External Anatomy of Insects: The Exoskeleton, Head and Mouthparts

1. Exoskeleton
Utilize some prepared slides, some of the specimen you collected last week and take a thin slice of exoskeleton from a grasshopper to determine the structure of the exoskeleton and associated structures.

a) Remember that the exoskeleton covering the insect’s body is an extremely thin structure consisting of two basic layers: a cellular epidermis and a non-cellular cuticle, which is further subdivided into epicuticle, exocuticle and endocuticle (together forming the procuticle). When preparing a thin section of exoskeleton for histological observation, insert the piece of exoskeleton into a styrofoam peanut (in an orientation that allows you to see the skeleton in cross-section when you are done) and make thin sections using a sharp single-edged razor blade (careful, do not cut yourself). You may want to collect the thin section you have created using a drop of water on a slide. Follow this collection by staining the section using methylene blue, which will allow you to stain the nucleated epidermis and highlight the nuclei. Cover the section using a cover slip and observe under the compound microscopes provided.

b) Use a bumble bee or moth in order to observe the setal modifications you may expect in certain insects. Bumble bees are covered in the hair-like setae. Place a drop of glycerine onto a clean slide, pull some setae from the body of a bumble bee (you may need to use the dissecting microscope) using forceps, place it onto the drop of glycerine and cover it with a cover slip. Observe your preparation under the microscope and draw the setae. Also utilize some moths or butterflies you collected and observe the setae in much the same manner. Be sure to take a scrape of the moth or butterfly wings for this part of the exercise, in order to correctly observe the setae.

2. Head and mouthparts
Preserved grasshoppers (leaf feeders, with biting and chewing mouthparts to observe head and mouth structures

The head is enclosed in a hard, heavily sclerotized, unsegmented, exoskeletal head capsule, or epicranium. The mouthparts are attached ventrally to the capsule, a condition known as hypognathus. The mouth, which you will see later, is located on the ventral surface of the head and is surrounded by the mouthparts. These mouthparts enclose a space, the preoral cavity, from which the mouth opens. The head is more or less ovoid in shape with a nearly vertical anterior surface. Note the composition of the head capsule. Most of the head is enclosed in a single hard piece of exoskeleton known as the epicranium. This is composed of the fused sclerites of the head segments. It covers the dorsal anterior and lateral aspects of the head and is divided into regions. The region of the epicranium anterior to the compound eyes is the frons. The side, or cheek, posterior to the compound eye is the gena. Ventral to the frons is the clypeus. The unpaired clypeus articulates with the epicranium. The short lateral edges of the clypeus are notched. The vertex is the top of the capsule, dorsal to the frons and between the compound eyes. The vertex extends anteriorly above the bases of the antennae as a prominent, pointed, concave rostrum. The posterior wall of the head capsule is penetrated by a large aperture, the foramen. Through it pass the organ systems, such as nerve cord, esophagus, salivary ducts, and musculature, connecting the head with the thorax. In an intact specimen the foramen is filled
with soft tissue but you can see its circular outline. The occiput (occipital arch) is a narrow band forming the posterior edge of the head capsule arching dorsally over the foramen. Pair of large multiarticulate, sensory antennae is attached in deep sockets on the antero-dorsal corners of the head. The antenna consists of two basal articles, the proximal scape and distal pedicel, to which is attached the long multiarticulate filamentous flagellum. The antennae are the first pair of segmental appendages of the insect head and are innervated by the deutocerebrum of the brain.

A large, bulging compound eye is located dorsolaterally on each side of the head just posterior to the base of the antenna. Examine the surface of a compound eye and note that it is composed of an uncountable number of small light-receiving units known as ommatidia. The surface of the eye is a specialized, transparent part of the exoskeleton divided into tiny hexagonal cuticular lenses, or corneas, one for each ommatidium.

In addition to the two compound eyes there are three tiny, simple eyes, or ocelli. These are not composed of ommatidia. Two of them are lateral ocelli located between the compound eyes and the antennae. The unpaired median ocellus is located on the anterior midline of the head in a pit on the vertical ridge between the two antennae. The labrum, or upper lip, is also located on the vertical anterior face of the head capsule. It is a large movable plate, equipped with muscles, ventral to the clypeus. It bears a small median notch on its ventral border and a median groove on its anterior surface. Some entomologists believe the labrum to be derived from a fused pair of anterior appendages and that the notch and groove represent the line of fusion between the fused right and left appendages.

The labrum is the anterior wall of the preoral cavity and it covers the more posterior mouthparts. Its hidden posterior surface bears abundant setae, or bristles. With fine forceps lift the labrum to demonstrate its mobility and to reveal the preoral cavity and the remaining head appendages. The labrum is innervated by the tritocerebrum indicating it is the homolog of the
crustacean second antenna and supporting the hypothesis that it is a segmental appendage. Immediately posterior to the labrum is a pair of mandibles. In grasshoppers these massive mouthparts are adapted for biting and chewing. Their heavily sclerotized and strongly toothed median surfaces are apparent when the labrum is moved aside. The mandibles are segmental appendages.

The toothed, median, cutting surface of the mandible includes a distal (ventral) incisor of sharp shearing teeth and a proximal molar of heavier grinding teeth. You can see these by lifting the labrum. You may later want to remove the mouthparts on one side for closer study but do not do so now.

The mandible articulates with the ventral edge of the posterior epicranium (gena). The mandibles lie on either side of the mouth and are the sides of the preoral cavity from which the mouth opens dorsally. You will not see the mouth at present. The mandibles are operated by powerful muscles with the motion entirely in the transverse plane. Grasshopper mandibles are dicondylic, meaning they are hinge joints, articulating with the epicranium at two points, known as condyles, thus limiting the range of motion to a single plane. A monocondylic articulation, on the other hand, would be a ball and socket joint with a much greater range of motion. Grasp a mandible with fine forceps and move it to demonstrate its motion.

The soft, fleshy hypopharynx extends into the preoral cavity as a fold of body wall ventrally from the head capsule just posterior to the mouth. This unpaired, tongue-like structure is not a segmental appendage. It divides the preoral cavity into an anterior cibarium, from which the mouth opens, and a posterior salivarium, into which the duct of the salivary glands open. The appendages immediately posterior to the mandible are the two maxillae. These also articulate with the gena of the epicranium. Each maxilla consists of two basal articles. One, the cardo, articulates with the gena. The other, the stipes, articulates with the cardo. From the stipes arises a spoon-shaped lateral galea and a toothed medial lacinia.

The galea and lacinia curve medially, just posterior to the mandibular incisor. The galea hides the lacinia from lateral view. You can roll the maxilla aside on its articulation with the gena to reveal these parts. A large, conspicuous, filamentary, and multiarticulate maxillary palp also arises from the stipes but on its lateral side. The palp is sensory.

The last pair of head appendages are fused to form the labium, or lower lip. The labium is easily seen in its entirety by looking at the posterior surface of the ventral head. It forms the posterior boundary of the preoral cavity. The labium articulates with a slender U-shaped arch of exoskeleton (a modified sternite) known as the gula. The arms of the gula extend anteriorly to the posterior edge of the gena. The basal portion of the labium consists of a small, more or less, rectangular, proximal submentum, which articulates with the gula, and the larger, more distal mentum. The anterior edge of the mentum is cleft medially, reminding us that the labium is formed evolutionarily of two fused segmental appendages. The mentum bears two large cupped ligulae. The lateral borders of the mentum each bear a filamentous, multiarticulate, sensory labial palp.

The labium forms the posterior wall of the preoral cavity. Push the labium posteriorly and look into the preoral cavity. Its anterior wall is the labrum. The mandibles and maxillae are the
sides. Inside the cavity you will see the large hypopharynx extending from the ventral wall of the head immediately posterior to the mouth. It is an unpaired fold of the body wall and is not a segmental appendage. The mouth lies between the base of the hypopharynx and the labrum.

3. Different Mouthparts
There are several slides of the different mouthparts of insects, depending on their feeding types and therefore lifestyles.

a) Observe the slide of the piercing mouthparts of blood feeding mosquitoes, detecting the stylet type mandibles and elongated labium, labrum and hypopharynx

b) Observe the slide of the fly head with the sponging mouthparts of flies that feed on particles that are soluble in saliva. Mandibles are absent, maxillae are non-functional though there are large maxillary palps. The mouth is mainly derived from the labium and forms an elongate proboscis bearing palps, a digital haustellum and sponge-like labella. Look closely at the labella for grooves
4. Antennae
   
   a) Slide of different antenial types: i.e. clavate, filiform, plumose, capitate, geniculate. Draw the different antenial types.
   
   b) Remove the antenne from some of your specimens collected last week and observe the antennae, classifying them according to type.