 6.3), identify the scutum (Sct), scutellum (Scl) (which together comprise the alinotum) and the postnotum (PN) of each segment. Move the base of the wing back

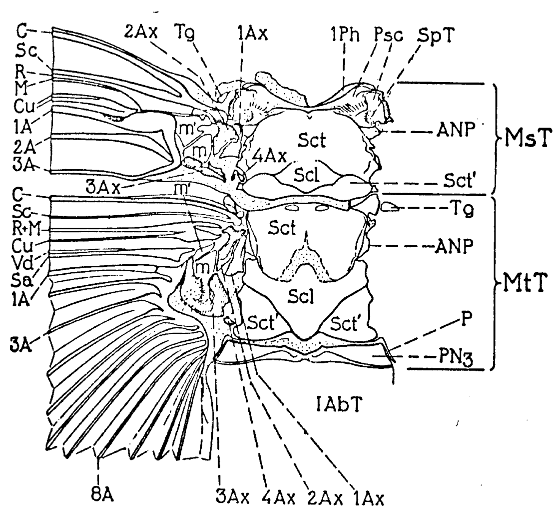


Fig. 7.—The pterothoracic terga and the bases of the wings of *Merellia remipes.*

1A, 2A, 3A, 8A, first, second, third, and eighth anal (vannal) veins; *ANP,* anterior notal wing process; *1Ax, 2Ax, 3Ax, 4Ax,* first, second, third, and fourth axillary sclerites; *C,* costa; *Cu,* cubitus; *IAbT,* first abdominal tergum; *M,* media; *m, m',* median plates of wing base; *MsT,* mesothoracic tergum; *MtT,* metathoracic tergum; *P,* tergal arm connected to anal veins of wing; *1Ph,* first phragma; *Psc,* lateral prescutal area; *R,* radius; *R+M,* united shafts of radius and media in hind wing; *Sa,* secondary anal vein; *Sc,* subcosta; *Scl,* scutellum; *Sct,* principal part of scutum; *Sct',* posterior, lateral subdivisions of scutum; *SpT,* spinose tubercle of lateral prescutal area of mesotergum; *Tg,* tegula; *Vd,* vena dividens.

Figure 6.3 Grasshopper pterothorax, dorsal view (Carbonnell, 1959)

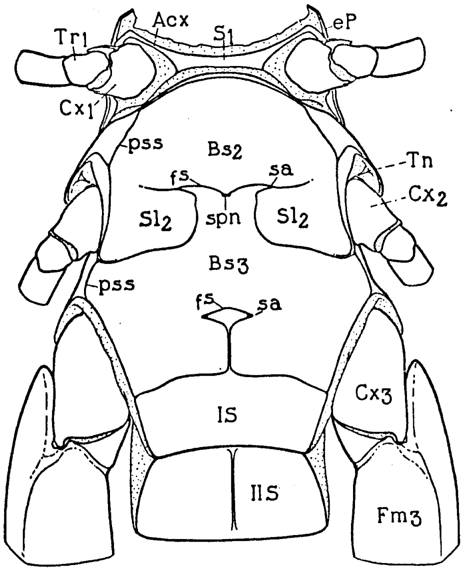


Fig. 9.—Thoracic sterna and base of abdomen of *Marellia remipes.*

Acx, antecostal bridge of prosternum; *Bs,* basisternum; *Cx,* coxa; *eP,* edge of pronotum; *Fm,* femur; *fs,* furcal suture; *pss,* pleurosternal suture; *IS,* first abdominal sternum; *IIS,* second abdominal sternum; *S1,* prothoracic sternal plate; *sa, sa,* roots of sternal apophyses; *Sl,* sternellum; *spn,* depression marking the site of the internal spina; *Tn,* trochantin; *Tr,* trochanter.

Figure 6.4 Grasshopper thorax, ventral view (Carbonnell, 1959)

and forth and try to identify the axillary sclerites (1Ax, 2Ax, 3Ax) and the median plate (m, m'). (Note that the median plate is itself divided by a membranous line and that it flexes when you move the wing.) Note how the sclerites of the wing base move as you move the wing from being parallel to the long axis of the body to being perpendicular.

In ventral view (Fig. 6.4), identify the paired sternal apophyseal pits (sa) which are connected by a transverse suture called the sternacostal suture (fs). This suture divides the sternum into an anterior basisternum (Bs) and a posterior sternellum (Sl). The intersegmental spinasterna are not visible in this species (but you will see these when you inspect the plecopteran thorax).

Finally, observe the cleared thorax of *Romalea* and identify the sternal and pleural apophyseal arms which are fused to form the furcae (singl., furca), strong bars on either side of the pterothorax which serve as

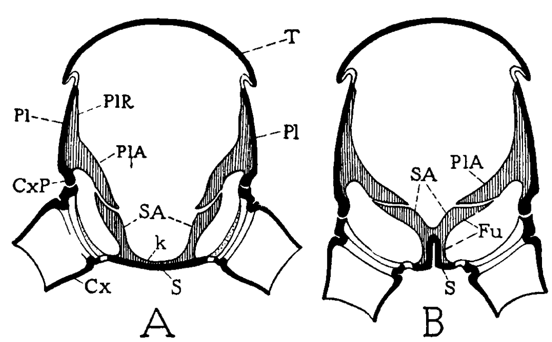


Fig. 92.—Diagrammatic cross section of thoracic segments illustrating the evolution of the furca (B, *Fu*) from the sternal apophyses (A, *SA*) and the inflected median part of the sternum (*S*).

Figure 6.5 (Snodgrass, 1935)

buttresses and sites of muscle attachment. Fig. 6.5 shows in diagrammatic view the relationship between the pleural and sternal apophyseal arms.

2.

Ever since Snodgrass, plecopteran nymphs have enjoyed an honored position in insect morphology because of their prothoracic pleuron. In several groups of apterygote insects, including certain Collembola and Protura, the pleural sclerites are narrow, concentric rings above and in front of the coxa (as in Myriopoda!). The upper sclerite is the anapleurite (Apl in Fig. 6.6) [the prefix "ana-" means "upper" or "up"], the lower one the coxopleurite (Cxpl) [because it contacts the coxa]. Plecoptera is the only group of pterygote insects in which the pleuron (of the prothorax only) has an anapleurite and coxopleurite, and this is generally interpreted as the ancestral condition for insects.

Examine the demonstration of the thoracic structure of a Plecoptera nymph (Perlidae). Note that the gills have been removed to facilitate observations, as have the legs below the trochanters. Examine the lateral

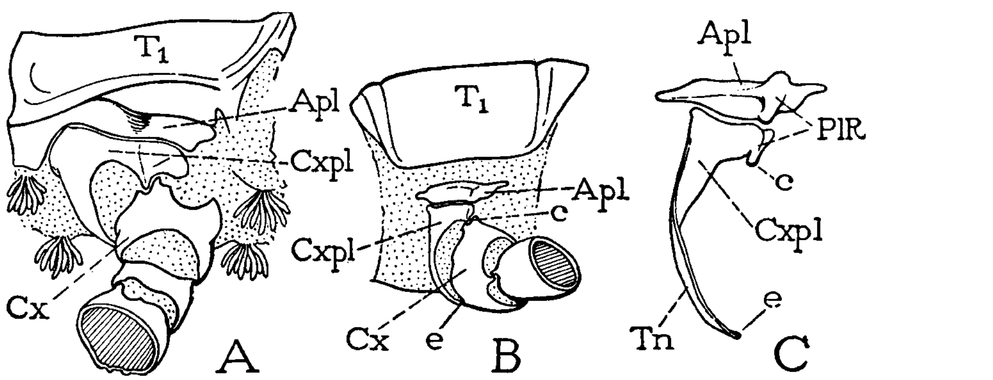


FIG. 90.—Examples of the retention of a distinct anapleurite and coxopleurite in the prothorax of pterygote insects (Plecoptera). A, larva of *Pteronarcys*. B, larva of *Perla*, external view. C, same, internal view.

Figure 6.6 stonefly prothorax (Snodgrass, 1935)

aspect of the nymph and identify the following structures of the prothorax with the help of Fig. 6.6).

Prothorax*:
tergum (T_1)
trochanter
coxa (Cx)
pleuro-coxal articulation
coxopleurite (=catapleurite) (Cxpl)
trochantin (lobe of coxopleurite)
anapleurite (Apl)

3.

Obtain your own specimen of an adult plecopteran. In lateral view, identify the following structures with the help of Fig. 6.6.

<u>Prothorax</u>*:	**<u>Meso- or Metathorax</u>:**
tergum (T_1)	**gill**
trochanter	**trochanter**
coxa (Cx)	**coxa**
pleuro-coxal articulation	**pleuro-coxal articulation**
coxopleurite (Cxpl)	**trochantin**
anapleurite (Apl)	**pleural suture**
trochantin (lobe of coxopleurite)	**episternum**
	epimeron

Examine the ventral aspect of the thorax and note that the mesothoracic sternum overlaps the prothoracic sternum anteriorly, as does the metasternum to the mesosternum. Note that the spinasternum is not a separate sclerite, but that median <u>spinal pits</u> are located at the posterior margins of sterna I and II. Identify the following:

furcal pits	**sternacostal suture**
sternellum	**basisternum**
trochantin	**coxae**
spinal pits	

In dorsal view of the thorax, identify the <u>alinotum</u> and the <u>postnotum</u> of the meso- and metathorax.

4.

Observe the demonstration of the cleared thorax of the plecopteran nymphal thorax. Note the apodemes invaginating from the sterna that comprise the "endoskeleton" to which muscles attach: the <u>sternal apophyseal arms</u> (arising from the <u>sternal apophyseal pits</u>), <u>sternacosta</u> (arising from the sternacostal suture) and the <u>spina</u> (arising from the spinal pit).

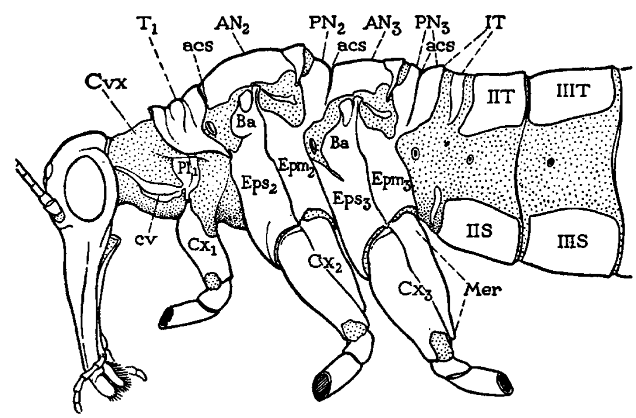


FIG. 99.—Head, thorax, and base of abdomen of *Panorpa consuetudinis*.

Figure 6.7 scorpionfly thorax (Snodgrass, 1935)

5.

Obtain a specimen of *Panorpa*, the scorpionfly (Mecoptera), an example of an insect with a generalized ptrerygote thorax. Judging by the degree of sclerotization, would you expect this insect to be a strong flier? Are both pterothoracic segments equally developed? Does this insect use predominantly one pair of wings in flight? How does the prothorax differ from the meso- and metathorax? Using Fig. 6.7, locate the following structures:

pronotum (T_1)
antecostal suture* (acs)
scutum* (AN)
scutellum*
postnotum* (PN)
abdominal tergum I (IT)
propleuron (Pl_1)
(=episternum 1)
episternum* (Eps)
epimeron* (Epm)
pleural suture*
pleural wing process
basalare (fused with episternum)* (Ba)
subalare*
coxae (Cx)
meron (Mer)*+
pleuro-coxal articulation (dorsal)
spiracles

***meso- and metathorax only**
+part of pleural wall in Diptera

The coxae nearly meet ventrally along the midline, as is typical of the Endopterygota. A small eusternum bearing furcal pits is present on the prothorax. The episterna of the meso- and metathorax appear to meet along the midline, marked by a groove, the discrimen. Median furcal pits can be seen between the meso- and metathoracic coxae on narrow furcasterna (Fu).

Examine the demonstration of the cleared thorax of the *Panorpa* in which the invaginations of the sterna have been exposed. Identify the median endoskeletons marked externally by the discrimen, and the V-shaped furca (with the help of Fig. 6.5B).

6.

Obtain a specimen of the honey bee (Hymenoptera: Apidae). Although the bee has two pairs of wings, only the forewing provides flight power. The metathorax is reduced to a narrow metanotum (N_3) and metapleuron (Pl_3 in Fig. 6.8). The first abdominal tergum is solidly attached to the metathorax, forming the propodeum (IT). The prothorax consists of a pronotum (N_1) that is fused to the mesothorax (N_2). The remainder of the prothorax, composed of the episternum (Eps), sternum, and legs, is movably attached to the pronotum.

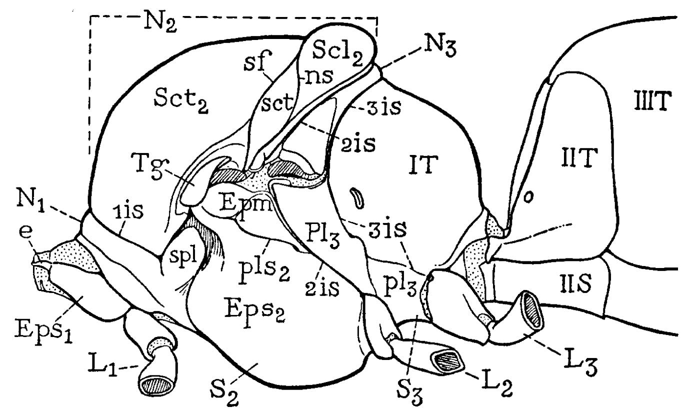


Fig. 30. Thorax and base of abdomen of a worker bee.
e, occipital process of prothoracic episternum. For explanation of abbreviations see pages 92–93.

Figure 6.8 honey bee thorax (Snodgrass, 1956)

The pterothoracic pleural area of the bee presents one of the most difficult problems of homology in the insect thorax. The pleural suture is not separately defined and perhaps is partly identical with the vertical portion of the meso-metapleural intersegmental groove (2iS). Locate the following parts of the mesothorax:

pleuron (=episternum) (Eps_2)
scutum (Sct_2)
scutellum ($Sc1_2$)

7.

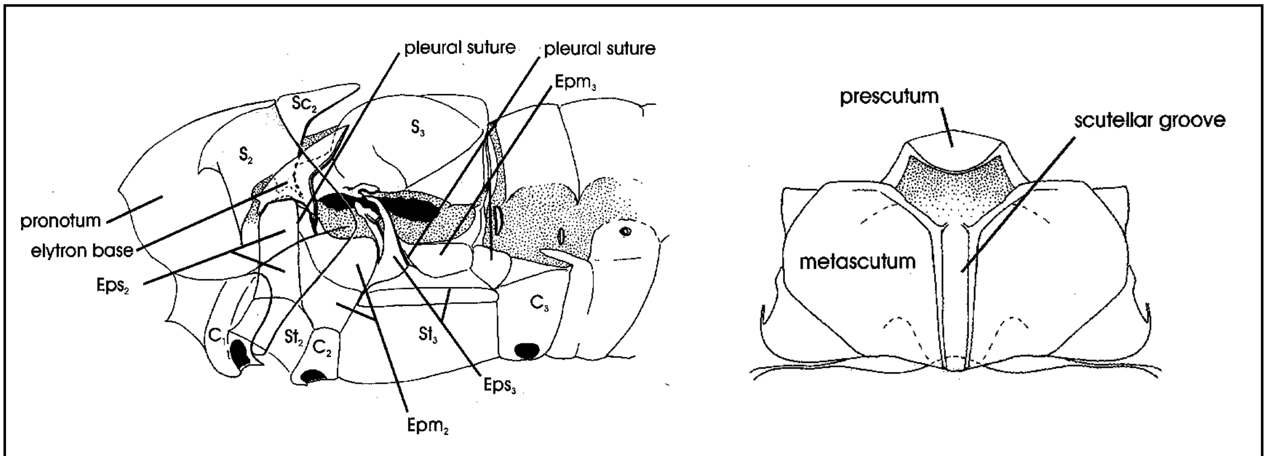
Obtain a specimen of the June beetle (Coleoptera: Scarabaeidae), an insect whose main flight force is provided by the hind wings. Note that the prothorax is movable upon the pterothorax and consists mainly of the pronotum (Fig. 6.9). The mesothorax is weakly developed in beetles because the first pair of wings, the elytra, play very minor role in flight. The elytra vibrate in phase with the hind wing but at a much lower amplitude and thus generate little additonal lift. Locate the following mesothoracic structures with the help of Figs. 6.9 and 6.10):

episternum (Eps_2)	**pleural suture**
epimeron (Epm_2)	**mesosternum (St_2)**
scutum (S_2)	**scutellum (Sc_2)**

The enlarged metathorax is the primary flight motor in beetles (as you can tell by comparing its size to that of the mesothorax). In dorsal view (Fig. 6.10) the beetle metathorax is difficult to interpret. The median depressed strip probably incorporates posteriorly part of the scutellum (defined internally) and anteriorly a median projection of the prescutum. Most of the rest of the dorsum is the scutum (S_3), with a narrow postnotum (Pn) on its posterior edge that extends to the wing bases.

The metapleuron in the june beetle should look quite different than the metapleuron in more generalized insect (such as *Romalea*). In beetles the entire metapleuron is rotated nearly 90° counter-clockwise so that the s-shaped pleural suture now runs horizontally rather than vertically. What does this suggest about the orientation of beetle indirect flight musculature? What effect might this change have on wing movements? In lateral view, locate:

episternum (Eps_3)	**pleural suture**
epimeron (Epm_3)	**metasternum (St_3)**
coxa 2 (C_2)	**coxa 3 (C_3)**



Figures 6.9 and 6.10 June beetle (Phyllophaga sp.) thorax; lateral view (right) and dorsal view of metathorax (left). C. Marshall

8.

Select three preserved specimens of your species. Carefully remove the wings, including the basal (axillary) sclerites, although do not destroy the thoracic sclerites. Heads will not be drawn and may be removed if necessary to expose prothoracic structures. In specimen 2, the end of the abdomen should be removed to facilitate penetration of the clearing agent, although the base should be intact. (Hint: work in alcohol or water. Identify the axillary sclerites before removing the wings, getting help from TA).

(a) Pin specimen 1 dorso-ventrally through the right side of the thorax and allow to dry. Hair or scales may be removed with a pin-point or brush if they obscure sutures.

(b) Split the thorax of specimen 2 longitudinally along the midline and clear both halves by placing them in a test tube with 10% KOH or NaOH. Place the test tube in a beaker of boiling water and allow to clear. Remove from the heat, pour the contents of the test tube into a dish, and allow to cool. Rinse the thorax halves in distilled water. Remove remaining crud from the insides with forceps and probes. (Hint: for well sclerotized insects, splitting in half may be left until later.)

If your specimen is heavily melanized, you may wish to bleach the cleaned thorax halves. After cleaning and rinsing in distilled water, place them in 10% hydrochloric acid for a few seconds. Then transfer to clorox and leave until color is removed. Repeat acid and clorox treatments if still too dark. Rinse in distilled water.

Cuticle staining: If your insect is relatively weakly sclerotized you may need to stain the cuticle following clearing with NaOH. If so, place it in a watch glass of aqueous Chlorazol Black E stain for a short period of time, less than a minute. Remove and rinse in distilled water and observe under the microscope. Repeat until the proper degree of staining is reached.

For both stained and unstained thoraces, rinse in water following the clearing steps above, then transfer to 70% ethanol or (better) glycerol in a depression slide. Once in glycerol the cleared thorax can be examined in detail and internal as well as external structures clearly seen. Note: it is often important to interpret some external structures (e.g. sulci, sutures) in light of internal structures (e.g., carinae, ridges, phragma, etc.). Before you begin the drawing (below) relate structures visible internally (in the cleared thorax) to those visible externally.

(c) Maintain the third specimen in alcohol.

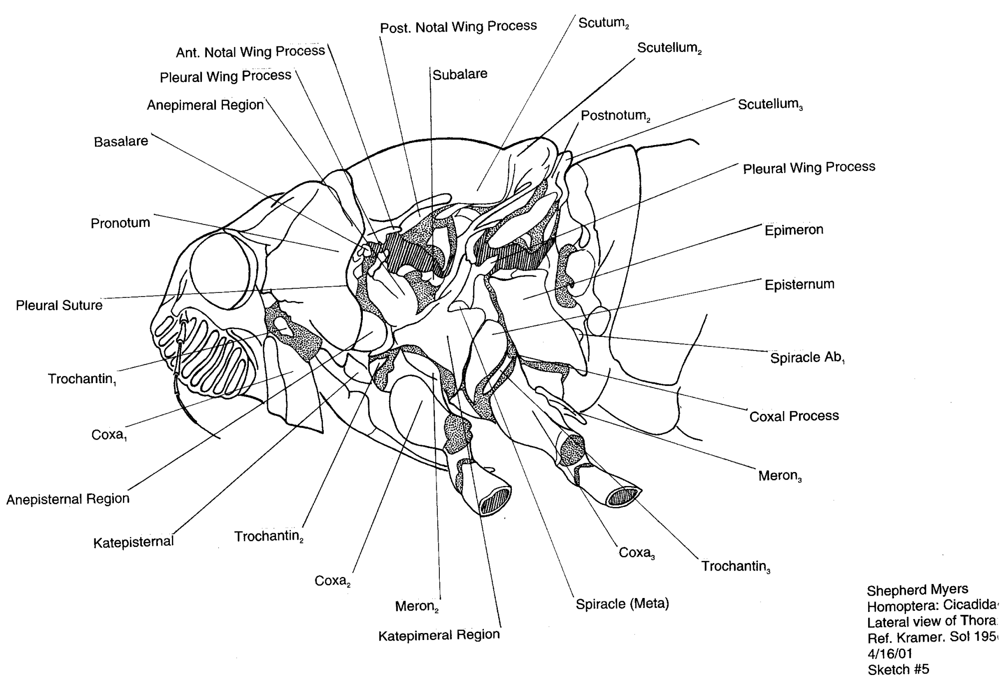
Examine your specimens as to the principal thoracic regions and sclerites. Dry, alcohol-preserved, cleared, and cleared and stained specimens may all prove valuable for different aspects of examination. There is a great deal of difference among orders as to sclerite development and nomenclature, and each student must largely work on his or her own, using pertinent references to his or her order. Identify the <u>prothorax</u>, <u>mesothorax</u>, and <u>metathorax</u> (Hymenopterists: and <u>propodeum</u>) and the intersegmental grooves separating them. Which segment is the largest? Does this correspond with wing development? Identify the principal sclerites in the thorax, ignoring small subdivisions of the sclerites (unless otherwise called for). You may find that hair or scales are a problem; you can tediously remove these from a dried specimen with the moistened end of a pin, although you will find that they are usually less of a problem in specimens observed under alcohol. You should be able to identify or account for the absence of:

prescutum	**sternellum**	**pleural wing process**
scutum	**basisternum**	**notal wing processes**
scutellum	**epimeron**	**basalare**
postnotum	**spinasternum**	**subalare**
episternum	**furcal pits**	
pleural suture	**discrimen (Endopterygota)**	
coxopleural articulation	**coxae**	
meron (Diptera)	**meso- and metathoracic spiracles**	
trochantin		
pre-episternum (Endopterygota)		

After you are satisfied with your knowledge of the external anatomy of the thorax, select any of the left halves that you prefer to draw. If alcohol-preserved, pin though the attached abdomen in a dissecting dish, lateral view, head to the left, and cover completely with 70% ethanol. If dry, pin to the cork, same view. Be sure that pins, legs, head, and abdomen do not obscure the thorax. (Hint: for most insects, the non-cleared thorax in alcohol will be best.)

Sketch #2: Lateral view of insect thorax.

Sketch the lateral view of the thorax. Do not show hair or scales, color pattern or various irregularities in the cuticle. Indicate only the principal sclerites and grooves in the thorax, as listed above. An outline drawing will suffice; membrane should be indicated by stippling (dots). Positions of cut wing bases should be indicated by parallel diagonal lines. Legs should be deleted below the trochanters. Include the base of abdominal segment 1 and at least the posterior edge of the head for reference.



Shepherd Myers (Spring, 2001).