Insect Morphology

MORPHOLOGY: THE STUDY OF FORM AND FUNCTION

Insects are **arthropods**:

Arthropoda: "jointed feet"

Insecta: from insectum; to cut into

General characteristics of arthropods:

Segmented bodies

Paired, segmented appendages

Bilateral Symmetry

Exoskeleton

Dorsal heart and open circulatory system

Ventral nerve cord

General characteristics of insects:

The body is comprised of 3 distinct body regions -- head, thorax, and abdomen

The thorax of adults bears 3 pairs of legs and 2 pairs of wings

The "breathing" system is comprised of air tubes

A look at the outside of an insect:

The **exoskeleton** is comprised of sclerites: hardened plates

Tergites: Dorsal plates

Sternites: Ventral plates

Pleuron: Lateral area, often membranous

The **integument** (body covering) is comprised of multiple layers:

The cuticle is the outermost layer, covering the entire outer body surface; it also lines the air tubes (tracheae, etc.), salivary glands, foregut, and hindgut

Strength and resilience (not hardness) are provided by **chitin**, a nitrogen-containing polymer common to the arthropods

The insect head bears: mouthparts, eyes, and antennae.

Mouthparts:

Labrum (1) (Upper lip)

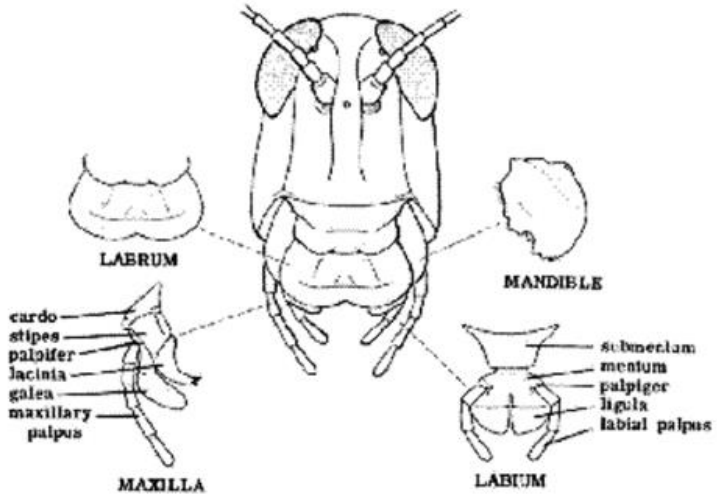
Mandibles (2) (Jaws)

Maxillae (2) (More jaws)

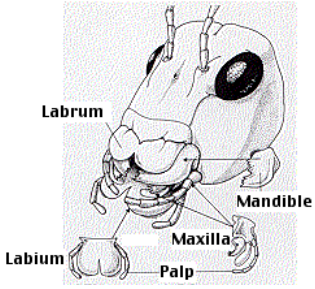
Labium (1) (Lower lip)

Hypopharynx (1) (Tongue-like, bears openings of salivary ducts)

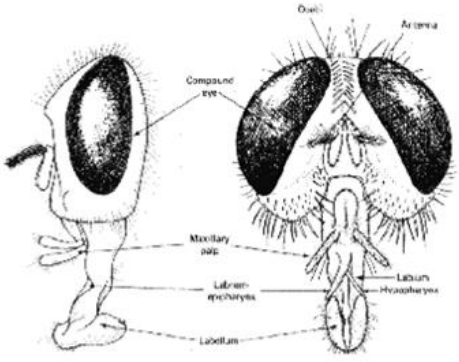
Labrum-epipharynx (1) (Fleshy inner surface of labrum - sensory)



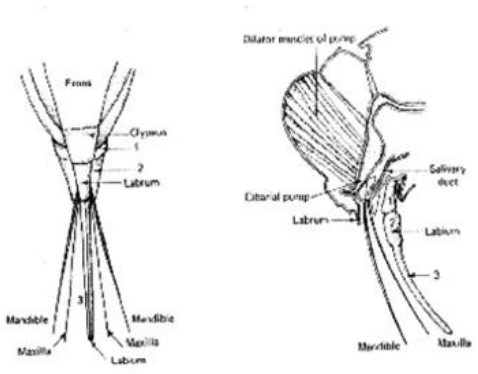
Grasshopper head and mouthparts.



Mouthparts may be modified greatly from the "generalized" plan ... see illustrations of the cicada and the house fly in comparison with the general form exhibited by the grasshopper.



House fly head and mouthparts.



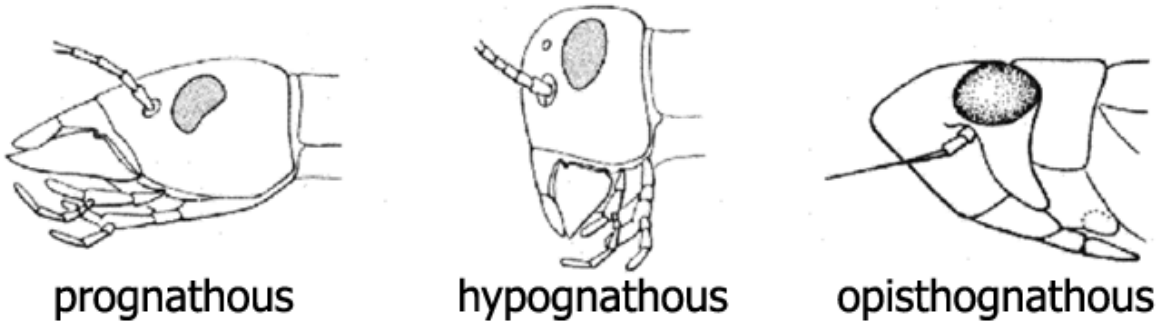
Cicada head and mouthparts.

The orientation of the mouthparts on the head may differ, and they may be described as:

Prognathous: projecting forward (horizontal)

Hypognathous: projecting downward

Opisthognathous: projecting obliquely or posteriorly



Eyes:

Compound eyes: Individual units are facets or ommatidia. 28,000 ommatidia comprise a single compound eye in dragonflies

Oellus (Ocelli), or simple eyes: small, usually a single lens

Antennae:

2 basal segments are the scape & pedicel

The filament is comprised of several segments (actually pseudo-segments lacking independent musculature)

a. setaceous: hair-like

b. and f. filiform: thread-like

c. moniliform: bead-like

d. serrate: sawtoothed

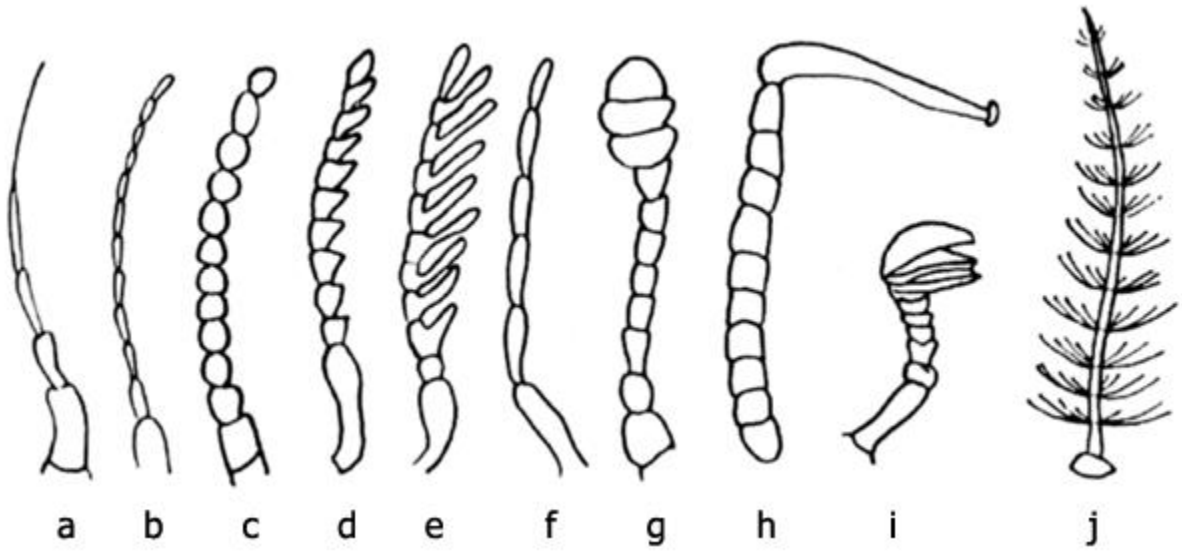
e. pectinate: comb-like

g. capitate: headlike (less enlarged at the tip would be clavate -- clublike)

h. geniculate: elbowed

i. lamellate: plate-like

j. plumose: plumed or feather-like



The insect thorax:

3 distinct segments:

Prothorax: Bears 1 pair of legs

Mesothorax: Bears 1 pair of legs, 1 pair of wings

Metathorax: Bears 1 pair of legs, 1 pair of wings

Sclerites that comprise the thorax are given specific names; each may be preceded by the prefixes pro-, meso-, or meta-.

Notum: Dorsal plate or sclerite. The **pronotum** is the dorsal sclerite on the prothorax.

Pleuron: Lateral plate

Sternum: Ventral plate

Legs are segmented. The names for each segment are (in order, beginning at the body and progressing outward.

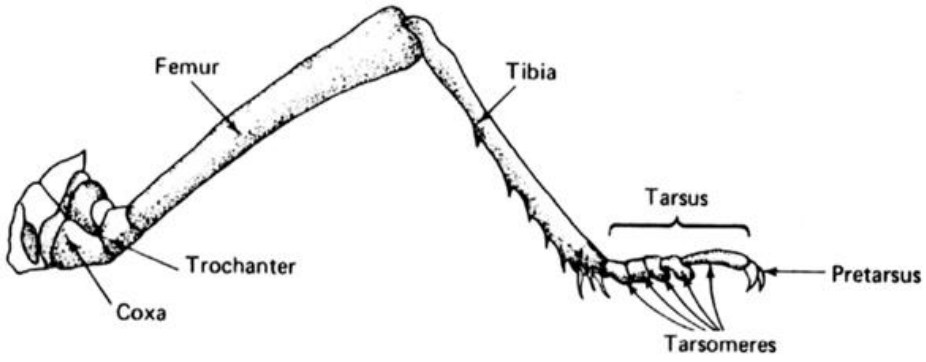
coxa

trochanter

femur

tibia

tarsus



The tarsus may be comprised of multiple segments (not really true segments; more accurately called tarsomeres); the terminal segment usually bears claws.

Legs may be modified for specific purposes:

Jumping: saltatorial -- grasshoppers, fleas

Running (or walking): cursorial -- ground beetles, cockroaches

Clinging: scansorial -- lice, sheep keds

Grasping (holding prey): raptorial -- mantids, giant water bugs

Digging: fossorial -- cicada nymphs, mole crickets

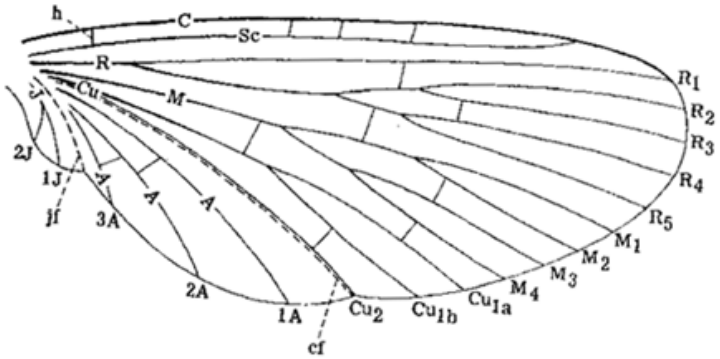
Swimming: natatorial -- water scavenger beetle, backswimmer

Wings

Mesothoracic wing = forewing

Metathoracic wing = hindwing

Wing veins and cells between veins are named according to the standard system illustrated below:



C = Costa
Sc = Subcosta
R = Radius
M = Media
Cu = Cubitus
A = Anal
J = Jugal
h = humeral

Wing modifications:

Halteres (Halter): Knob-like reduced hind wings of Diptera

Elytra (Elytron): Hardened, protective forewings of Coleoptera

Hemelytra: Half-hardened, half-membranous forewings of Hemiptera (Heteroptera)

Fringed wings: Modified wing structure of the Thysanoptera (Thrips)

Scales and hairs: Lepidoptera, Trichoptera, some Diptera

The insect abdomen …

… is comprised of 6 to 10 segments. Terminal structures include:

Cerci: Paired sensory projections from the terminal abdominal segment

Ovipositor: Egg-laying apparatus (may be modified for other purposes)

Aedeagus: Male copulatory organ, analogous to the penis in vertebrates

(*Homologous* = structures with similar evolutionary origin but different function, such as the different forms of mandibles in insects. *Analogous* = structures with similar functions but different evolutionary origins, such as the wings in birds versus insects.)

Inside the insect:

Digestive System: A tube that extends from the mouth to the anus; there are 3 sections:

Foregut:

Pharynx (throat)

Esophagus (gullet)

Crop (storage)

Proventriculus (may be muscled, gizzard-like)

Midgut:

Gastric caecae (blind sacs) (food storage and enzymes)

Ventriculus (most digestion, absorption here)

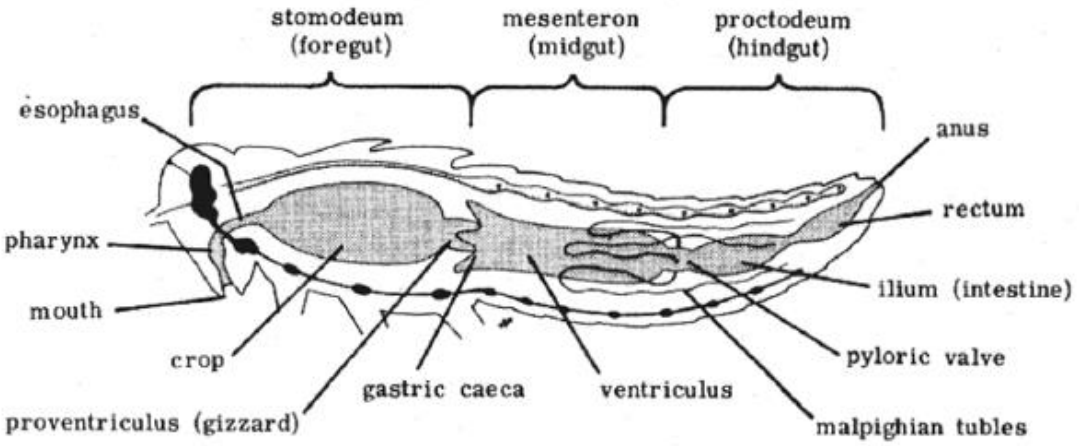
Hindgut:

Anterior intestine (excretory organs empty in)

Rectum (reabsorption of water)

Anus

In embryonic development, the foregut and hindgut are formed from ectoderm ... their surfaces are shed during molting. The midgut is formed from the endoderm; its surface is retained during molting.



The "generalized" digestive system of insects.

Digestion:

Some insects use external digestion in addition that which occurs internally ...

leafhoppers inject saliva into plant tissues

house flies regurgitate salivary enzymes onto the surface of food

diving beetles inject prey with salivary juices

Most digestive action is in the midgut; gastric caecae are rich in enzymes. Enzyme diversity varies with the range of foods that different insects eat ... more proteolytic enzymes in blood feeders, cellulase in wood-boring beetles, etc.

Excretory system:

Purpose of excretion:

Removal of nitrogenous wastes

Maintenance / regulation of salts and water balance

Primary excretory organs: **Malpighian tubules** and the **rectum**. Malpighian tubules "float" in the hemolymph; active transport moves wastes (uric acid salts from the fat body) into tubules. Malpighian tubules empty into the hind gut; water is reabsorbed. Excretory and fecal wastes are combined.

Nervous system:

The brain = the supraesophageal ganglion (nerve cell mass above the esophagus)

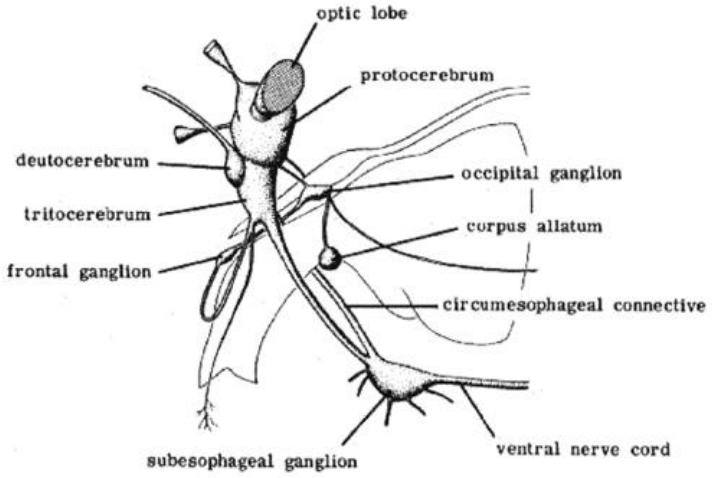
Optic lobes (paired): the largest lobes of the brain; each protrudes from the protocerebrum

Protocerebrum (paired): innervates compound eyes and ocelli

Deutocerebrum (paired) innervates antennae

Tritocerebrum (paired) connect to the visceral nervous system

Circumesophageal connectives (paired) -- from the dorsal brain to the ventral nerve cord



Components of the insect brain.

The **ventral nerve cord**: connects segmental **ganglia** (nerve cell bundles). Thoracic and abdominal ganglia control many body operations.

The corpora cardiaca and corpora allata are neuroendocrine glands. Lecture 3 will include more on neurohormones and their function.

Chemoreceptors (taste and smell) take the form of sensory pegs on various body structures, particularly antennae, tarsi, and palpi.

Photoreceptors are located in the compound eyes and the ocelli (and also the cuticle).

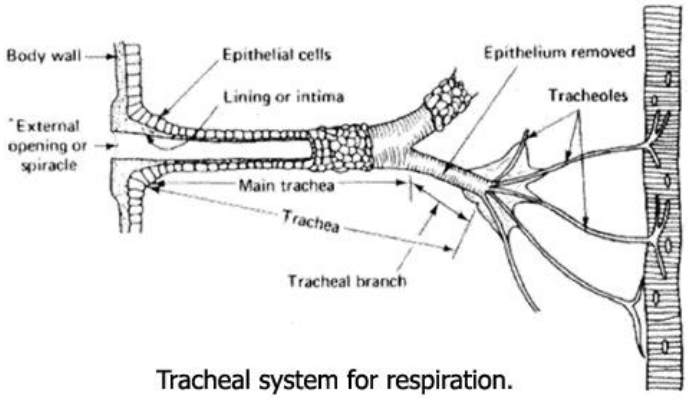
Hearing organs may be located on the abdomen (grasshoppers), tibiae (crickets), or thorax (moths).

Respiratory system (tracheal system):

Spiracles: External openings on each side of most body segments

Tracheae: large tubes that run the length of the body on each side. Smaller tubes are called tracheal branches and tracheoles.

Air sacs that store air (air, not just oxygen) may be located in the abdomen and/or the thorax.



Tracheal system for respiration.

Special modifications oxygen and CO_2 exchange:

Stoneflies and mayflies: external gills

Dragonflies: Rectal gills; water is drawn in and out over these gills

Aquatic beetles (some): Plastron ... air bubble held against the abdomen by the spiracles

Circulatory system:

Insects have what is termed an "open" circulatory system. It is comprised of a dorsal vessel with a posterior "heart" and an anterior aorta. The heart pumps blood (**hemolymph**) forward and empties it over the brain. Blood percolates backwards. Specialized pulsating organs in some insects contribute to blood flow, including flow through wing veins.

The role of blood in insects is the transport of nutrients, wastes, and hormones. It is **NOT the primary means of moving oxygen and carbon dioxide**. (There is no hemoglobin in insects except in immature *Chironomus* spp. and a few others.)

Reproductive system:

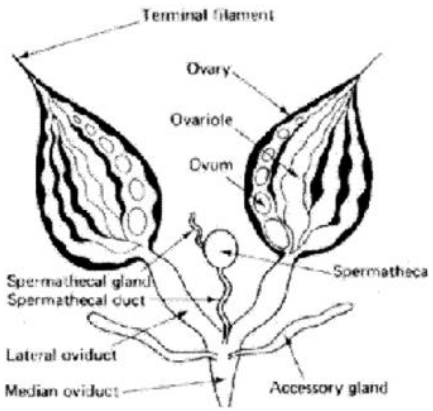
Structures are named by similar terms as those in vertebrates. Key differences:

Spermatheca: Receives and stores sperm in the female

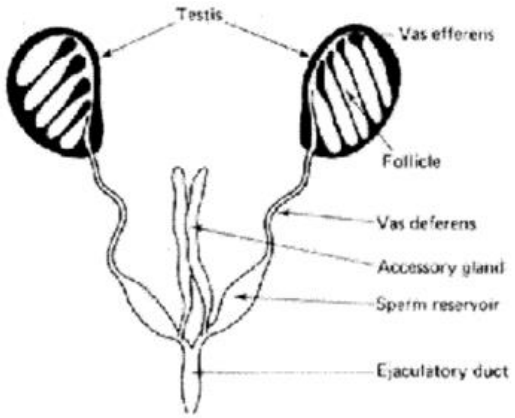
Spermathecal gland: Supplies nutrients for maintaining the sperm (in the female)

Female accessory glands: Secrete adhesive and protective coverings for eggs

Spermatophore: A "capsule" that contains sperm (spermatophore is produced by the male)



Female reproductive organs.



Male reproductive organs.

Musculature:

Muscles and flight:

> Direct musculature is involved in the flight of more primitive insects (for example, the Odonata); but in more advanced fliers, only indirect flight muscles are used. Indirect muscle contractions and relaxations move the notum up and down, and thoracic pleurites serve as a fulcrum. This mechanism allows phenomenal wingbeat frequencies ... 1,000 beats per second.

For more information ...

For an extensive discussion of insect morphology, check the Wikipedia page on insect morphology: http://en.wikipedia.org/wiki/Insect_morphology .

Your textbook, ***How to Know the Insects***, 3rd edition (Bland and Jaques) provides a very brief overview of insect structure and development on pages 30-35.