INSECT MORPHOLOGY - LEGS

* The fact that arthropods are and have been serially metameric animals from their very early beginnings has provided an evolutionary platform from which great diversity has been achieved. The presence of similar appendages on each of the metameres which were presumably primitively designed for walking has in great part been responsible for the great diversity seen today.

* Today the segmental appendages serve many functions. Walking, swimming, jumping, carrying, digging, grasping, feeding, etc.

* The most primitive arthropods known, the trilobites had segmental appendages which were fully segmented in available fossils. Note the labrum over the mouth and the 18 pairs of segmental appendages (4+3+11) which are all similar and apparently function for walking. The fossil record does not extend further back to the trilobite ancestors to allow us a glimpse of how arthropod legs arrived at a primitively 8-segmented condition. So, we must turn to embryology and comparative anatomy to gain insight into phylogenetic relationships among the arthropods. We still will gain very little understanding into the phylogenetic development of arthropod limbs.

* Embryological evidence shows that regardless of the final adult form, all arthropod appendages have the same origin in the embryo, namely, from paired, lateroventral bud-like lobes of the body segments. Also, the embryonic development of the legs in the arthropods is very similar to that seen in the onychophorans, suggesting that they are homologous. The musculature of the 2 groups also supports their being homologous.

* The leg is a tubular outgrowth of the body wall. Its movable sections are called **podomeres**, and are merely the sclerotized parts of the tube, and the **joints** are short unsclerotized parts between them. Snodgrass equates podomeres and podites, but this is no longer true. In fact, in later writings of Snodgrass he admits that there is a difference. A **podomere** is simply a segment of a limb. A **podite** is a true segment of the limb that can be recognized by have muscles inserted on the walls of the segment. A podite is a type of podomere. The true segments may be subdivided into subsegments. This is especially true in the tarsus where up to 5 subsegments are recognized. These are more correctly called **tarsomeres**. The only known case where true tarsal segments are known is in the male pycnogonid where individual tarsomeres are individually musculated.

* To limit the movement at the intersegmental limb joint, the ends of the adjoining segments are specifically articulated on each other. An **<u>articulation</u>** is usually formed by the extension of an articular process from the base of the distal segment through the joint membrane and is received in a socket on the end of the proximal segment. The hinge is sometimes vertical; sometimes horizontal and as in B, there may only be one articulation. Articulations are generally absent between non-musculated subsegments, allowing free movement in all directions.

* The joint between the coxa and the body wall may be monocondylic, dicondylic, or even more complicated. It may articulate with any one of several small sclerites, with the pleura, and/or the sternum. The joint between the coxa and the trochanter is always a dicondylic joint with motion restricted to a forward and backward direction. The joint between the trochanter and the femur is usually fairly firmly attached or with only a small amount of movement posible. The joint between the femur and the tibia is another dicondylic joint similar to the coxo-trochanteral joint.

* The joints are named in a special way. When naming them use the more proximal part as the first part of a compound adjective and the more distal part as the second part. The first part ends in "o" and the second part in "al" as:

coxo-trochanteral joint, femoro-tibial, etc.

* The primitive limb probably had 8 segments as in the trilobites. Zoologists give special names to them not often used by entomologists.

* The limb can first be divided into a **basis** (the **coxopodite**) and a distal arm, the **telopodite.**

1. **COXO**podite	Coxa + subcoxa
2. **BASI**podite	1st trochanter
3. **ISCHIO**podite	2nd trochanter
4. **MERO**podite	femur
5. patella	patella
6. **CARPO**podite	tibia
7. **PRO**podite	tarsus
8. **DACTYLO**podite	pretarsus

* **TRILOBITES** - Fig. 19A. All segments about equal except for the small 3-clawed pretarsus. The patella is present in trilobites.

* **EURYPTERIDS** - Fig. 19B. The last 2 pairs of legs appear to be 9-segmented but two rings following coxa may be subdivision because they are not present on other legs.

* **PYCNOGONIDS** - Fig. 19C. What appears to be a leg segment is part of the body wall. Three-clawed pretarsus is present.

* **SOME ARACHNIDS (SOLPUGIDS AND ACARINA)** - Fig. 19D. Same 8 segments present. Second trochanter may be reduced.

* **OTHER ARACHNIDS (SCORPIONS AND MOST OTHERS)** - Fig. 19E. Have only 7 segments by elimination of one of the trochanters. The tarsus is subdivided to include 2 subsegments. The patella is characteristically present in all Chelicerata, including Xiphosurida, which also has only one trochanter.

* **MANDIBULATA** - Figs. 19F-I. Typically lacks a patella, but 2 trochanters are present in most species. Therefore the Crustacea (F) and myriapods typically have 7-segmented legs. The trochanters vary in size.

* The differentiation of the primitive arthropod leg into organs for purposes other than walking or running has been due in large part to the development of outgrowths of various kinds from the outer and inner surfaces of the limb segments. Outgrowths from the outer surface are called **exites**, outgrowths from the inner surface are called **endites**. Coxal exites are always called **epipodites** regardless of their function. They can be seen in trilobites where they probably served in respiration as gills (Figd. 19A, 21B in overhead).

* Crustacea, expecially larval forms, have an exite on the 2nd leg segment (basipodite or first trochanter) which is always called an **exopodite** (Fig. 21A). The presence of the crustacean exopodite has led to this limb being called **biramous.** In many crustaceans, these exopodites serve as temporary swimming organs. They are often reduced in gnathal segments when the pleopods (swimming leg) of the adult assume a swimming function. The pleopods usually retain the biramous form, but never have the structure or segmentation of functional legs, suggesting that their growth is arrested at an early stage of development, if they ever were functional legs.

* The distal parts of limbs may have endites as well. In the crustacea, a **chela** is formed by an endite process of the tarsus (propodite) opposed to the movable pretarsus (dactylopodite) (Fig. 21L). In the scorpion, the movable member of the chela is the tarsus. The tarsus and pretarsus are fused; the endite is formed from the tibia (carpopodite) (Fig. 21K).

* **INSECTS** - Fig. 19J. Insect legs are typically 6-segmented (**coxa, trochanter, femur, tibia, tarsus, pretarsus**) usually having only one trochanter and lacking a patella. The tarsus is subdivided and there is typically a 2-clawed pretarsus. A 2-segmented trochanter (only one is musculated) occurs in the Odonata and in some Hymenoptera, but the second trochanter actually appears to be a part of the femur.

* **Coxae** - The first segment of the insect leg is the **coxa**. It may be variously shaped, but is often in the form of a cone that articulates with the body wall proximally, and with the trochanter distally. The articulation with the body wall may be singular (fig. 8.2a) - this allows for a lot of flexibility, but is not as strong. The articulation may be dicondylic, one articulation with the body wall, and another with the trochantin (fig. 8.2b); this limits flexibility a little, but since the trochantin, itself, is flexibly articulated with the episternum, there is still some freedom of movement. The coxa may have two articulations with the body wall, a pleural articulation and a sternal articulation (fig. 8.2c) - this makes for a stronger joint, but limits articulation to one plane of movement. Finally, in some groups, the hind coxae are fused to the body wall (Coleoptera: Adephaga) or both the middle and hind coxae are fused to the body wall (Lepidoptera).

* Sometimes the basal portion of the coxae is subdivided from the rest of the coxa by a suture, the **basicostal suture**; this suture forms an internal ridge that strengthens the basal area of the coxa for the above articulations. The resulting narrow sclerite at the coxal base is called the **basicoxite**, in some cases, the basicoxite may have a smaller anterior part, and a larger posterior part, this enlarged posterior part is called the **meron**.

* **Trochanter** - This is usually a small segment, it has a dicondylic articulation with the coxa which limits movement to the vertical plane (fig. 81b). See above notes about double trochanters in Hymenoptera and Odonata.

* **Femur** - Often small in larval insects, but usually the largest and strongest leg segment in adult insects. It is usually more or less fused with the trochanter, sometimes there is a little flexion between the two segments.

* **Tibia** - Often a long narrow segment, with a dicondylic articulation with the femur - moves in a vertical plane (fig. 8.1c). The proximal end of the tibia is often bent so that when the tibia is folded inward, it can lie up against the femur.

* **Tarsus** - The tarsi comprise the foot or contact surface of the leg. The tarsus, in most insects, is subdivided into from two to five **tarsomeres**, but never exceeds five. These tarsomeres are not true segments as they lack individual musculature as seen in the other segments. The basal segment, the **basitarsus**, has a monocondylic articulation with the tibia; the rest of the joints lack true articulatory structures, they are freely moveable in the membranous joints. In a few groups, the tarsus is unsegmented and/or fused with the tibia. A pad-like ventral surface or **euplantula** (sometimes called **pulvilli**) on the tarsal segments may enhance the traction of the animal.

* **Pretarsus** - The **pretarsus** of most insects consists of a membranous base supporting a median lobe, the **arolium**, and a pair of **tarsal claws**. The claws (sometimes called **ungues**) articulate with a median process of the last tarsomere called the **unguifer**. There is a ventral plate, called the **unguitractor**, and between this plate and the claws are small plates called **auxilliae**. There is no arolium in most Diptera, but rather a membranous **pulvillus** arises from the base of each auxillia, while a median **empodium** arises from the unguitractor (may be spine-like or lobe-like). In most insects, the tarsal claws are rather uniform in size and shape, but in others one claw may be more highly developed than the other, and in some groups there is a single claw.

* **General Comments on Leg Musculature** - Another way muscles can be categorized: **extrinsic** (arising from outside the leg) and **intrinsic** (occurring totally within the leg, and running from one segment to the next). The coxa is moved by extrinsic muscles, arising in the thorax. The remaining segments are moved by pairs of antagonistic muscles in each segment. There may be extensor and flexor muscles, or levator and depressor muscles. There are no muscles within the tarsus moving the tarsomeres. The pretarsus does have

a depressor muscle, but no levator muscle; levation of the pretarsus results from the elasticity of the basal parts. This depressor muscle is composed of small fibers arising in the femur and tibia which combine to form a long apodeme that inserts onto the unguitractor plate.

* **Specialized leg types and structures**. I am not going over these. Like the different antennal types, I expect you to already know the basic leg types (**raptorial, natatorial, ambulatory, saltatorial, cursorial, fossorial**, etc.).

* Terms related to the movement of legs:

protraction - forward movement of the entire limb.
promotion - movement of the coxa resulting in protraction.
retraction - posterior movement of the entire limb.
remotion - movement of the coxa resulting in retraction.
adduction - movement towards the body, or midline of the body.
abduction - movement away from the body, or midline of the body.
levation - the raising of the leg or a part of the leg.
depression - the lowering of the leg or a part of the leg.
extension - an increase in the angle between two leg segments.
flexion - a decrease in the angle between two leg segments.

* Simple leg movement - At slower speeds, the legs may move in different patterns, but in general, and at higher speeds, insects use an alternating tripod type of movement. By this I mean that the foreleg and hindleg on one side of the body, and the middle leg on the other side of the body will all three be lifted and moved forward at the same time. They then come to rest on the ground and the other three legs are lifted in moved forward. This means that there are always three legs on the ground at a time, and in the shape of a triangle or tripod - this is a fairly stable arrangement.