* The usual number of abdominal segments ranges from 9 to 12. The basic number of segments in the abdomen is eleven plus the **telson** which bears the **anus** (**note:** Matsuda considers the telson to be a true segment). It appears the maximum number in even primitive forms is 12 (only adult proturans and the embryos of some hemimetabolous insects have 12 segments). In the more highly evolved forms there is a tendancy towards a reduction of the first abdominal metamere and a modification of the posterior metameres along with specialization of the appendages employed in copulation and oviposition, so in general, hemimetabolous insects will have more abdominal segments than holometabolous insects. Collembola are exceptional in that they only have six abdominal segments.

* Some Diptera appear to only have 5 abdominal segments, but actually have 9. Segments 6, 7, 8, and 9 form a **pseudo-ovipositor** which is retracted into the abdomen when not in use.

* Most adult insects have the same number of abdominal segments as the immature forms. This means that all of the abdominal segments are developed in the embryo so that both the immatures and the adults have the same number of abdominal segments. This type of development is called **epimorphic**. This is not true in the proturans. They start with 8 abdominal segments and increase to 11 segments and a telson by the 4th instar. This type of development is called **anamorphic**.

* Hymenoptera - In most insects, the abdomen is clearly differentiated from the thorax, but in most of the Hymenoptera (Apocrita), the 1st abdominal segment is fused with the metathorax (called the **propodaeum**) and the 2nd abdominal segment often forms a **petiole** (restricted or narrow) between the thorax + 1st abdominal segment and the rest of the abdomen (now called the **gaster**).

* The abdomen can be divided into 3 regions:
    1. The pregenital (or visceral) region - segments 1-7.
    2. The genital region - segments 8-9.
    3. The postgenital region - segments 10-11 (or more if present).

* **The pregenital segments** - segments 1-7. We have already discussed much of the general structure of these segments when we discussed segmentation. The pre-genital segments are generally unmodified, although segment 1 is often reduced or absent. Remember how the primary intersegmental point of articulation has become sclerotized forming an internal ridge called the **antecosta**. There has developed a secondary point of articulation anterior to the antecosta and the narrow sclerotized plate just anterior to the antecosta. This narrow ridge is the **acrotergite** if associated with the dorsal plates or the **acrosternite** is with the ventral plates.

* Most insects have only 2 sclerites per abdominal segment: a tergum, and a combined pleural area and sternum. True pleurites are found only in a few cases (for example in some of the Thysanura). Laterotergites may appear to be in pleural area. These take in the spiracles which are always dorsal. Laterotergites are often referred to as epipleurites.

* **Spiracles** - these always arise primitively in the tergum; any modification is due to the pleural or sternal regions extending or expanding. Spiracles may occur in the pleural membrane, they may be on small sclerites within the pleural membrane, or more commonly, they may be on the tergites. The greatest possible number of spiracles is 16 pairs (including other body regions, not just abdomen):

    1. one pair on labial segment - seen in honey bee embryos
    2. one pair on prothorax
    3. two pairs on mesothorax
    4. two pairs on metathorax
    5. up to 10 pairs on abdomen - only this many in some embryos

Not all of above are seen in any one insect. Generally, in insects with 11 abdominal segments there will be 8 pairs of abdominal spiracles.

* **The genital segments** - will discuss later as separate topic.

* **The postgenital segments** - When only one postgenital segment is present it is usually the 10th segment. If 2 postgenital segments are present the 10th is usually reduced and may be united with either the 9th or 11th segments. [see text - p. 254, fig. 140]

* In many insects the 10th segment is a complete annulus, that is it forms a complete sclerite around the insect. [see text p. 254, fig. 140A, C, I] In other insects (grasshopper) only a portion of the 10th segment is visible - the sternal area is often reduced to a membranous state.

* In general the 11th segment is the last true somite of the adult insect. In all insects the 11th segment is reduced. In the grasshopper, the 11th segment is reduced to a tergal plate called the **epiproct,** and 2 lateroventral plates called **paraprocts.** It can also be united with the 10th segment (as in some Homoptera) to form an anal tube. Sometimes the 11th segment is suppressed or completely absent forming a 10 segmented abdomen (in all holometabolous insects). The 11th segment is the only postgenital segment with any indication of having true appendages called **cerci**.

* Cerci are often implanted in the intersegmental membrane between the 10th and 11th segments or between the epiproct and paraprocts. They are not present in all insects.

* **Musculature of abdomen** - In insects where the abdominal integument is not sclerotized (many holometabolous larvae), the muscles simply run from one intersegmental fold to the next. In most insects the dorsal and ventral longitudinal muscles are in 2 series, external and internal [see Chapman fig. 170 and 171]. The internal muscles run from one antecosta to the next and so retract the segments within each other. The external muscles are much shorter and only extend from the posterior end of one segment to the anterior end of the next and, because of the degree of overlap between the segments, the origins may be posterior to the insertions [see Chapman fig. 171B]. In this case they may act as protractor muscles. If the protractor muscles are absent then the abdomen is protracted by its own elasticity and the pressure of the blood in the abdomen.

* There are also lateral muscles which usually extend from the tergum to the sternum, but sometimes arise or are inserted into the pleuron. They are usually intrasegmental, but sometimes cross from one segment to another. Their function is to compress the abdomen dorsoventrally.

* **Abdominal appendages** - Primitive appendages.

* The appendages of segment 11 form a pair of structures called cerci which arise from the membranes between the epiproct and the paraprocts, and even where segment 11 is absent the cerci may be present, appearing to arise from segment 10.

* Cerci are present in the Apterygota and in the hemimetabolous insects other than the hemipteroid orders. In the holometabolous groups, only Mecoptera and some Diptera may have cerci. The cerci may be simple and unsegmented [see Chapman fig. 172A] as in grasshoppers, or they may be annulated [see Chapman fig. 172B] as in cockroaches. They may be very short to very long.

* The cerci usually function as sense organs being sensitive to tactile stimuli, sometimes to aid movement, and sometimes they may act as sound receivers. In some insects the cerci take different forms according to the sex. This is some indication that they may play a role in copulation [see Chapman fig. 172D]. Forceps-like

in Dermaptera and some Thysanura. In some Ephemeroptera they can help in swimming. In water scorpions they have been modified into a long breathing tube for underwater.

* **Collembola** -

Collophore or ventral tube - on ventral surface of 1st abdominal segment; fleshy, may function as either an adhesive organ for walking or for water uptake. The unpaired basal part of the ventral tube is believed to represent fused coxae.

Furcula - comes off 5th abdominal segment, but muscle attachments connect with the 4th abdominal segment, so it is probably a true appendage of the 4th segment. It folds up and catches on the tenaculum; is used for jumping.

Tenaculum - a catch on the ventral surface of the 3rd abdominal segment; is a catch to hold the furcula. [sometimes called the **retinaculum**].

* **Protura** - There are pairs of appendages on each of the first 3 segments of the abdomen of Protura. At their most fully developed they are 2 segmented with an eversible vesicle at the tip [see Chapman fig. 173A]. The appendages are moved by extrinsic and intrinsic muscles which include a retractor muscle of the vesicle.

* **Thysanura and Diplura** - jumping bristle tails. These have styli that arise from flattened plates called the coxopodites which are homologous to primitive coxae of legs; Since the coxa of some Thysanura also have styli on the coxa it is believed that these abdominal styli are regarded as coxal styli.

* **Secondary Appendages** - Appendages are absent from the pregenital segments of adult insects other than Apterygota, but are widely present in the larvae of holometabolous insects and, as gills, in diverse aquatic forms. Some authorities regard these appendages as being derived from primitive segmental appendages [Snodgrass], but it is probably more reasonable to regard most of them as secondary developments.

* **Pterygote larvae** - abdominal appendages are common - gills (Ephemeroptera, Plecoptera, Megaloptera, Trichoptera, and some Coleoptera), prolegs (Diptera, Lepidoptera, Mecoptera, and Trichoptera), etc. All are developed from primitive limb rudimants - true abdominal legs according to Snodgrass. Molecular studies indicate that the prolegs of caterpillars are homologous with the thoracic legs. Lepidopterous larvae usually have a series of hooks on the end of the prolegs called **crochets**; larvae of the Mecoptera and the Hymenoptera (Symphyta) have prolegs without the crochets.

* **Other Appendages** - Many of these appendages are not believed to be derived from true abdominal legs, but rather are a consequence of evolution. These include pseudopods of the Diptera, the secondary penis of Odonata, the cornicles of aphids, median caudal filaments in Thysanura and Ephemeroptera. Some Coleoptera have outgrowths of the tergum of segment 9 called urogomphi.