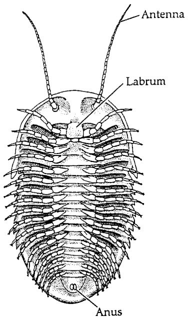

ENTOMOLOGY 322 LAB 5
Arthropod Appendages and Locomotion

The phylum Arthropoda (arthro-, jointed; -pod, foot) was recognized by early systematists as a discrete (monophyletic) group because of the distinctive nature of their jointed appendages. The primitive condition for arthropods is for each segment of the body to bear a single pair of multi-segmented appendages. With the increasing evolutionary specialization of different body regions (tagmosis), the legs have also become regionally differentiated. Arthropod legs have become specialized for, among other things, walking, jumping, feeding, carrying eggs, respiration (aquatic and terrestrial), sperm transfer, and swimming. In some groups (such as Crustacea) these specializations may even be found on the same individual!

The terminology that has developed around identifying homologous elements in arthropod legs is extremely complex. Arthropods show two basic leg configurations: uniramous and biramous. Uniramous appendages are present in insects (Fig. 5.1F), myriopods, chelicerates (Fig. 5.1E), trilobites

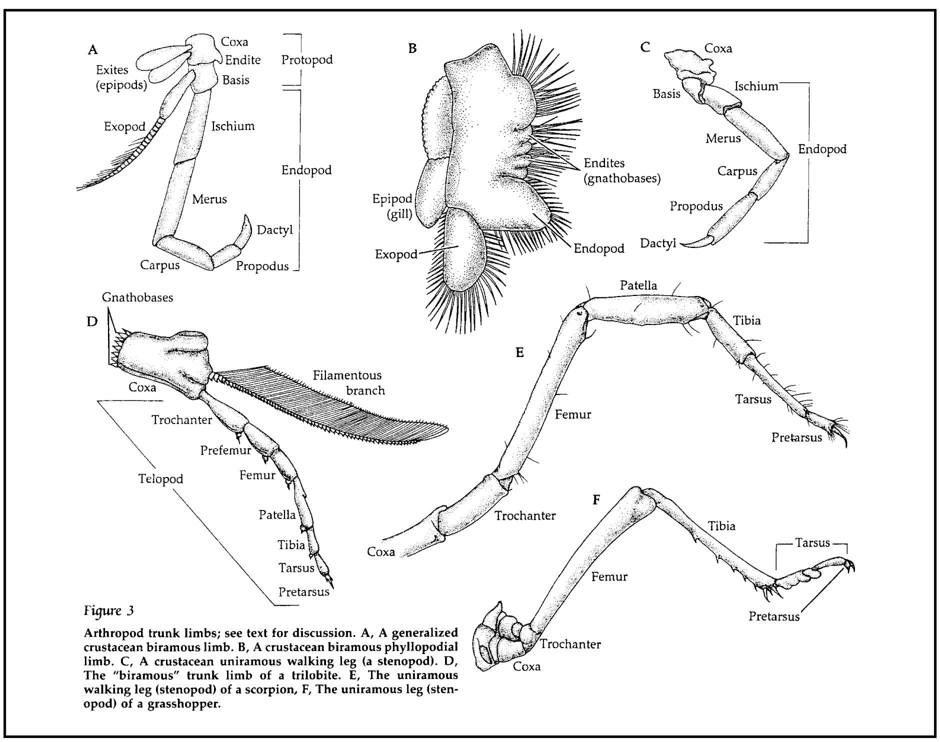

Figure 3

Arthropod trunk limbs; see text for discussion. A, A generalized crustacean biramous limb. B, A crustacean biramous phyllopodial limb. C, A crustacean uniramous walking leg (a stenopod). D, The "biramous" trunk limb of a trilobite. E, The uniramous walking leg (stenopod) of a scorpion, F, The uniramous leg (stenopod) of a grasshopper.

Figure 5.1 Comparison of various arthropod limb types (Brusca & Brusca, 1990).

(Fig. 5.1D) and some crustaceans (Fig. 5.1C). In uniramous appendages the leg consists of a large, basal coxa, which gives rise to the elongate telopodite. While uniramous limbs may have additional branches, called epipodites, these invariably arise from the coxa. True biramous limbs are only present in the Crustacea (Fig. 5.1A). In biramous appendages the basal segment is again the coxa, but arising laterally from the trochanter is a second ramus of the leg, the exopodite. To make matters worse, the biramous limbs of the Crustacea may also have epipodites (arising from the coxa), thus appearing multiramous.

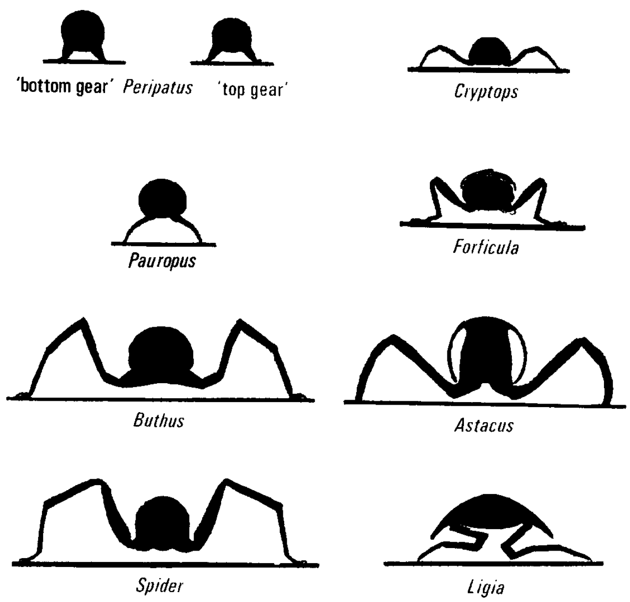

FIG. 5.1. Single segments of a series of arthropods in transverse section, with their limbs drawn relative to the ground as seen in living animals. The two figures of *Peripatus* represent the same segment employing different gaits. The scorpion and spider show walking legs 3, *Astacus* walking leg 2, and *Ligia* walking leg 6. (After Manton 1952*a*.)

Figure 5.2 Body postures in selected arthropods (Manton, 19--).

Trilobites (Fig. 5.1D) present an exceptionally difficult morphology which has been interpreted as either biramous or uniramous. We shall follow Snodgrass (1935) and Brusca & Brusca (1990) and consider the outer ramus of the trilobite limb an epipodite, thus interpreting their limbs as uniramous.

1.

Examine the demonstration of an onychophoran. Note that the integument is entirely flexible and only the claws on the appendages are sclerotized, and that the ringed trunk is not segmented externally. The unsegmented appendages, lobopods, expand and contract accordian-like when the onychophoran walks.

2.

Examine the demonstration of a <u>pleopod</u> (abdominal appendage) of a crayfish, an example of a biramous appendage typical of Crustacea (Fig. 5.3). Note that there are two branches arising from the second podite: an inner branch (the <u>telopodite</u>) and an outer branch (an <u>exopodite</u>).

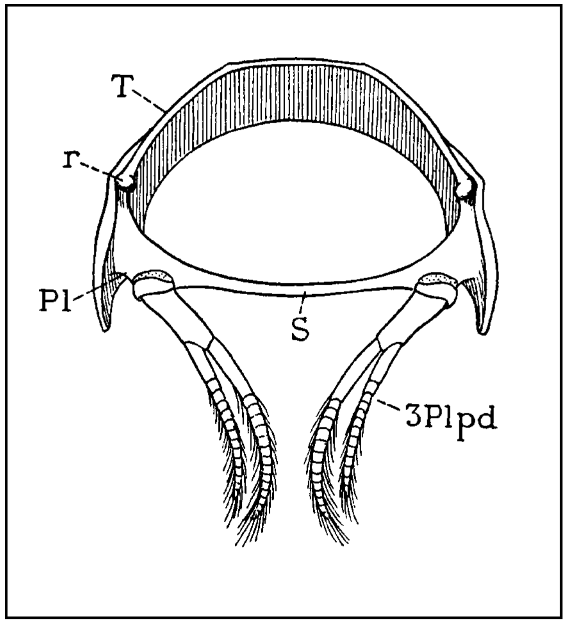

Figure 5.3 Crayfish pleopods (Snodgrass, 1935).

3.

Obtain a live daddy-longlegs (Arachnida: Opiliones) and observe its locomotion. In what order are the legs moved? Where is the "knee"? How is the leg brought forwards and back (protraction and retraction) in relation to the body? How is the body held in relation to the legs? Can the animal move backwards?

4.

Obtain a live millipede (Myriapoda: Diplopoda) and ask the same questions as you did for the daddy-longlegs (the "knee" will probably not be visible). Note how the waves of leg movement pass down the animal.

5.

Obtain a preserved lubber grasshopper (*Romalea micropteryx*). Examine the legs and identify the following podites (using Fig. 5.4 for help):

coxa	**tibia**
trochanter	**tarsus**
femur	**pretarsus**

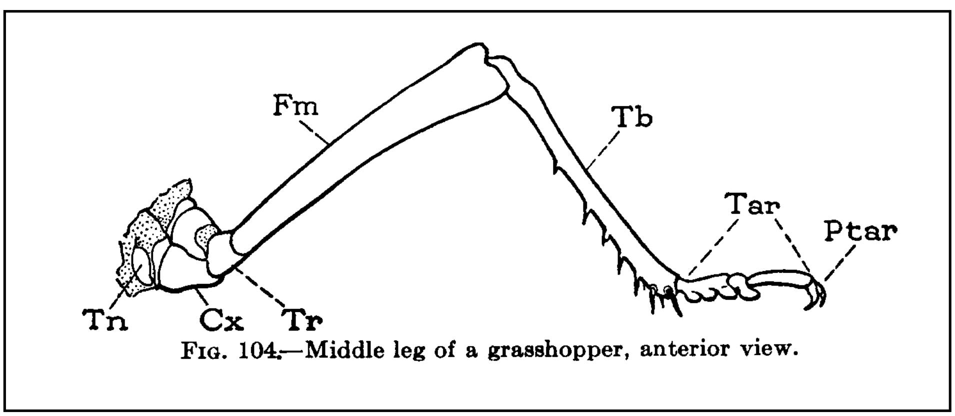

Figure 5.4 Middle leg of a grasshopper (Snodgrass, 1935).

Move the front and middle leg with your fingers. Observe how the podites move in relation to each other. At which joints do the following motions occur?

promotion-remotion of the coxa
levation-depression of the leg
abduction-adduction

Examine the tibia-femoral joint in detail. Locate the arthrodial membrane joining the podites and the articulations (the "hinges" upon which the tibia swings). Is this a monocondylic or dicondylic articulation?

Examine the coxa of the middle leg in detail. Can you tell whether its articulation with the thorax is monocondylic or dicondylic? How does the coxa move in relation to the thorax? How far forward and backward can the leg move? Locate the following structures (using Fig. 5.5 for help):

basicoxite (Bcx)
anterior coxotrochanteral articulation (f)
basicostal sulcus (bcs)
coxal sulcus (cxs)
meron (Mer)
trochantin (Tn)

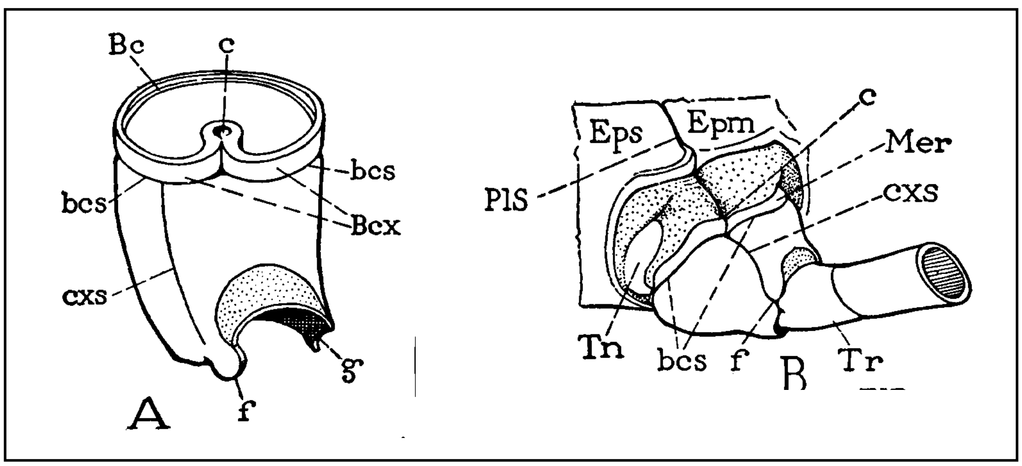

Figure 5.5 Grasshopper coxa, diagramatic (A) and actual (B) (Snodgrass, 1935).

Now examine the articulations of the front and hind legs with the thorax, comparing the coxal structure and degree of leg movement that is possible in each case

Examine the tarsus of the middle leg in more detail. How is it articulated with the tibia? How many tarsomeres are there, and how are they connected to each other? Note the development of pads on the bottom surfaces of the tarsomeres. Examine the pretarsus and note the lateral claws and the median pad or arolium. The arolium adheres to smooth surfaces.

Examine the demonstration of the "cleared" pretarsus of a grasshopper. Locate the following (with the help of Fig. 5.6):

claws (Un -- ungues)
arolium (Ar)
unguitractor plate (Utr)
planta (Pln)
apodeme of the depressor muscle (110Ap) -- which depresses the pretarsus.

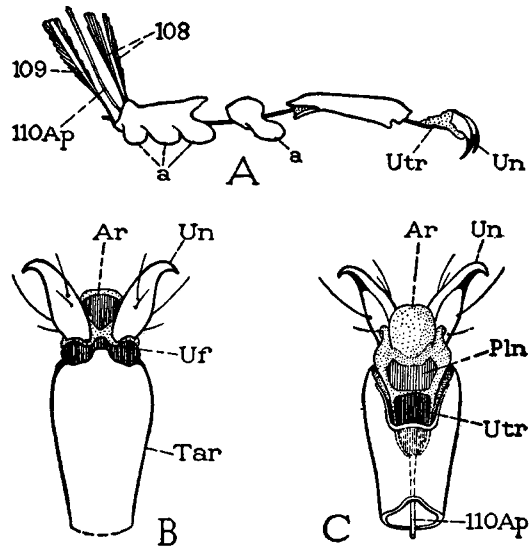

FIG. 118.—Pretarsus of a grasshopper, *Dissosteira carolina*. A, tarsus and pretarsus disjointed, showing tendonlike apodeme (*110Ap*) of depressor of pretarsus. B, pretarsus and end of tarsus, dorsal view. C, same, ventral view. *Ar*, arolium; *Pln*, planta; *Tar*, tarsus; *Uf*, unguifer; *Un*, ungues; *Utr*, unguitractor plate.

Figure 5.6 Pretarsus of a grasshopper (Snodgrass, 1935).

Observe the demonstration dissections of the muscles of the hind leg. In the dissection of the thorax, note the extrinsic leg muscles originating in the thorax and extending into the leg to insert on the coxa and trochanter. With the help of Fig. 5.7, indentify the following muscles:

tergal promotor of the coxa (muscle 118)
tergal remotor of the coxa (muscle 119 & 120)
extra-coxal depressor of the trochanter (133c and 133d)

While these names refer to the actions of these muscles on the legs, some of these muscles also act on the wing base, thereby causing important changes in wing direction during flight. We shall examine these same muscles again in a later lab on wing movement.

In the dissection of the leg (Fig. 5.8), note the intrinsic muscles that originate in the femur and insert in the base of the tibia. Which are larger, the extensors (levators; 135a,b) or the flexors (depressors; 136a)? How does this correlate with the power needed for jumping? Note the numerous, short, thick

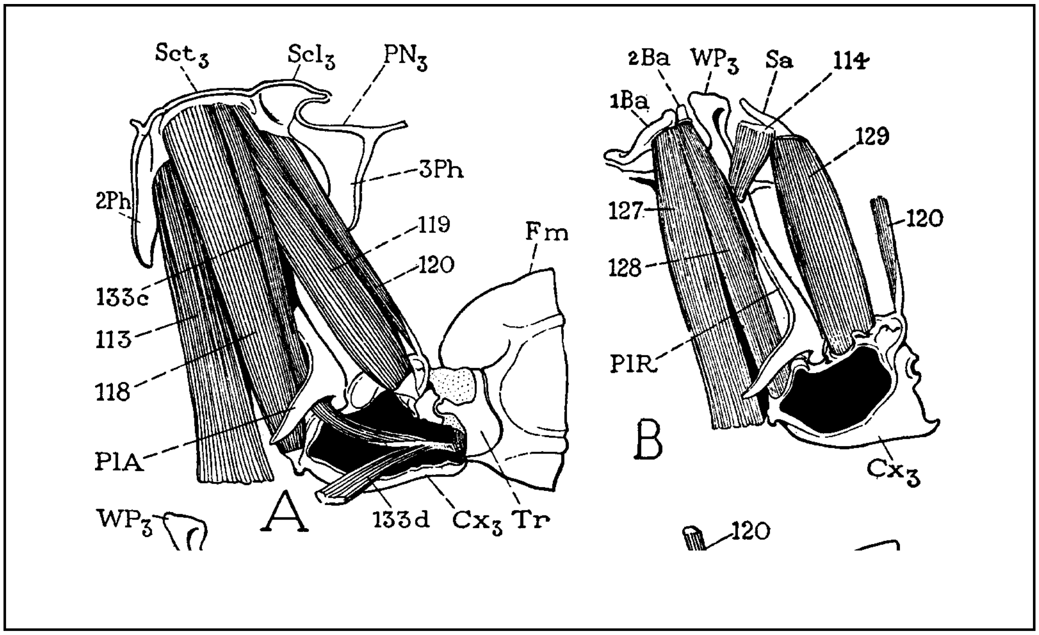

Figure 5.7 Extrinsic leg muscles (Snodgrass, 1935).

extensor muscles that originate on the face of the femur and insert on the apodeme (135Ap) that extends from the tibia. In the coxa, note the thick antagonistic intrinsic muscles that originate on the coxal walls and insert on the trochanter (131, 132, 133a). What movements do they impart to the leg?

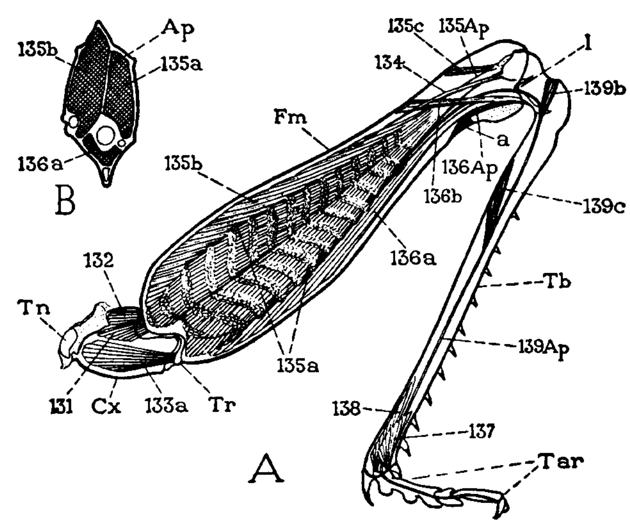

FIG. 116.—Muscles of the hind leg of a grasshopper, *Dissosteira carolina*: *131*, *132*, levators of trochanter; *133a*, coxal branch of depressor of trochanter; *134*, *135*, levators of tibia; *136*, depressor of tibia; *137*, *138*, levator and depressor of tarsus; *139*, depressor of pretarsus (retractor of claws).

Figure 5.8 Musculature of the grasshopper leg (Snodgrass, 1935)

6.

Obtain a live grasshopper and allow it to walk. How does it use its hind legs? Provoke it to jump. How does it hold its hind legs before jumping? How are these legs used in jumping? Hold the grasshopper in the palm of your hand, and feel the pressure applied by the hind legs.

7.

Obtain a live milkweed bug (Hemiptera: *Oncopeltus fasciatus*) (or any live insect that is available) and place it in a covered petri-dish. Observe the walking and running movements. In what succession do the legs move? What are the fields of movement of each leg? How many legs are on the substrate at one time? Can you see why insects are said to have "alternating tripod gait." While walking, how do the leg podites move in relation to each other? How far above the substrate is the body held? Flip the petri-dish over to force the mildweed bug to walk upside down on the clear plastic surface of the petri dish. What portions of the leg touch the substrate while walking? Can you tell how these insects can retain traction on a smooth surface of the petri dish? (You may have to view the feet under the microscope to see this clearly.)

8.

Examine the legs of your insect. How are the legs positioned on the thorax? Identify the podites of each leg. Which are the most developed? How does this coincide with the principal movements of the leg? What special modifications are present in your insect's legs that are not present in the roach's legs?

Remove the tarsus with the pretarsus from both legs of the largest pair and place one in a test tube with 10% potassium hydroxide (KOH) or sodium hydroxide (NaOH). Place this test tube in a beaker of boiling water on a hotplate. Heat the structure until it is "clear" (the muscles are dissolved); the dark pigments are in the cuticle and cannot be removed by this process. With a test-tube holder, pour the test tube contents into a watch glass, and then decant the clearing solution and replace it with distilled water. Use care in handling the KOH or NaOH; it is "caustic" and can burn fingers and damage clothing. If you get any on your skin, wash immediately.

You can examine the cleared pretarsus and tarsus under water in the watch glass, or you can make a temporary slide-mount by placing it in glycerine on a clean microscope slide and covering with a cover slip. The slide-mount can be examined under a compound microscope. In what ways is the pretarsus adapted for grasping surfaces? Using Fig. 5.9 identify the following if present:

claws
arolium (or empodium in Diptera)
pulvilli*
unguitractor plate
apodeme of depressor muscle
auxiliary sclerites
planta*
manubrium*

***only in certain insects.**

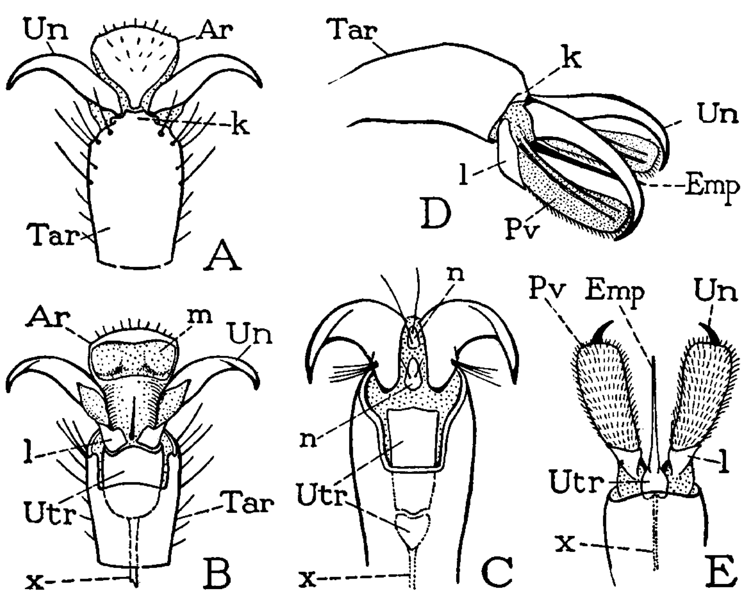

FIG. 111.—Examples of "foot" structures of insects. A, *Periplaneta americana*, dorsal view. B, same, ventral view. C, *Magicicada septendecim*, ventral view. D, asilid fly, lateral view. E, same, ventral view. *Ar*, arolium (dorsal lobe); *Emp*, empodium (median ventral process or lobe); *k*, unguifer process of tarsus; *l*, auxilia; *m*, aroliar pad; *n*, accessory sclerites between claws; *Pv*, pulvillus (lateral ventral lobe); *Tar*, tarsus; *Un*, ungues (lateral pretarsal claws); *Utr*, ungitractor plate; *x*, "tendon" of depressor muscle of pretarsus (retractor of claws).

Figure 5.9 Morphology of the pretarsus in insects (Snodgrass, 1935).

Sketch #1: Lateral view of insect leg.

Sort through your bugs and find one (or more) with intact and relatively flexible legs. Pick a leg that shows interesting morphological adaptations for a particular function, such as swimming, grasping, capturing prey, etc. Do a sagittal section of this bug (i.e., split it down the midline) and pin the specimen left-side-up in a dissecting pan covered with 70% ethanol. Pin a leg so that all the important structures are clearly visible in the least possible amount of space (use minutins to position the leg). Draw enough of othe thorax to see the attachment of the leg. Do not show hair or scales, color patterns, or various irregularities in the cuticle. Sclerites should be indicated in outline only and membranes should be stippled. Label the structures indicated below as they appear in your bug. Refer to Appendix III for additional information on sketching techniques.

coxa	basicoxite
trochanter	basicostal suture
femur	coxal sulcus
tibia	meron
tarsus	trochantin
pretarsus	claws
arolium	

Note: If you have pinned specimens of your bug and the legs are intact and in good shape, you may wish to make the drawing using pinned material. If so, find a pinned specimen in which the leg you wish to draw is in a good position for drawing (i.e. in a flat plane). Position this specimen under the microscope and follow the directions above.