Feeding I: Structure and Function of Mouthparts

Orientation of the mouthparts:

- **Hypognathous.** Mouthparts are directed ventrally downward. Primitive condition in Insecta. Common in phytophagous groups inhabiting open habitats (Thysanura, cockroaches, mantids, phytophagous beetles).

- **Prognathous.** Mouthparts directed forward. Common in carnivorous groups that actively pursue prey (earwigs, larval neuropterans, coleopterans, termite soldiers and ants).

- **Opisthognathous.** Mouthparts directed backward. Common in hemipteroid orders with sucking mouthparts.
Generalized Structure & Function

• Generalized chewing mouthparts are found in the Thysanura, Odonata, all Polyneoptera orders, Neuroptera, Coleoptera, Mecoptera, many Hymenoptera, and immatures in the Emphenemoptera, Siphonaptera, Trichoptera and Lepidoptera.

• Modified sucking mouthparts are found in all the Paraneoptera orders, adult Siphonaptera, Diptera, bees and Lepidoptera.

• Basal or generalized insect mouthparts consist of 5 basic structures. Moving from anterior to posterior these structures are: the labrum, the paired mandibles, the paired maxillae, and the labium. The hypopharynx is located medially to the mandibles and the maxillae.
The Labrum

- The **labrum** is the anterior-most mouthpart. It forms a broad lobe suspended from the clypeus and protects the more delicate mouthparts behind it. The inner surface is frequently membranous and may be produced into a median lobe called the **epipharynx**. The epipharynx is covered with **chemoreceptors** and **mechanoreceptors** used in food selection.

- Muscles attached to the labrum move it outward, away from the other mouthparts and inward toward the other mouthparts during feeding. Some limited lateral movement is also possible.
The Mandibles

- The **mandibles** are used to capture food and break it up into smaller pieces. Size and shape of the incisors and molar cusps varies with diet. Predators have strong shearing, pointed cusps. Grasshoppers feeding on vegetation other than grasses have a series of sharp pointed cusps, while grass-feeding species have chisel-edged incisor cusps and molar cusps with flattened ridges for grinding.

- Mandibles of primitively wingless insects (Archaeognatha) have only one articulation with the head capsule (**monocondylous**). Movement about the point of articulation is accomplished with anterior and posterior rotator muscles, remotor muscles and transverse adductor muscles that directly connect the two mandibles.

- Mandibles of the Pterygota have two points of articulation with the head capsule (**dicondylous**). Movement about the points of articulation is accomplished by **abductor muscles** (opening) and **adductor muscles** (closing). Adductor muscles in many pterygotes are extremely powerful. These muscles are homologous with the rotator muscles in the archaeognathans.
The Maxillae

• The **maxillae** (single **maxilla**) are positioned laterally behind the mandibles. They are held in place by a single point of articulation with the head capsule and membraneous connections that allow freedom of movement.

• The main body of the maxilla is composed of the proximally located **cardo** and the distally located **stipes**. Distally on the stipes are two lobes, an inner **lacinia** and an outer **galea**. More laterally on the stipes is a jointed leg-like **palpus**.

• The whole maxilla, including the lacinia and galea, move food particles backwards into the preoral cavity. The maxillary palps are sensory organs used to test the quality of the food. In addition to its role in directing food into the mouth, the galea is used to clean the palps, antennae and forelegs.

• Muscle attachments are roughly similar to those of the mandibles. Lateral adductor muscles are attached to the **tentorium**.
The Labium

- The **labium** is the posterior-most mouthpart and is derived from the fusion of two maxillae-like appendages. It forms the protective “lower lip” to the mouth.

- The main body of the labium consists of three plate-like segments (**submentum**, **mentum** and **prementum**). The most distally located segment bears four lobes, two inner **glossae** and two outer **paraglossae**. A pair of **palps** also arise laterally from this most distally located segment. These labial palps typically act as sensory organs similar to the maxillary palps. In some larval odonates these palps are modified into raptorial appendages to capture prey.

- Muscle attachments are roughly similar to those of the maxillae, with some attached to the **tentorium**.
The Hypopharynx

- The **hypopharynx** is located medially to the mandibles and the maxillae. It is behind the preoral cavity and in front of the labium.

- The hypopharynx is mostly membraneous and closely associated with the salivary glands and/or salivary ducts.

- The hypopharynx functions as a tongue, moving food around in the preoral cavity. This is accomplished by muscle attachments that move it back and forth.
Common Features of Sucking Mouthparts

• Presence of a **sucking tube**. The sucking tube is the means by which liquid food is drawn into the mouth. Mouthparts used to form this structure varies among groups.

• Presence of a **sucking pump**. The sucking pump creates the negative pressure necessary to draw the food into the mouth. How the sucking pump is formed varies among groups. Many insects with sucking mouthparts also have a **salivary pump** for injecting saliva into the preoral cavity.
Paraneoptera Mouthparts

- The sucking tube (beak) in the Hemiptera is formed from the mandibles, maxillae and the labium. The labium forms the protective sheath that folds back during feeding. The mandibles form the outer stylets that surround the inner stylets. The laciniae of the maxillae form the inner stylets with the food and salivary channels.

- The sucking pump is formed in the cibarium. Negative pressure is generated by the enlargement of the cibarial dilator muscle attached to the clypeus.

- The sucking tube in the Anoplura is formed by the labium.
Honeybee Mouthparts

- Maxillae and labium are fused into a single structure. The sucking tube (tongue) is formed by the fusion of the glossae of the labium, sometimes together with the paraglossae. Maxillae galeae are enlarged and modified to form a cutting appendage used by short tongue bees to cut holes in flowers. Laciniae are lost and the maxillary palps reduced.

- Mandibles are flattened and used for grasping and manipulating objects, rather than for biting and cutting.

- The sucking pump is formed by the cibarium, the pharynx and the buccal cavity. Muscles associated with the sucking pump are attached to the frons and the clypeus.
Lepidoptera Mouthparts

- The sucking tube (proboscis) is formed from the maxillae galeae with the food channel running down the center. Outer walls of the galeae alternate scleritized and membranous rows. This arrangement facilitates coiling (think of a vacuum hose). Extension of the proboscis is accomplished by blood pressure. Coiling is automatic.

- Mandibles are completely lost in most derived groups.

- Labrum is reduced to a small transverse sclerite and the labium is reduced to a small flap. Labial palps however are large.

- Sucking pump is formed by the cibarium and the pharynx. Muscle attachments are similar to those in the Hymenoptera. The sucking pump is absent in Lepidoptera that do not feed as adults.
**Diptera Adult Mouthparts**

**Biting flies (mosquitos, black flies, deer flies, horse flies)**

- Mandibles are present and used for piercing the host’s skin. They are long and sharply pointed.

- The sucking tube is formed by the labrum anteriorly and the mandibles posteriorly. Food is drawn up the food channel which is a groove on the posterior side of the labrum.

- The maxillae retain most of the components of the typical biting form, but the galeae are long and bladelike and the palps are enlarged.

- The hypopharynx is styletlike and contains the salivary duct.

- The labium is a large, thick appendage with a deep anterior groove into which the other mouthparts normally fit. Distally the labium bears two large **labellar lobes** with **pseudotracheae**, which directs the blood towards the food canal.

- In mosquitos the food canal is formed between the hypopharynx and the labium.

- The sucking pump is formed in the cibarium.
Diptera Adult Mouthparts

Lapping Muscids (houseflies, blowflies)

- Sucking tube (*proboscis*) is a composite structure that includes the labrum, hypopharynx and labium. The tube is divisible into a basal *rostrum* bearing the maxillary palps, a median flexible *haustellum* and two apical *labellae*. The labellae are broad sponging pads, equipped with *pseudotracheae* along which food passes to the oral aperture.

- Mandibles are completely lost.

- The sucking pump is formed from the cibarium and its dilator muscles.

Biting Muscids (tsetse flies, stable flies)

- Piercing, sucking tube is a composite structure as in the lapping Muscids. However, the haustellum is elongate and rigid, and the distal labellar lobes are small and bear rows of *prestomal teeth* on their inner walls.

- The labrum and labium interlock to form the food canal within which lies the hypopharynx enclosing the salivary duct.
Diptera Larval Mouthparts

• Nematoceran larvae have typical chewing mouthparts as do the larvae of most holometabolous insects.

• Basal Brachycera larvae show modifications away from the typical chewing mouthparts.

• Derived Brachycera larvae in the Cyclorrhapha have highly modified mouthparts in which the typical mouthparts are lost or fused. Mandibles are modified into vertically directed **mouth hooks**.