ENTOMOLOGY I

INTRODUCTION TO INSECTS

BIOL 355

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The Taxonomic Hierarchy is:

- Kingdom ----- Animalia

–Phylum ----- Arthropoda

- Class ----- Insecta

Introduction to Phylum Arthropoda

- Arthropoda means animals with jointed legs
  - arthro: jointed
  - poda: legs
- Animals of this phylum have occupied almost all possible niches in this planet

land

soil

water

Common Structural Characteristics of Arthropods

- A chitinous exoskeleton
  - Support
  - Protection
  - Body covering
  - Muscle attachment
  - Water conservation
  - Growth restrictions

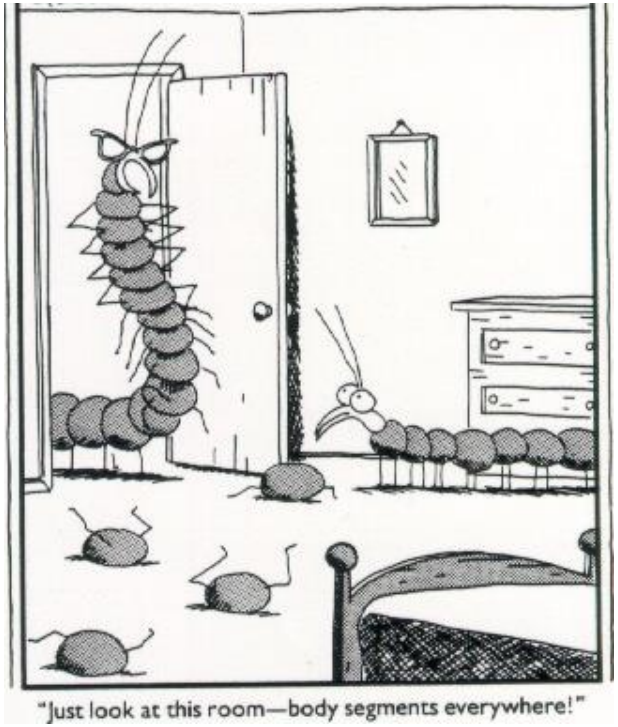
Common Structural Characteristics of Arthropods

- Bilateral Symmetry

Common Structural Characteristics of Arthropods

Jointed Appendages

Segmented bodies



Common Characteristics of Arthropods

- Molting

Arthropods must shed their outer coverings in order to grow.

Common Characteristics of Arthropods

Feeding and Digestion

- Types feeding methods- hebivore, carnivore, parasite, filter feeders, detritus
- Arthropods have a complete, one-way digestive system with a mouth, gut, and an anus, along with various glands that produce digestive enzymes.


locusts

spiders, centipedes

FLEA

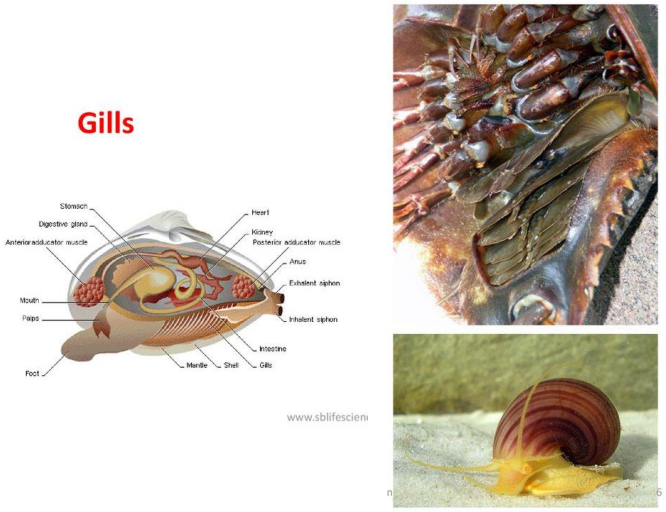
TICK

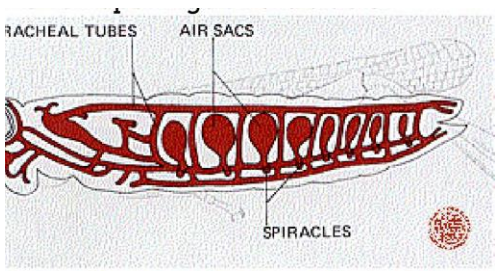
marine arthropods

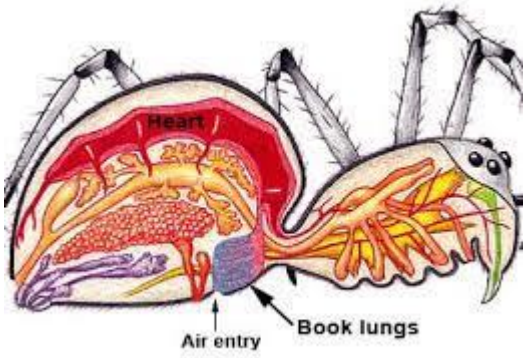
Common Characteristics of Arthropods

- Respiration

Arthropods obtain oxygen by using one of three structures—gills, tracheal tubes, or book lungs.



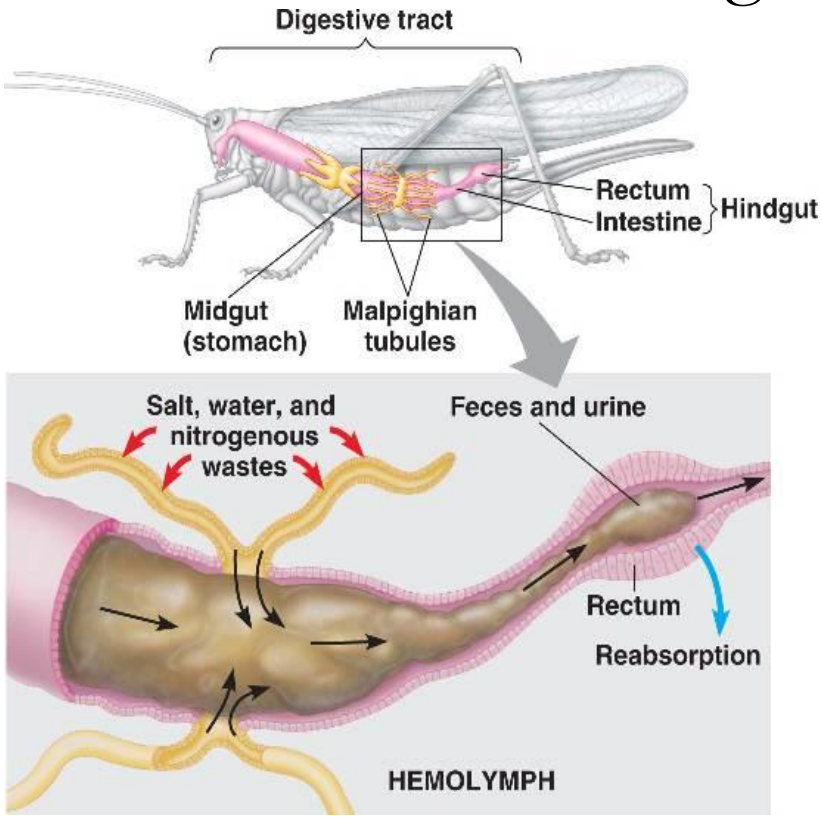




Common Characteristics of Arthropods

Excretion

- Cellular wastes are removed from the blood through Malpighian tubules.
- Malpighian tubules are attached to and empty into the gut, which contains the undigested food wastes to be eliminated from the body.



Common Characteristics of Arthropods

Vision

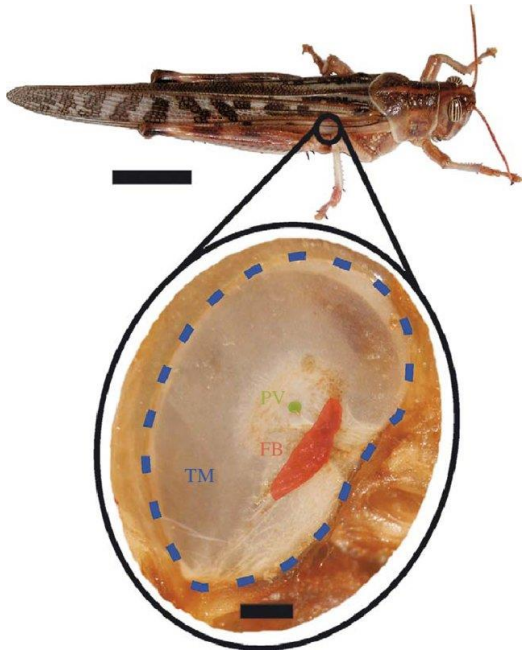
- Most arthropods have at least one of two types of eye: lateral compound eyes, and smaller simple eye(s). A compound eye has many facets, which are hexagonal in shape (ommatidia). Each facet sees part of an image. The brain combines the images into a mosaic. Compound eyes with many lenses used to detect movement and color
- Simple eyes – *ocelli* are "stand-alone" eyes made up of a lens, photoreceptors/sensory cells, and a connection to the ocular. Ocelli detect motion and light but do not transmit images. Most insects have one to three of these simple eyes. Simple eyes with one lens used to detect light

Common Characteristics of Arthropods

- Hearing

Many arthropods have a sense organ called a tympanum, which is a flat membrane used for hearing.

Arthropod tympanums can be located on the forelegs, on the abdomen, or on the thorax.

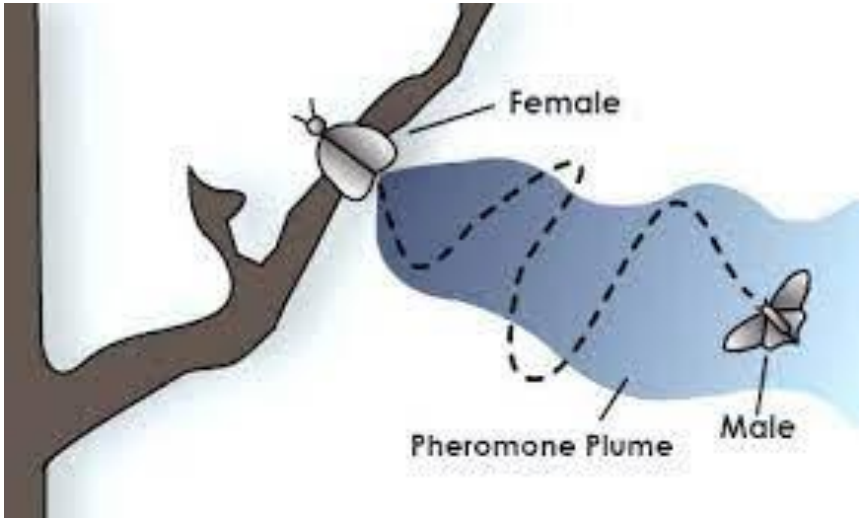


tympanal membrane;

Common Characteristics of Arthropods

- Chemicals

Pheromones are chemicals secreted by many animal species that influence the behavior of other animals of the same species.

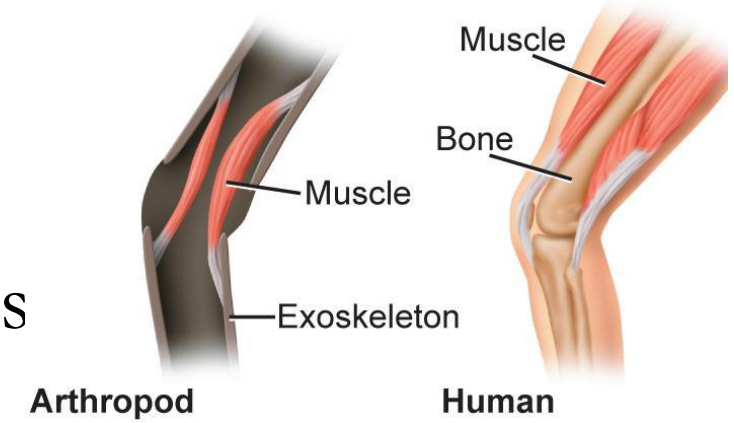


Common Characteristics of Arthropods

- Movement

The muscles are attached to the inner surface of the exoskeleton on both sides of the joint.

The strength of muscle contraction depends on the rate at which nerve impulses stimulate muscles.



Phylum Arthropoda includes:

Chelicerata = mouthparts outside the head

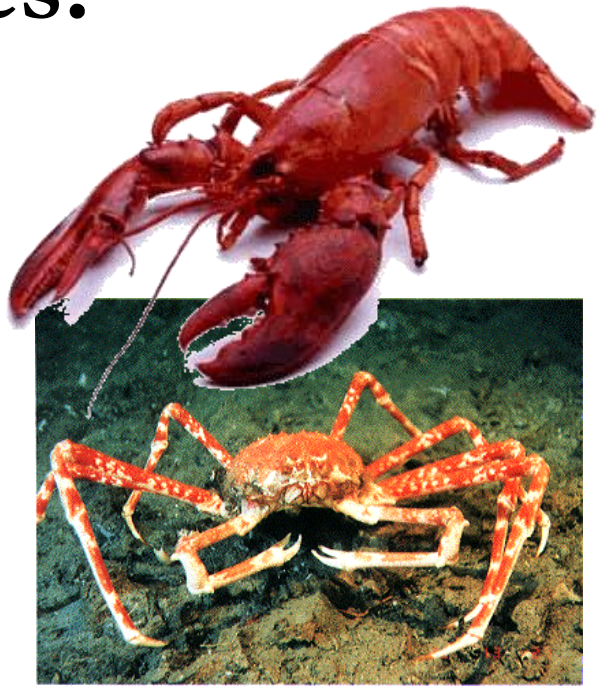
Class Arachnida

- Most arachnids have two body sections—a cephalothorax and an abdomen—and six pairs of jointed appendages, 4 pairs of legs and 2 pairs of mouthpart.
- An arachnid's most anterior pair of appendages is modified into mouthparts called chelicerae and the pedipalps.

Scorpion

Phylum Arthropoda includes:

Mandibulata = mouthparts inside the head



Class Crustacea

- Most crustaceans, such as crayfishes, lobsters, and crabs, have five pairs of legs.
- Behind the next four pairs of walking legs are the swimmerets, appendages that are used for reproduction and as flippers during swimming.
- The first pair of legs—the chelipeds—has large claws adapted to catch and crush food.

Phylum Arthropoda includes:

Mandibulata = mouthparts ***inside the head***

Class Chilopoda

- Centipedes have long, segmented bodies, and each segment has one pair of jointed legs.
- The first pair of appendages is modified to form poison claws.
- Most species of centipedes are not harmful to humans.

Phylum Arthropoda includes:

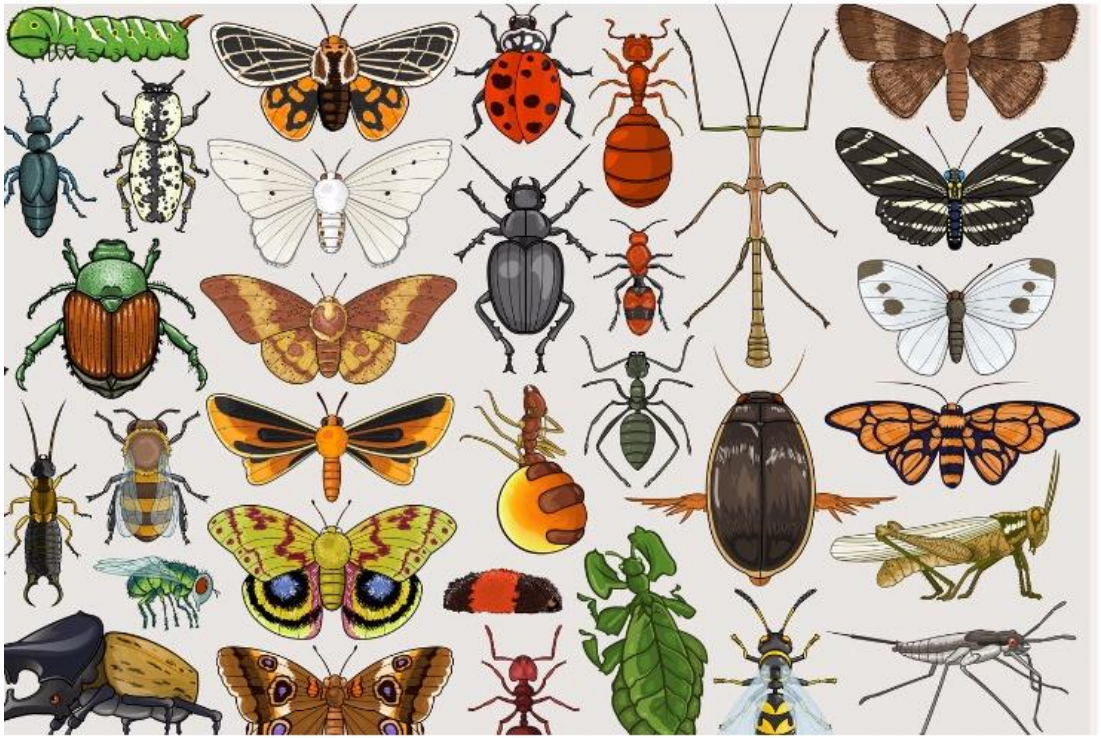
Mandibulata = mouthparts ***inside the head***

Class Diplopoda

- Millipedes have two pairs of appendages on their abdominal segments and one pair on their thorax.
- Walk with a slow, graceful motion
- They do not have poison claws and feed primarily on damp and decaying vegetation.

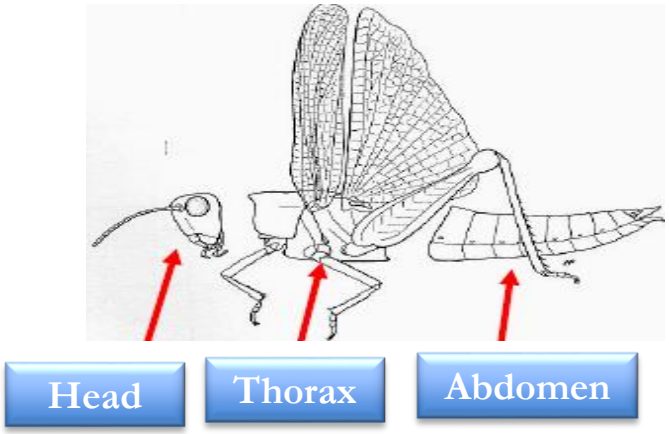
Mandibulata also include:

The Class Insecta:



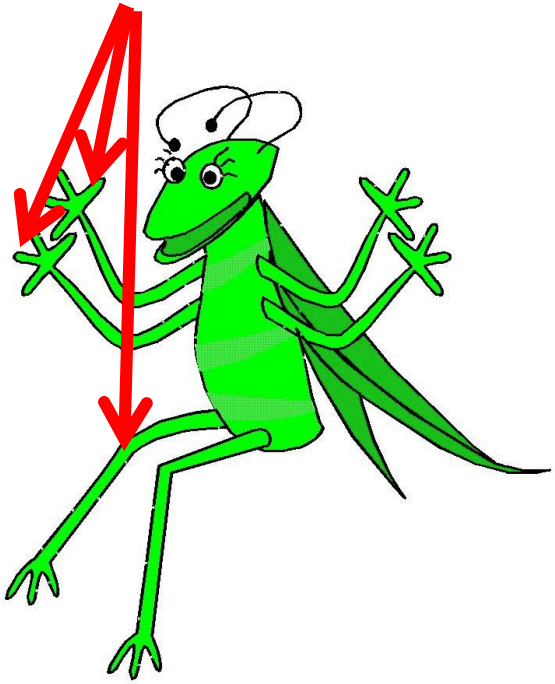
Characteristics and Identification of Insects

- The body of an insect is mainly divided into head, thorax and abdomen
- The abdomen lacks ambulatory appendages and the genital opening is situated near the posterior end of the body

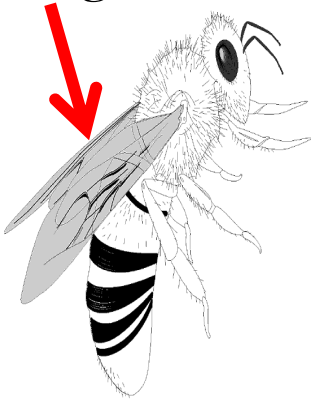


Characteristics and Identification

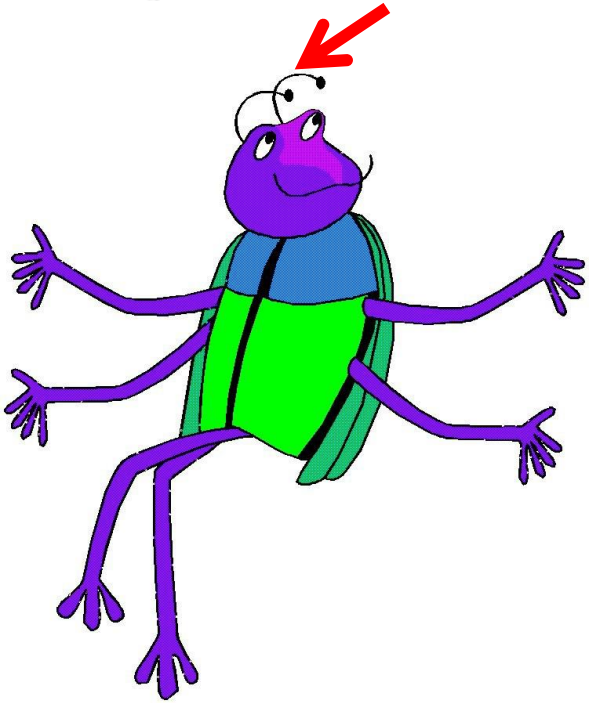
3 pairs of legs



May have 0 to 2 pairs of wings



1 pair of antennae



Reasons for Success of Insects

- General Adaptability:
  - Insects have ability to adapt to a wide range of environments, e.g. can live in environments of temperatures from -50°C (artic) to more than 40°C in hot springs.
  - Also adapted to a wide range of food, e.g. every species of plant is feed on by at least one species of insects.
  - They feed on vertebrate and decomposing matter.

Reasons for Success of Insects

- Exoskeleton
  - Made up of cuticular protein called chitin. This is light in weight and gives strength, rigidity and flexibility to the insect body.
  - The exoskeleton consist of hard plates called sclerites connected by soft membranous region which allow flexibility where required.

Reasons for Success of Insects

- Small size:
  - The size enables many populations to exist on very small quantities of food.
  - Insects can easily hide from predators by using microhabitats and ecological niches.
  - Again, because off-the use of microhabitats, more habitats are available for use by insects compared to larger animals.
  - They require less energy and time to complete development.

Reasons for Success of Insects

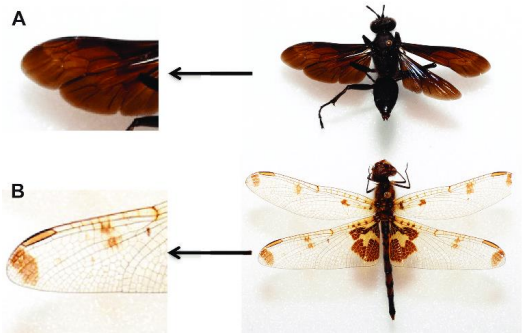
- Water Loss
  - Because insects are relatively small they have relatively high surface area to volume ratio. Thus they may lose water rapidly due to evaporation. As a results insects have several mechanisms to reduce water loss.
    - One structural mechanism is the waxy coating over the exoskeleton of insects.
    - Most insects do not excrete liquid water; they reabsorb water from their waste products.

Reasons for Success of Insects

- Enteronephric excretion
  - Uric acid is excreted with faeces so there is no water loss.
  - This arrangement is well suited for water conservation as well as for the absorption of unwanted waste metabolites at a quicker rate.

Reasons for Success of Insects

- Special Appendages
  - Insects have different types of appendages (e.g. Legs, wings and mouthparts). Insect species posses various forms of mouthparts that are used to feed on a wide variety of substances.



Reasons for Success of Insects

- High fecundity.
  - Fecundity is defined as the egg laying capacity sofa female insects.
  - It helps to increase the population at faster rate.

- Method of reproduction
  - Insects can reproduce both sexually as well as parthenogenitically.
  - This parthenogenitic reproduction coupled with high fecundity help insects to increase their populations to large numbers, when all the biotic and abiotic factors are favourable.

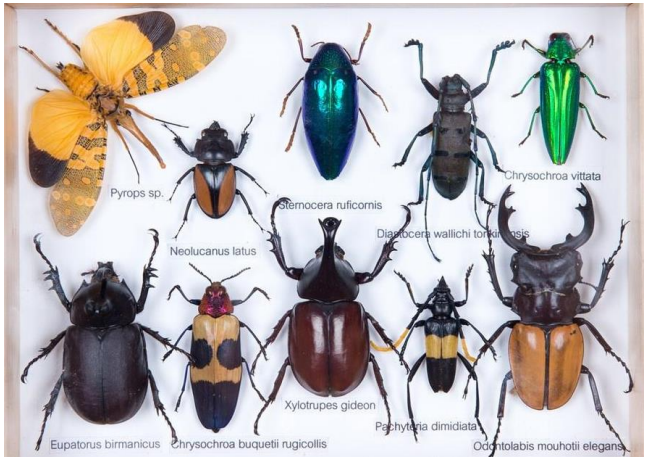
Reasons for Success of Insects

Development

- As an insect grows it goes through life stages that may be very different in structure and function. Many insect species are found in one type of habitat in the immature stages and another in the adult stage.
- For many insect species, the immature and adults feed on different foods and do not compete with each other for food. For example a caterpillar feeds on plant matter while an adult butterfly feeds on plant nectar

Abundance of Insects

- There is much variation in insects; size and shape of the insects.
- There are over one (1) million described species of insects.



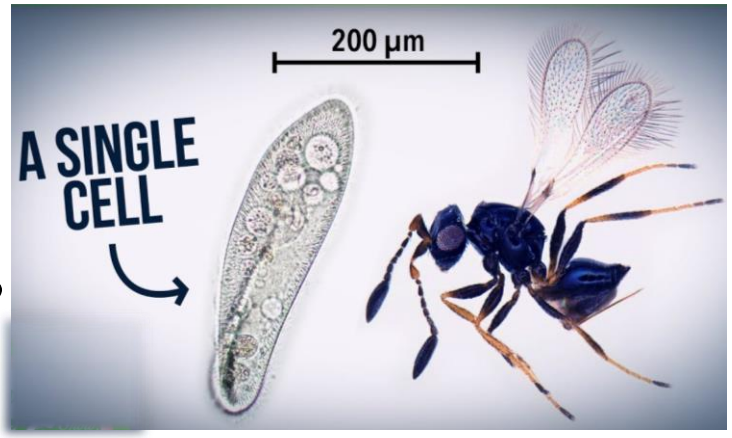
- Insects comprise 75% of all animal species that scientists have named and described.
- All insect species are divided up into 32 orders, depending on the taxonomic system used.

Abundance of Insects

- The largest order is the Coleoptera (beetles)with 125 different families and around 500,000 species.
- Thirty percent (30%) of insects described belong to order Coleoptera (beetles) and it is the most diverse order of insects is followed by Lepidoptera (butterflies), Hymenoptera (bees) and Diptera (true flies).

Abundance of Insects

- Among living insects, the largest size insect is the South American Loonghorn beetle, *Titanus giganteus*, with a body length (not including the antennae) of over 16cm (6.5ins)
- The smallest known insect in the world is a parasitic wasp, *Dicopomorpha echmepterygis*



Below are pictures of different arthropods. Some are insects and some are not. Armed with your new definition, can you pick out the non-insects?

END

ENTOMOLOGY I

BODY DIVISIONS OF AN INSECT SEGMENT

BIOL 355

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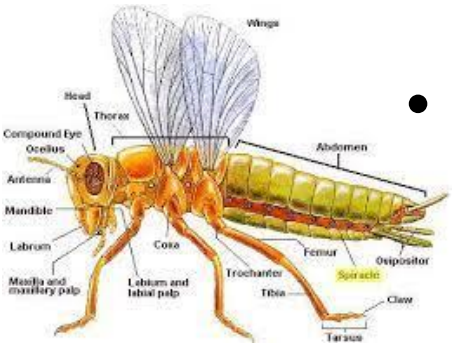
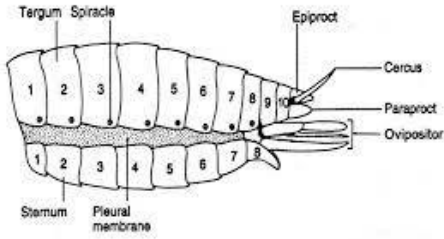
Body Division of an Insect



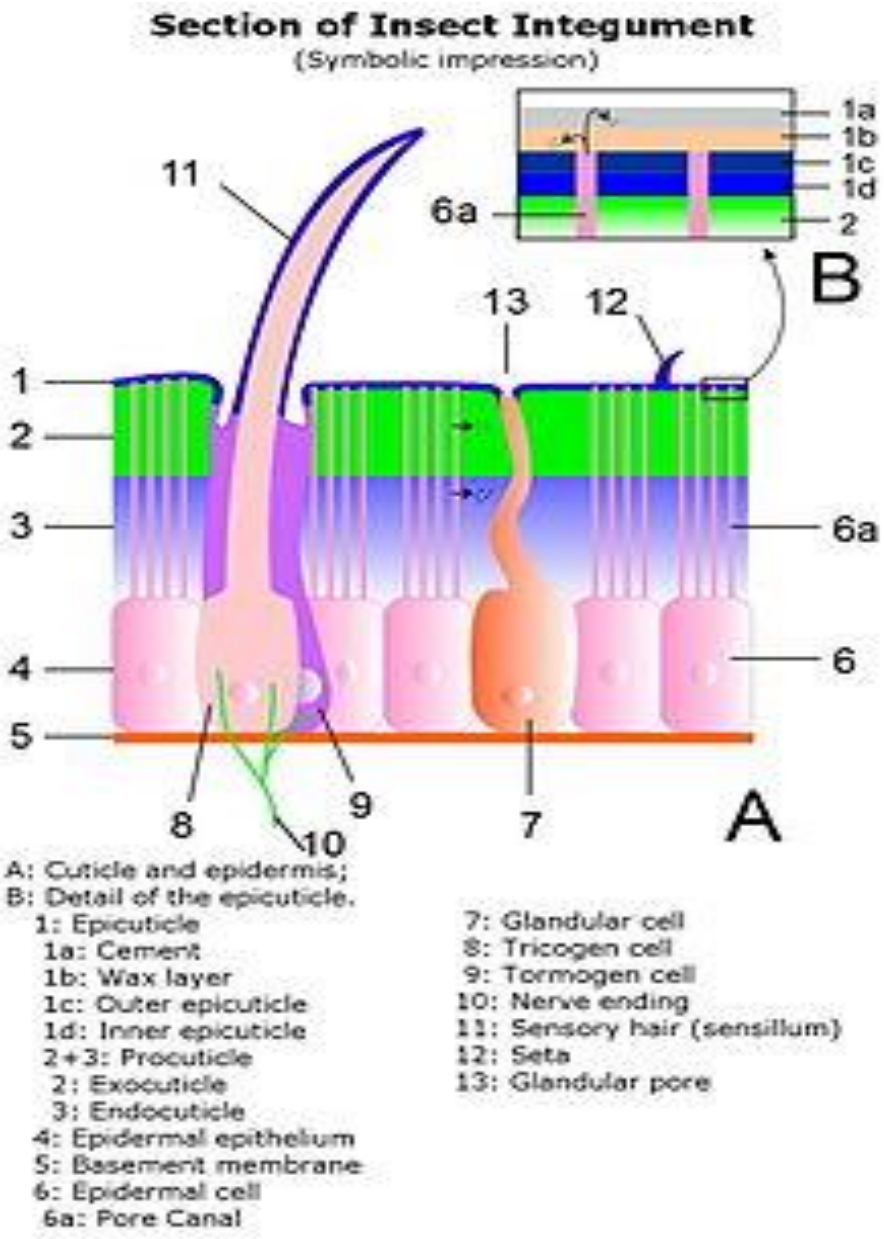
- In most adult insects their larvae, the body wall of a typical body segment is divisible into 4 definite sclerotized regions :



- Dorsal region : There are made up of sclerites composing the tergum known as tergites.
- Ventral region : There are made up of sternum (sternites)
- 2 lateral regions: They constitute each pleuron called pleurites

The Integument

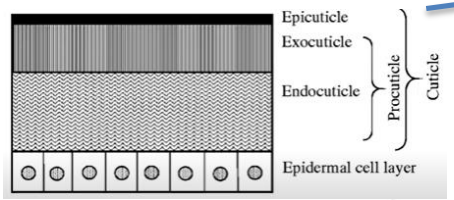
- The entire body wall or integument is made up of 3 parts:
  - The outer cuticle and its attendant bristles and hairs
  - Middle epidermis
  - Inner basement membrane



1. The Cuticle

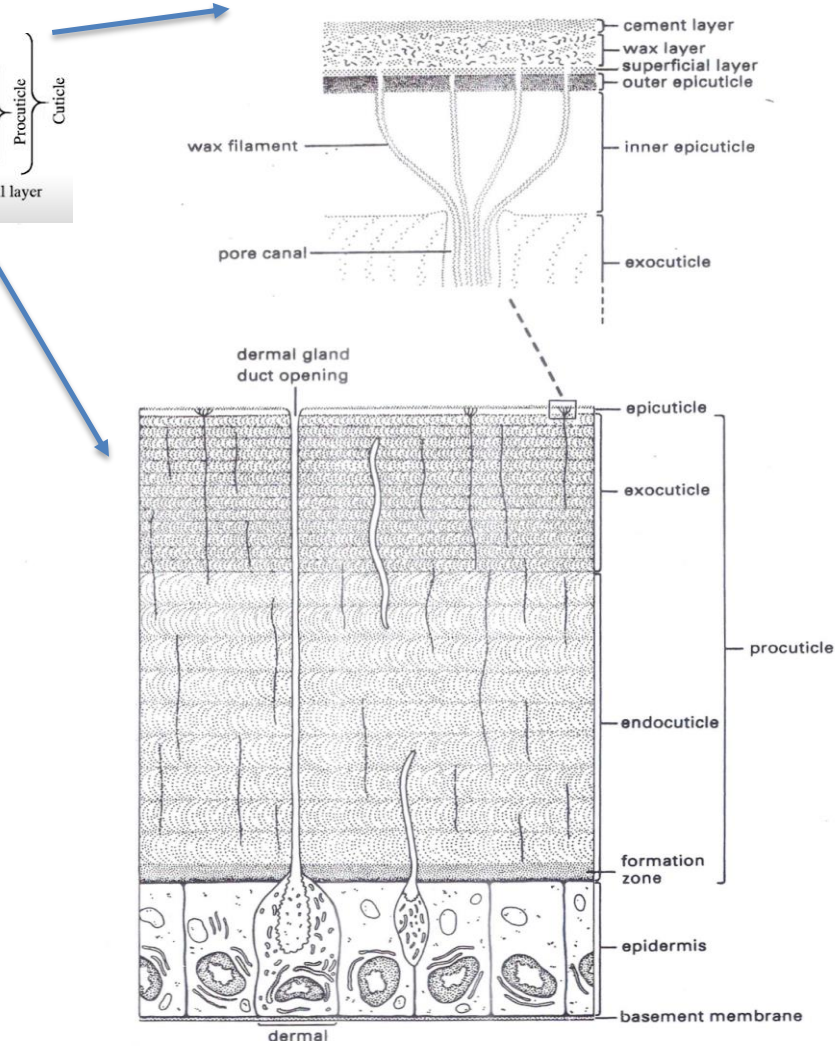
- The insect exoskeleton is usually called a cuticle.
- Is a complex non-cellular, outermost layer of integument secreted by the epidermis which lines the external surface of the body.
- It is flexible, elastic and white when first formed and stays this way in many larval forms.
- In most adult insects however, the greater part of the cuticle undergoes chemical processes known as sclerotization whereby it becomes hardened and darkened to form a rigid sclerites.
- The sclerites are separated from each other by membranous zones of soft cuticle.

The Cuticle



- The cuticle can be divided into 2 layers:

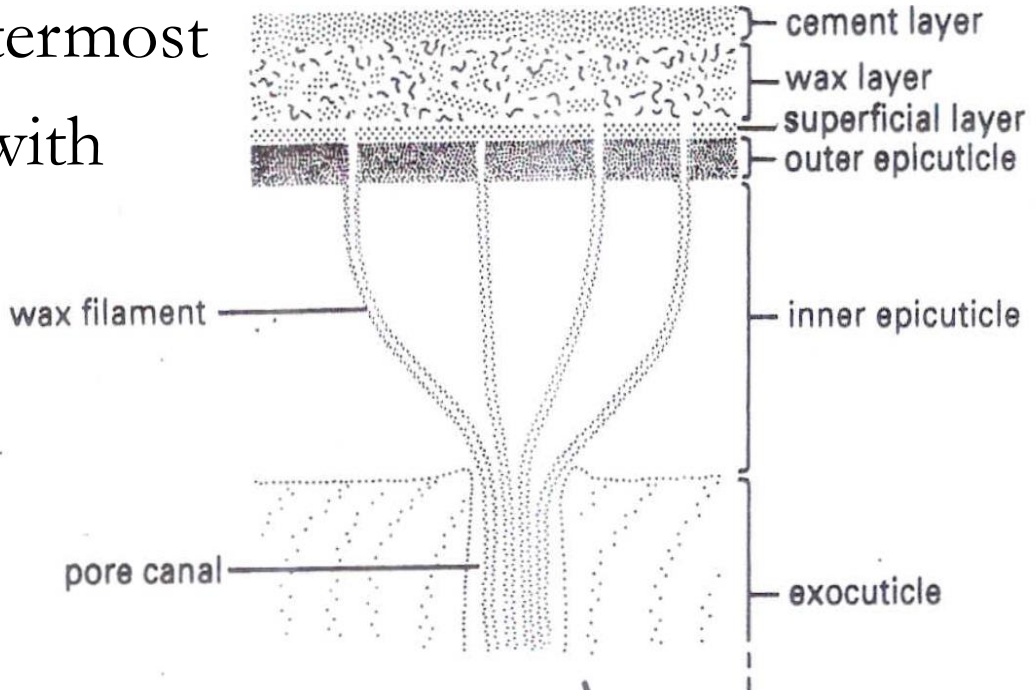
1. The Upper Epicuticle
   - A very thin outer layer which contains no chitin and is highly resistant to water and solvents
   - It consists of lipid and polyphenols
2. The Inner Procuticle
   - Thicker inner layer.



The general structure of insect cuticle; the enlargement above shows details of the epicuticle.

The Epicuticle

- The epicuticle is the first layer to be secreted in the cycle of cuticle formation, arising on top of epidermal microvilli.
- The epicuticle is a thin outermost layer varying in thickness with chitin being absent
- Consist of 3 layers
  1. An inner Epicuticle
  2. An outer Epicuticle
  3. Superficial layer



The Epicuticle

- The superficial layer is covered by a lipid or wax layer with its external being the cement layer.

1. Cement Layer:
   - It is secreted by dermal glands and is composed of lipoprotein.
   - It protects the body from external damage.
2. Wax Layer:
   - It is prominent layer consisting of long chain hydrocarbons, esters of fatty acids and alcohol.
   - It serves as a water proof layer preventing water loss from the body.

The Procuticle

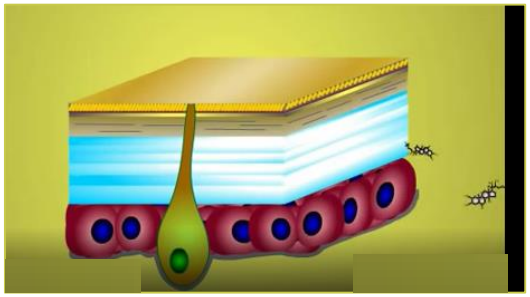
- Makes up the bulk of the integument.
- The procuticle is divided into 2 distinct layers after sclerotization process:
  1. An outer hardened Exocuticle
     - The layer in which sclerotization occurs and and consists mainly of chitin and a hard protein called sclerotin.
  2. An inner softer Endocuticle
     - The Endocuticle is soft, light coloured and unsclerotized.
     - It contains more chitin but lacks sclerotin thus creating an extremely tough and flexible components.

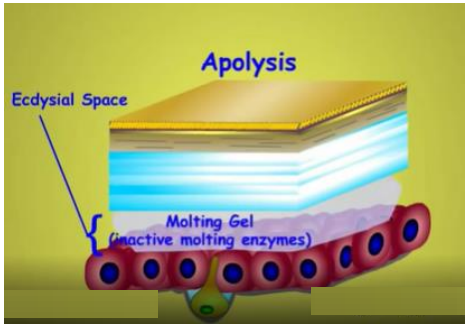
2. The Epidermis

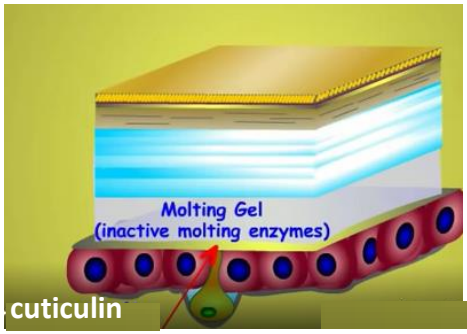
- It is a continuous single layer of cells
- Scattered among the normal epidermal cells are specialized gland cells and muscle attachment which penetrates the epidermis.
- Cuticular structural components, waxes, cement, pheromones and defensive as well as other components are produced by the epidermis.
- Many of these compounds are secreted to the outside of the insect epicuticle.
- Numerous fine pore canals traverse the procuticle and branch into numerous finer wax canals within the epicuticle; this system transports lipids (waxes) from the epidermis to the cuticular surface.

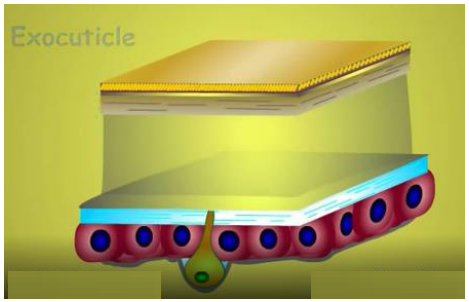
The Epidermis

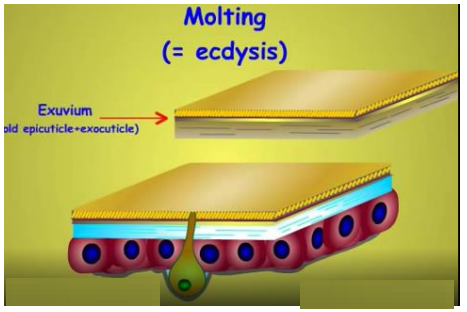
- The epidermis is closely associated with moulting/ecdysis.
- It produces the moulting fluid, which dissolves the old endocuticle before the immature insect moults.
- The epidermis also absorbs the digestion products of the old endocuticle, repairs wounds and differentiates in such a way as to determine the surface patterns of the insect.





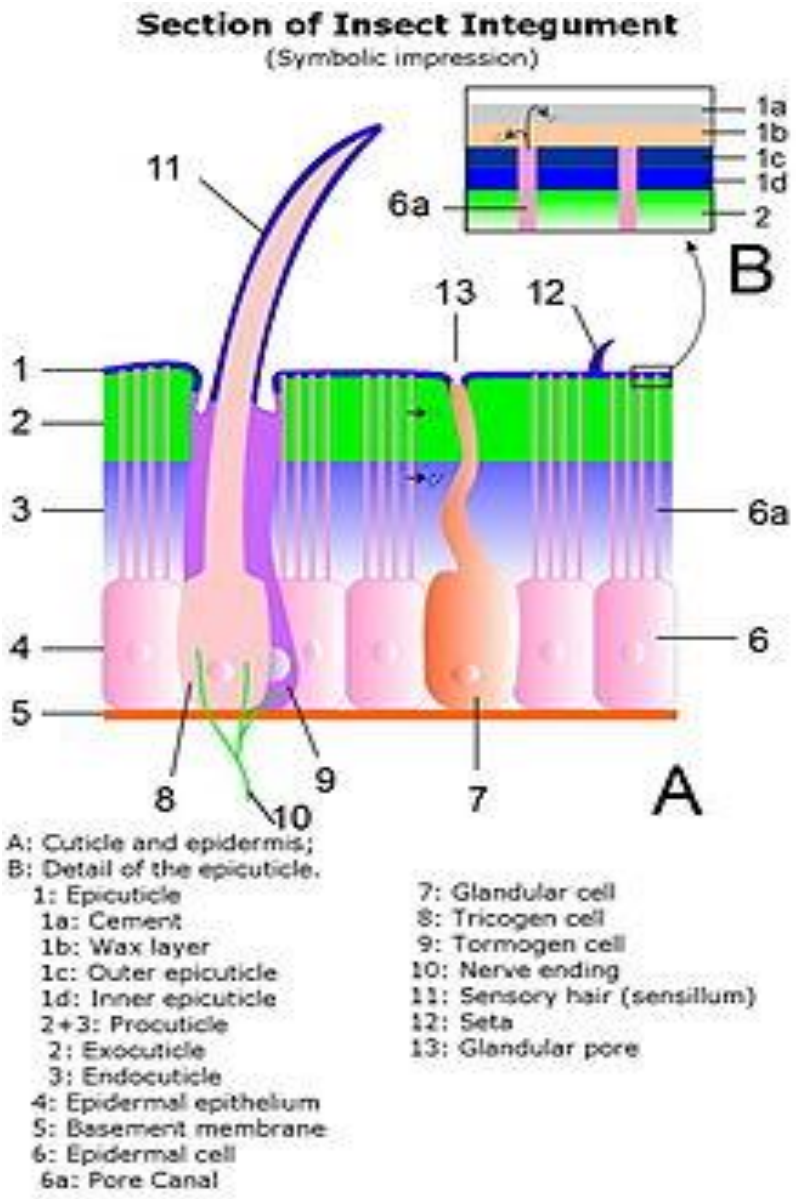






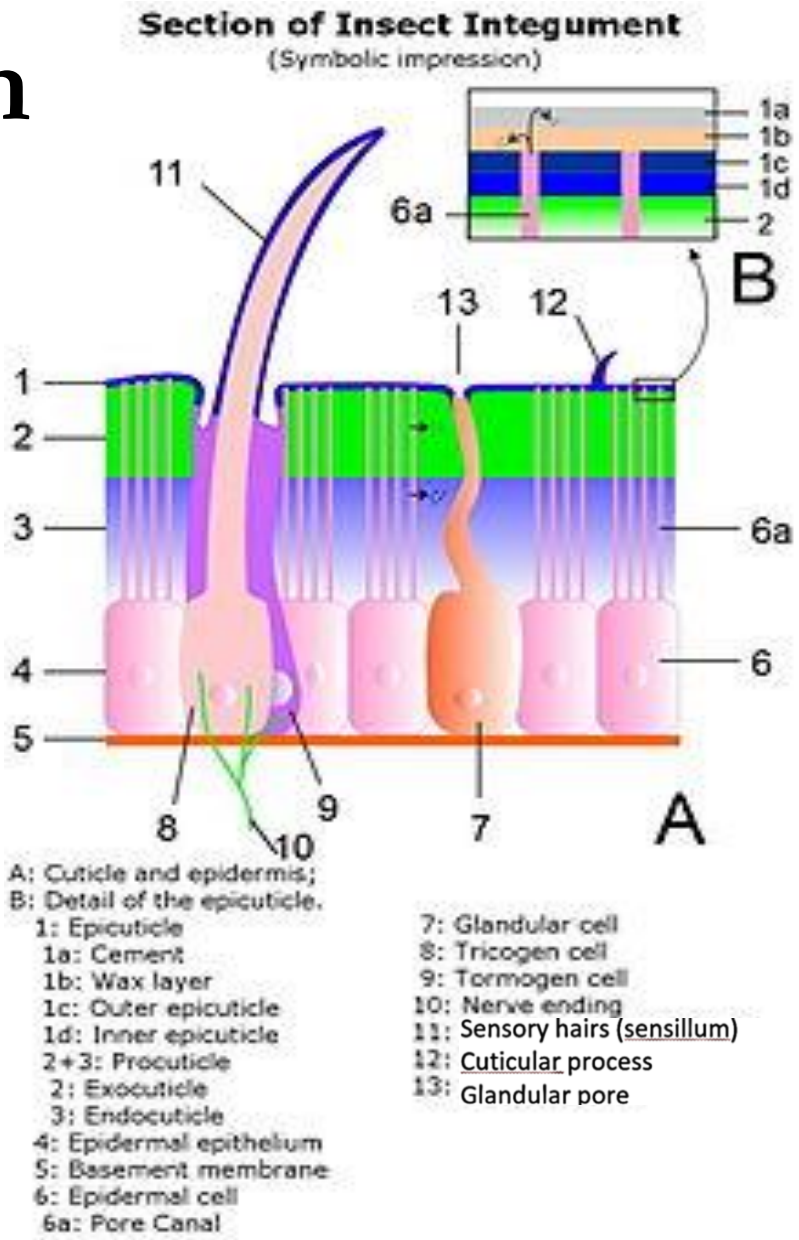
3. The Basement Membrane

- The basement membrane is a continuous sheet, where muscles are attached, and becomes continuous.
- Tracheoles and nerves run to it or through it.



Cuticular Outgrowth

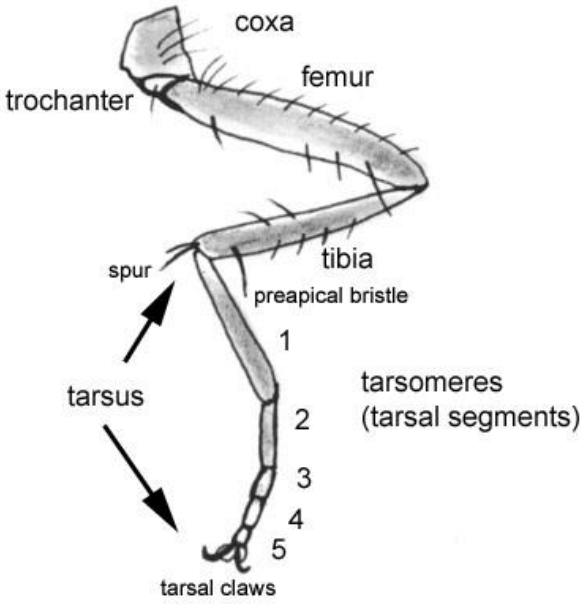
- They are divided into
  - Cuticular appendages
  - Cuticular processes

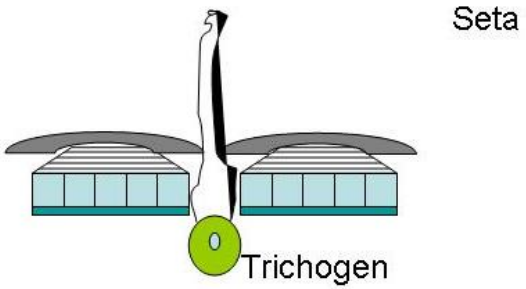


Cuticular Appendages

- Include all outgrowths of the cuticle which arise from modified epidermal cells.

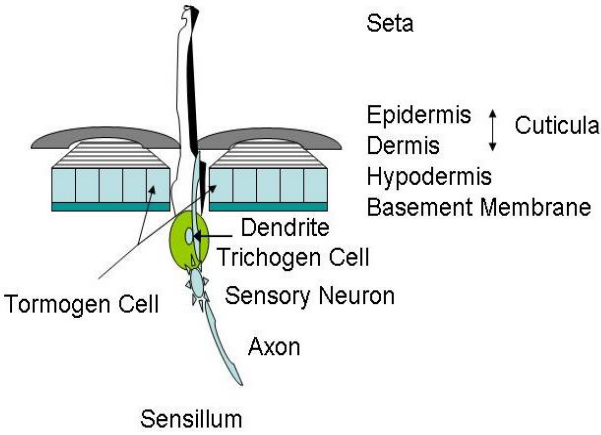
- They are classified into
  - Setae
  - Spurs



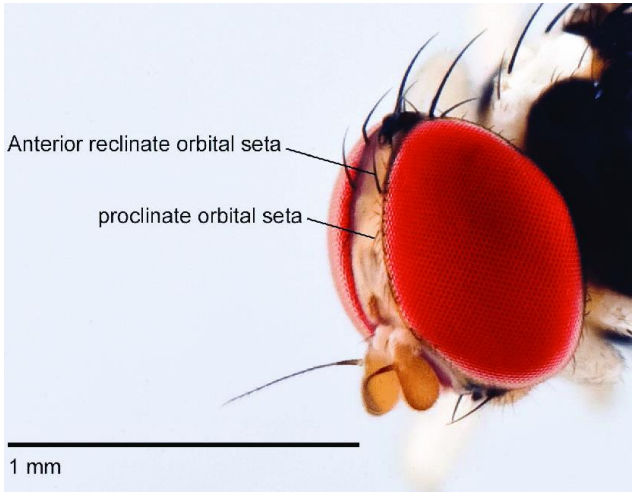


Section of Body Wall of an Insect

Setae



- They are commonly known as hairs.
- Setae are hollow, and associated with one single cell- the trichogen.
- Setae serve many purposes. There may be gland cells opening into the setae, or a nerve may extend into the hollow shaft, forming a sensory device—a sensillum. In such cases the trichogen cell grows the conical hair, another cell [tormogen] grows the socket.
- Setae have role of taxonomic importance and vary from species to species.



Different types of Setae

1. Clothing hairs
   - These are hair like structures that may cover the entire body, legs and wings.
   - May be formed on the general body surface or its appendages
   - When they have threadlike branches they are termed plumose hairs
   - Setae that are stout, rigid and large are called bristles or chaetae.

Different types of Setae

2. Scales

- These are varying pigmented plate like structures covering the body as well as wings of adult moths and butterflies.

3. Glandular setae

- Those setae which function as the outlet for the secretion of epidermal glands.
- If they are stout and rigid they are termed glandular bristles.

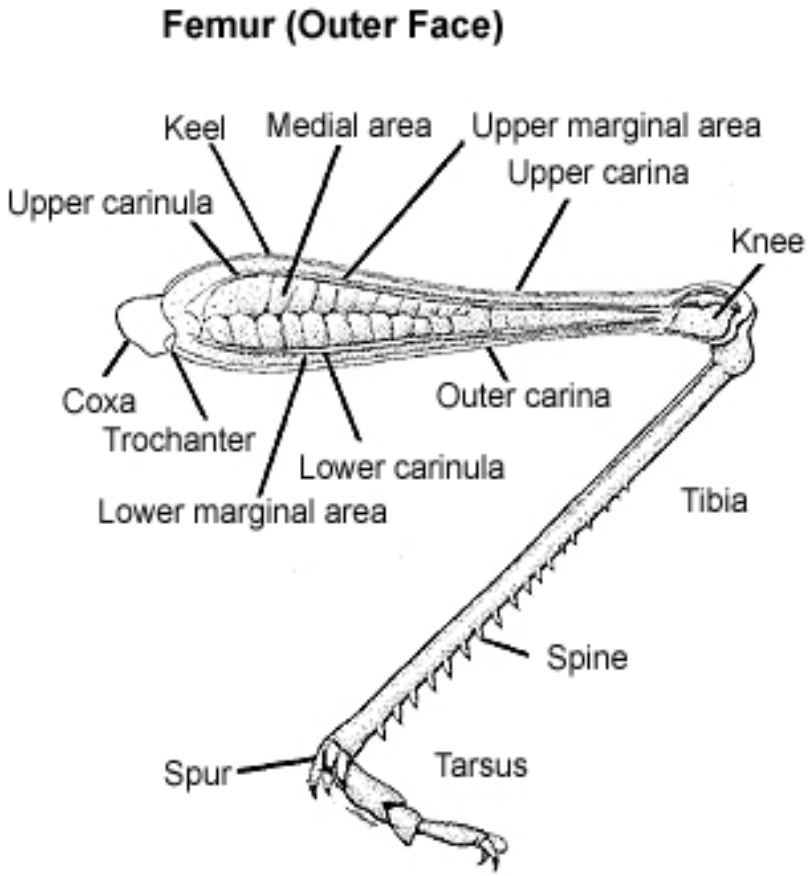
4. Sensory setae

- The setae on certain parts of the body which are modified to become sensory in function.
- Sensory setae are in all cases connected with the nervous system.

Cuticular Appendages

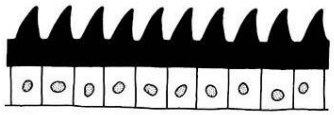
Spurs

- Spur is an articulated spine occuring on the legs of many insects.
- It may be used for piercing plants, cleaning antennae, walking on rough surfaces, nuptial activities.
- Differ from setae in being of muticellular in origin.

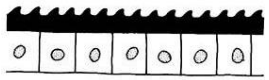


Cuticular Processes

- Are outgrowths of the external surface of the cuticle.
- They are connected with the cuticle having no membranous articulation and therefore readily separable from cuticular appendages.
- There are two types cuticular processes.
- Microtrichia: They are minute hair like structures, found on certain Diptera.
- Spines: Outgrowths of the cuticle which are thorn like in form



spines



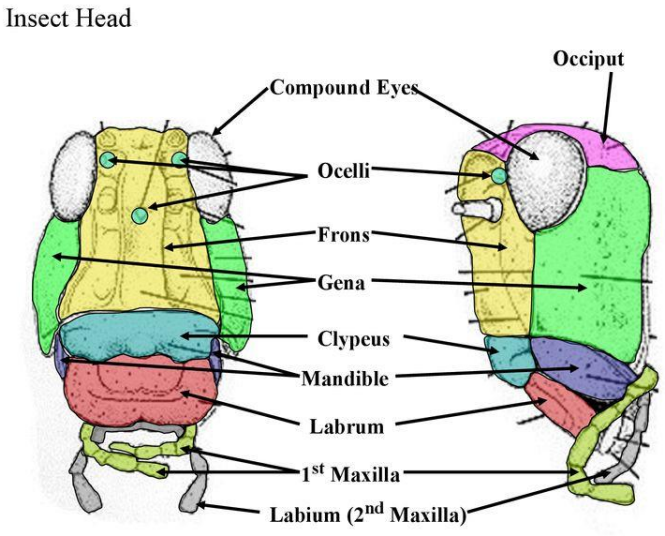
microtrichia

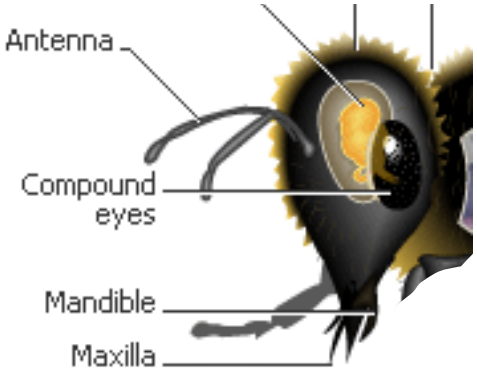
Body Divisions of an Insect

- The insects' bodies are made up of segments and divided into about 20 segments which are grouped into three regions or tagmata namely:
  - Head ➔ perception, food intake
  - Thorax ➔ locomotion, food processing
  - Abdomen ➔ reproduction, excretion

The Head

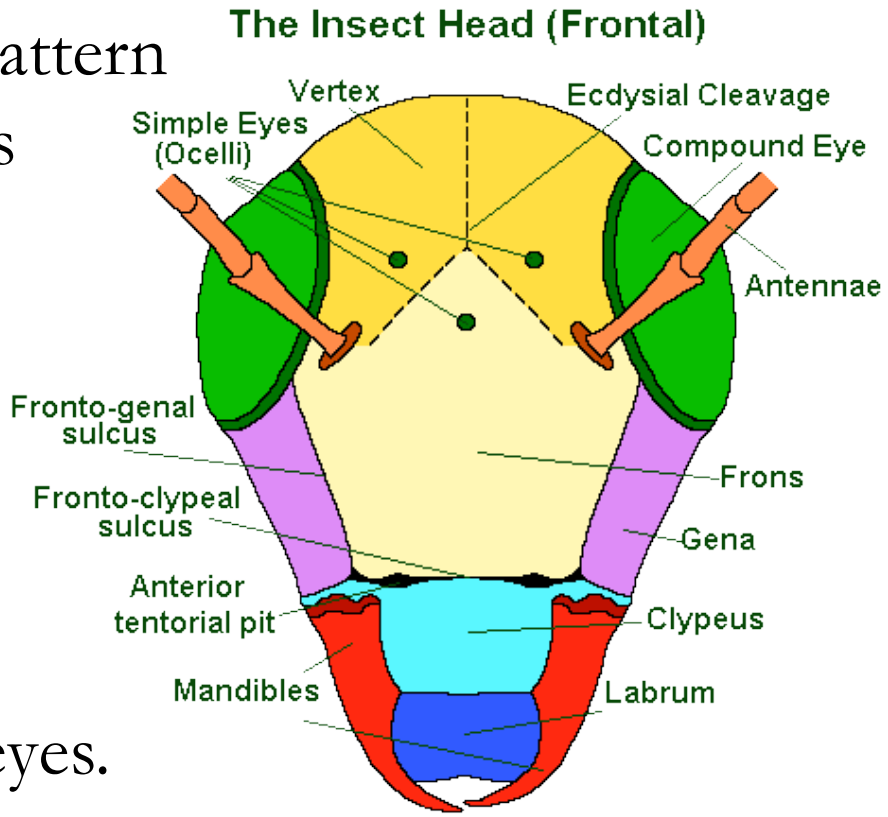
- Insect head is a hard and highly sclerotized compact structure
- It is the foremost part in insect body consisting of 6 segments that are fused to form a head capsule
- The insect head houses
  - Brain
  - Mouth opening and mouthparts
  - Major sense organs (including antennae, compound eyes and ocelli).





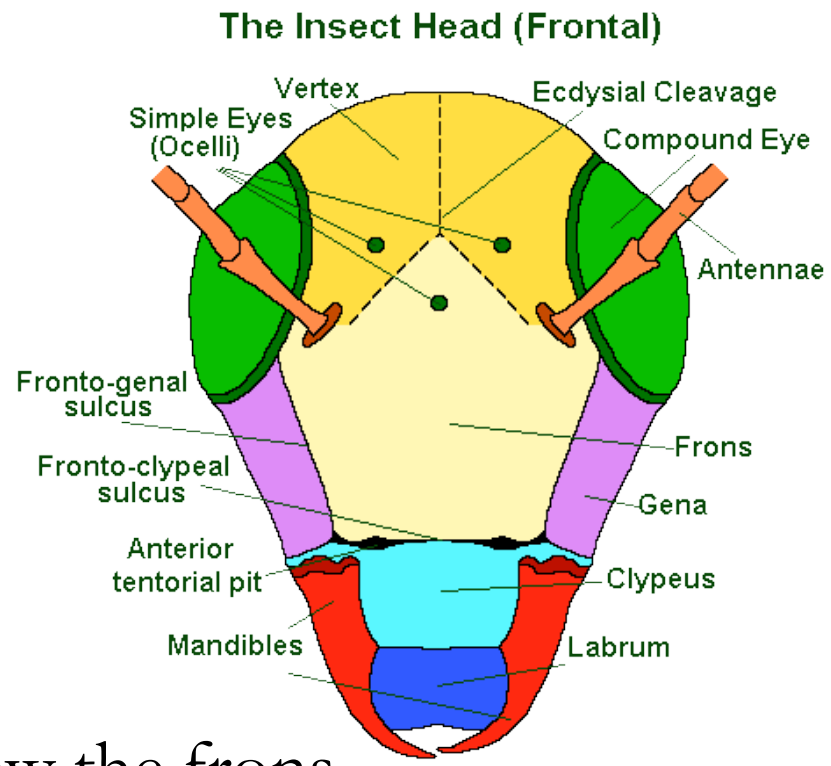
The Head (frontal view)

- The surface of the head is divided into regions (sclerites) by a pattern of shallow grooves known as sutures or sulci
- The uppermost sclerites (dorsal surface) of the head is known as the vertex. It is behind the frons or the area between the two compound eyes.



The Head (frontal view)

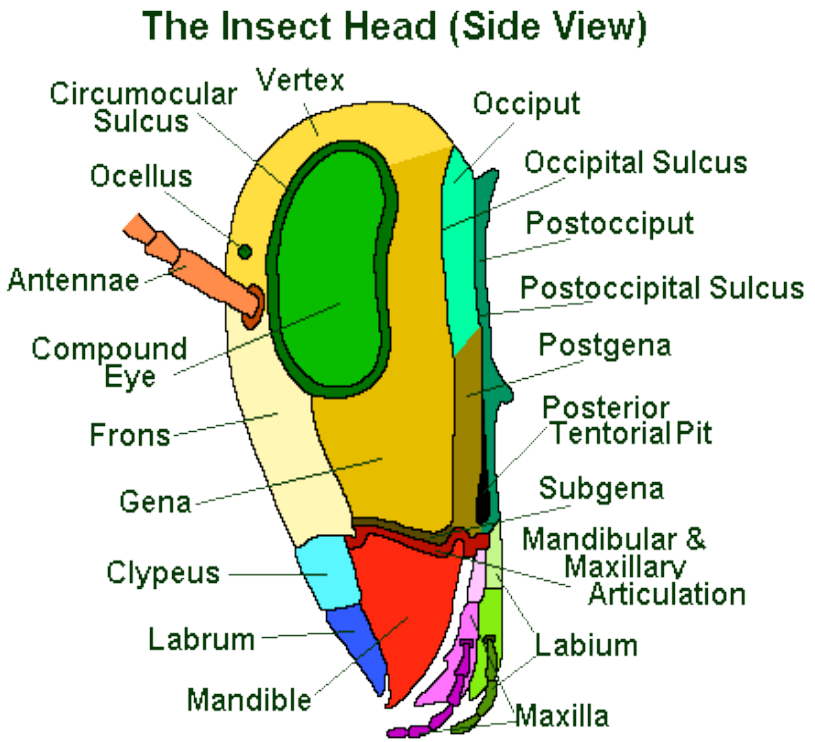
- A coronal suture or ecdysial cleavage line usually runs along the midline of the vertex and splits it into two frontal sutures
- The triangular sclerites that lies below the two 'ocelli' is called the frons. The frons bear the median ocellus.



- The clypeus lies immediately below the frons
- The genae (cheeks) are lateral sclerites that lie on each side of the head posterior to the eyes.

The Head (side view)

- Near the back of the head, an occipital suture circumscribes the head capsule at the posterior margin of the vertex and genae.
- Just behind the occipital suture lie the occiput and postgenae.

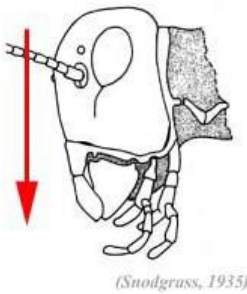


- At the posterior- most margin of the head is a faint postoccipital suture and a thin, band- like sclerite, the post occiput, that adjoins the neck membrane.

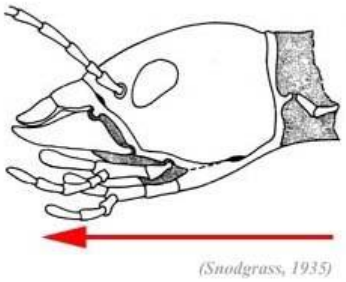
The Head

- The head of the insects are divisible into three types depending on the inclination of the long axis of the head and the position of the mouth parts
  - Hypognathous
  - Prognathous
  - Opisthognathous

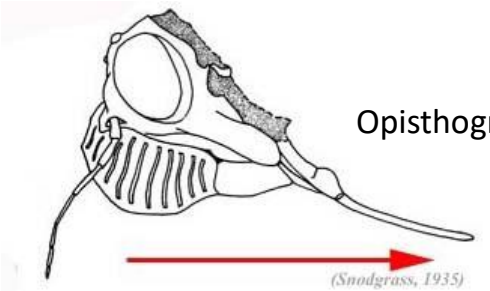
Hypognathous



Prognathous

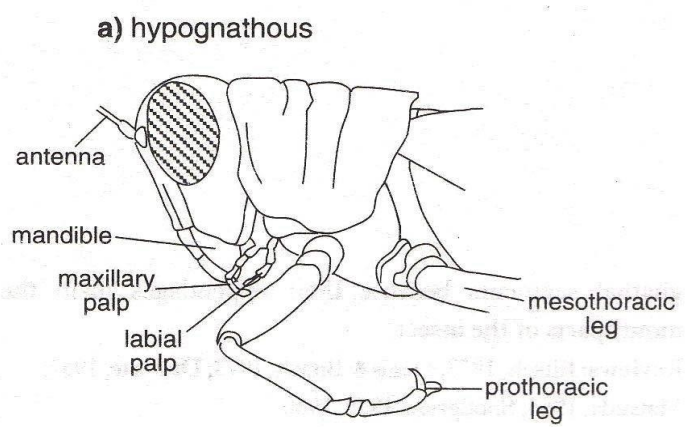


Opisthognathous



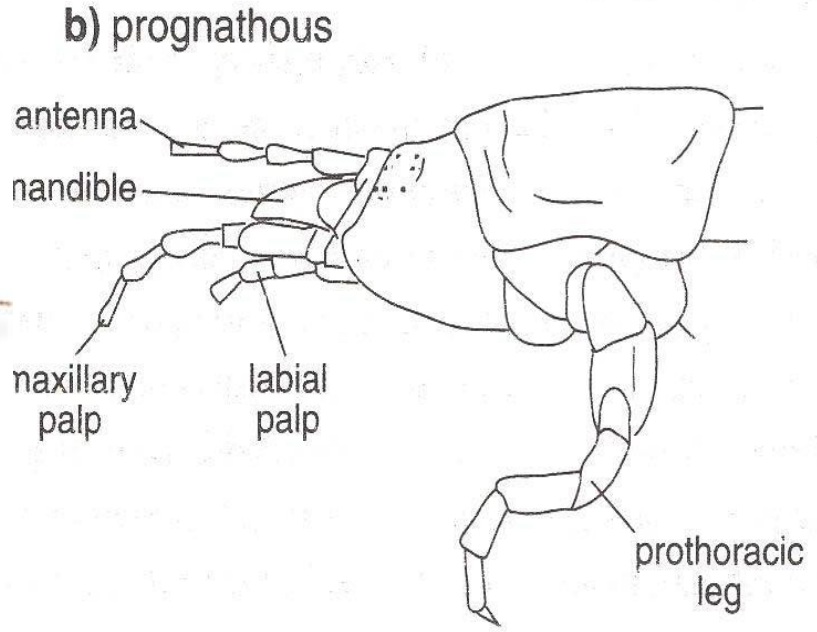
Hypognathous (Hypo-Below: Gnathous-Jaw)

- In Hypognathous type the long axis of the head is vertical and the mouthparts directed vertically
- Eg the grasshopper, cockroach, mantid



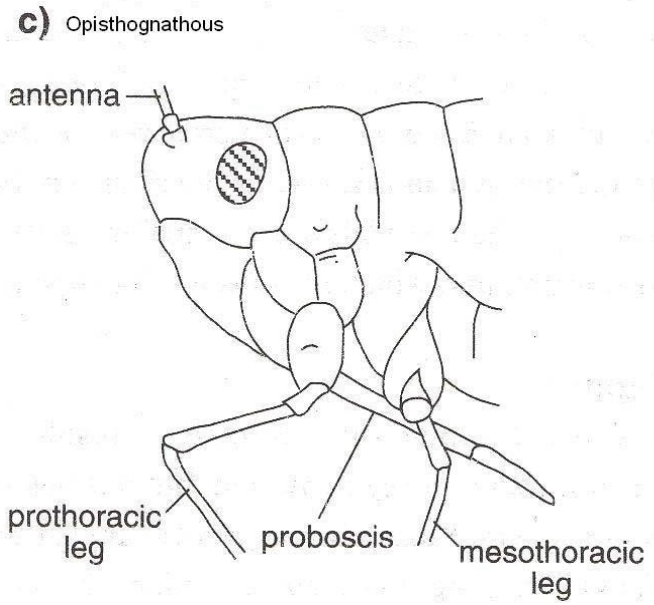
Prognathous
(pro-infront: Gnathous - Jaw)

- The long axis is horizontal; the head is horizontal and the mouth parts are projected forward
- They are found in carnivorous insects that burrow in wood or soil
- Eg: beetles and termites



Opisthognathous
(Opistho-Behind: Gnathous- Jaw)

- In Opisthognathous condition the head is deflexed such that the mouthpart is directed backward and held in between the forelegs.
- Eg: Aphids

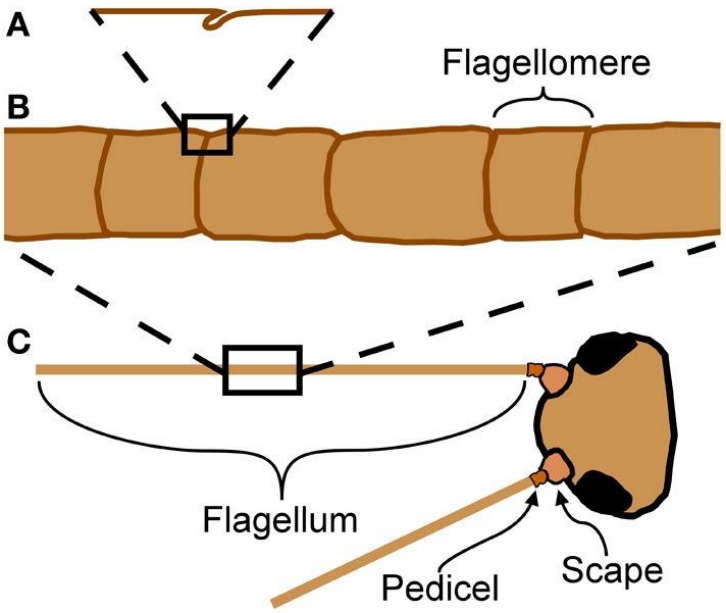


Sensory Organ ~ Antennae

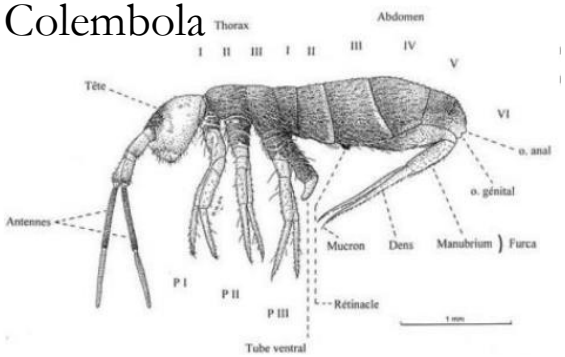
- These are a pair of mobile, jointed appendages that extend from the front of the head, usually between and slightly above the insect's head.
- They are sensitive to touch and smell. They are lined with numerous olfactory nerves which insects rely on to smell food and detect pheromones or odour-carrying molecules, released by potential mates.

Antennae

- Insects have one pair of antennae
  - Grown from the insect's head
  - Flexible
  - Come in a variety of shapes and forms
  - They are used by entomologists in insect identification

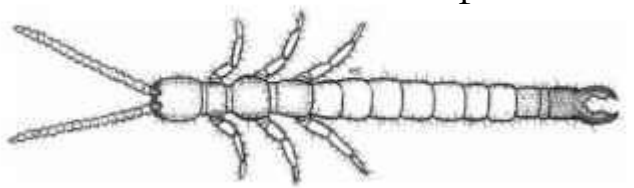


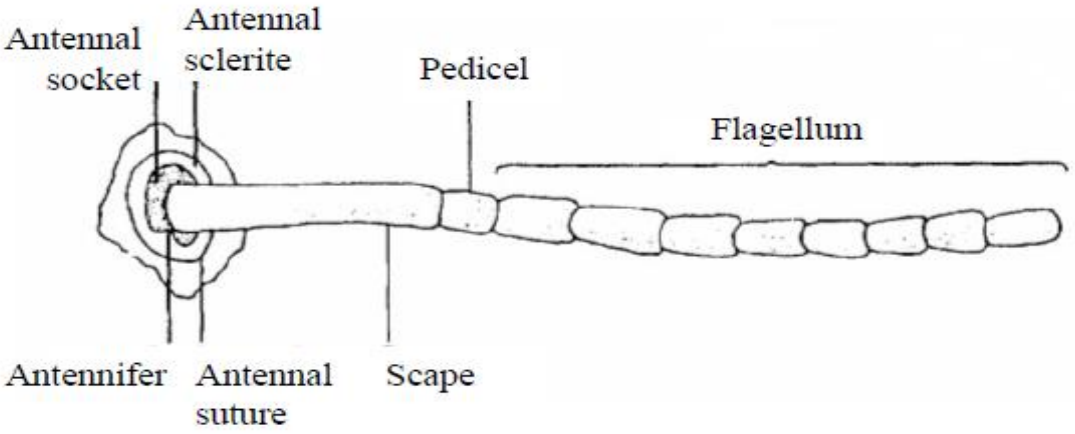
Colembola



Antennae

Diplura

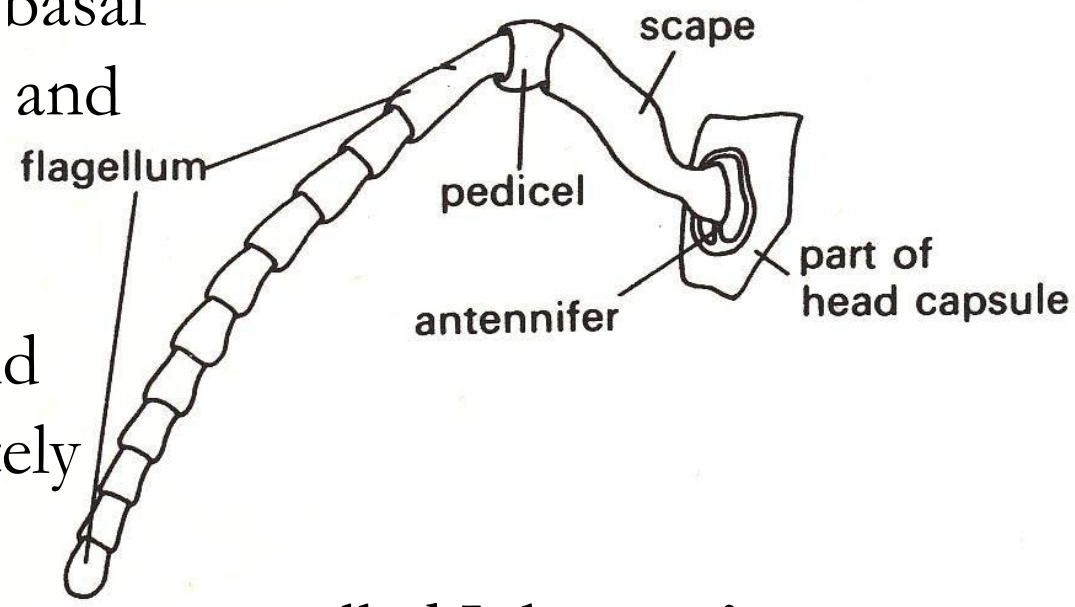




- Antennae are mostly composed of three segments
  - Flagellum
  - Scape
  - Pedicel
- In two orders Diplura and Colembola the antennae lack pedicel
- Antennae are however absent from the Protura

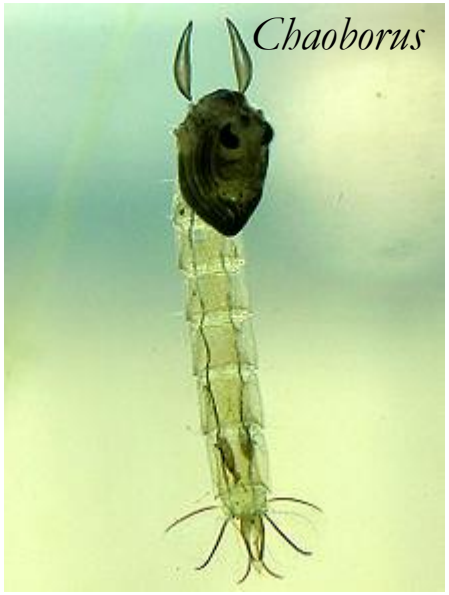
Antennae

- The **scape** is the first or basal segment of the antennae and is often larger than the other segments.
- The **pedicel** is the second segment which immediately follows the scape. It contains a mechanosensory organ called Johnston's organ.
- The **flagellum** is often filamentous and multi-segmented with many flagellomeres. These are small segments contain many specialised sensory cells and may be reduced or variously modified.



Antennae

- The antennae are an insects primary, non-visual, sense organs.
- In a few rare instances they have become adapted for other purposes such as seizing prey items (i.e. the larva of *Chaoborus* sp./ midges) or holding females during mating (i.e. the males of *Meloe* sp. (Coleoptera).
- Numerous sensory organs, or sensilla, in the form of hairs, pegs, pits or cones, occur on the antennae and function as chemoreceptors, mechanoreceptors
- Antennae come in a wide variety of shapes and sizes.



Types of Antennae
1. Setaceous ~ Bristle-like

The segments of flagellum are taper towards apex

Example :

Dragonfly

2. Filiform ~ Thread-like

The segments of flagellum are of same thickness and thread-like.

Example :

Grasshopper

Moniliform ~ Bead-like

The segments of flagellum are bead-like

Example :

Termites

Serrate/Dentate ~ Tooth-like

The segments of flagellum have tooth-like projections on one side.

Example :

Pulse beetle

Pulse beetle

Pectinate ~ Comb-like

The segments of flagellum have long stiff projections on one side.

Example :

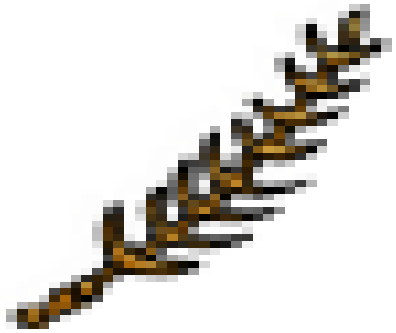
Cardinal beetle

Bipectinate

The segments of flagellum have long stiff projections on both sides.

Example :

Silkworm moth



Plumose ~ Feather-like

The segments of flagellum have thick whorls of long hairs

Example :

Male mosquito

Pilose ~ Hairy

The segments of flagellum have very thin whorls of hairs .

Example :

Female mosquito

Clavate ~ Club-like

The segments of flagellum are gradually broaden towards the apex

Example :

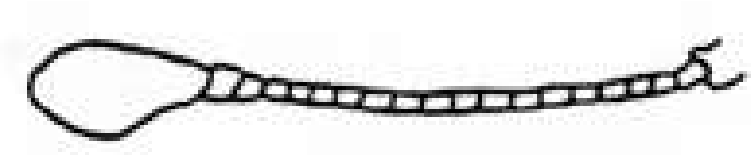
Butterfly

Capitate ~ Head-like

The segments of flagellum suddenly thickened to form a head-like structure.

Example :

Red flour beetle

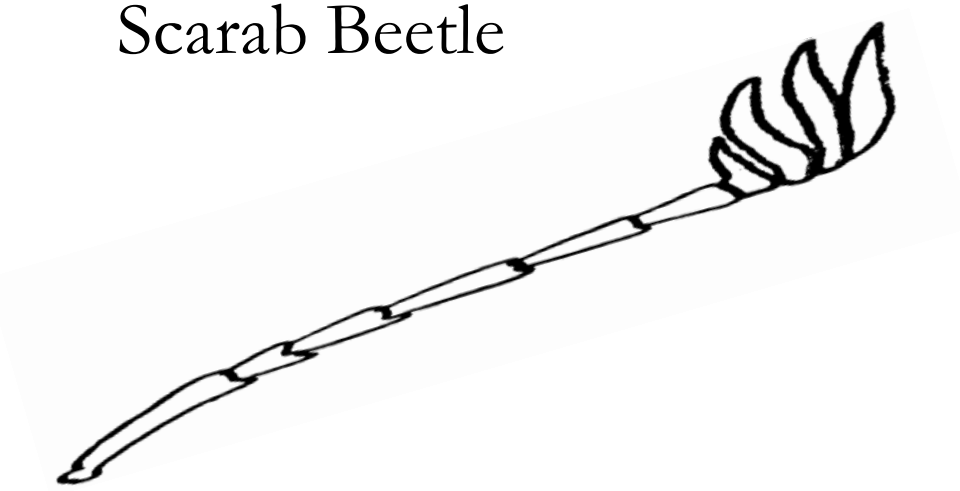


Lamellate ~ Leaf-like

The terminal segment of flagellum are extended into leaf-like plates on one side.

Example :

Scarab Beetle

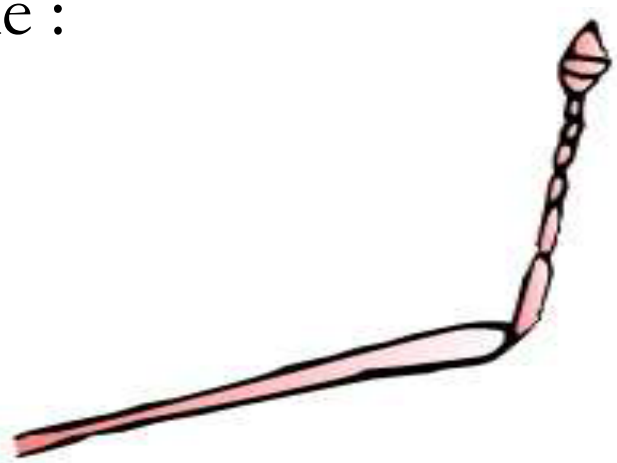


Genicule ~ Elbow-like

In these the scape is very long and forms a sharp bend like a flexed arm.

Example :

Ant

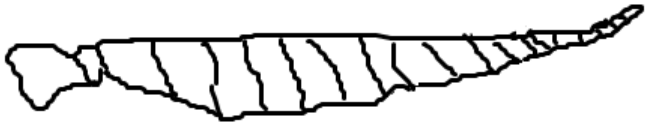


Ensiform ~ Sword-like

The segments of flagellum are thin and gradually taper towards the apex and form a leaf-blade-like structure.

Example :

Green Grasshopper

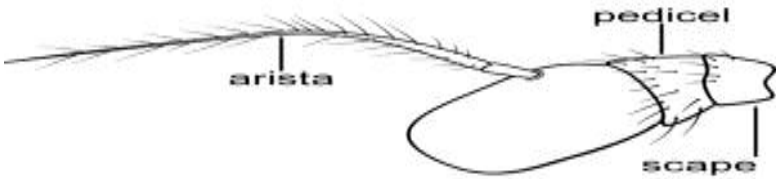


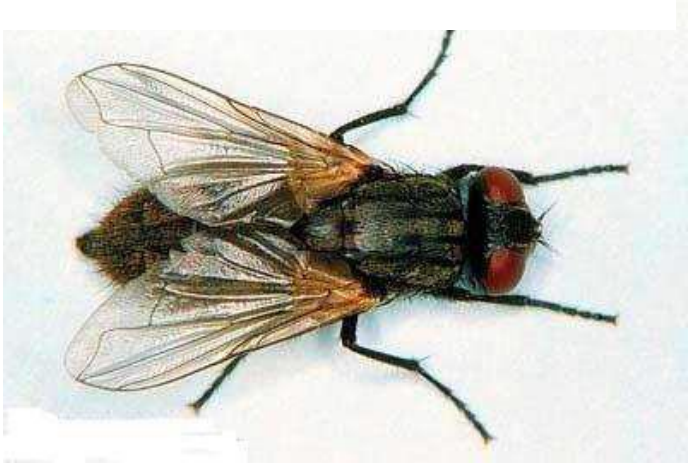
Aristate ~ Arista-like

The segments of flagellum form a bristle-like process

Example :

House-fly

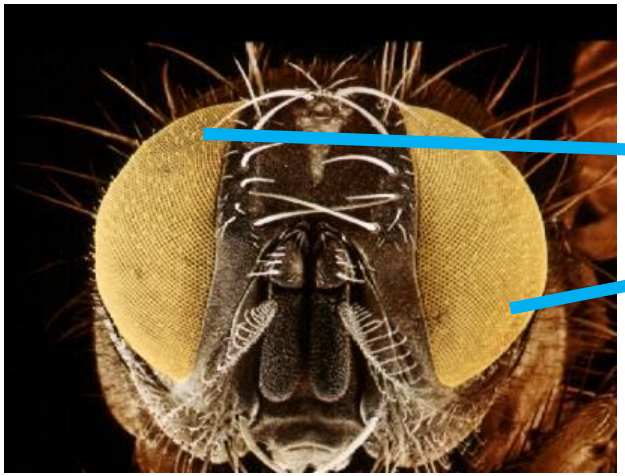


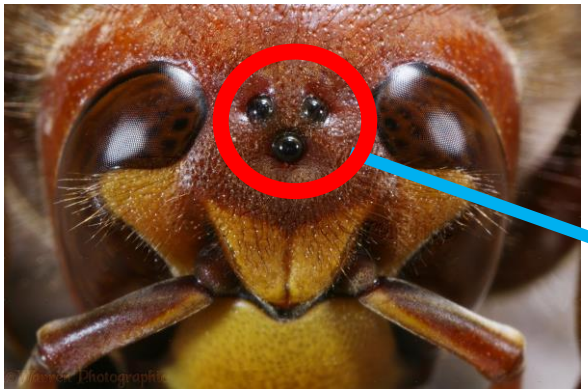


Vision ~ Eye

Most insects posses 2 kinds of eyes

- Compound Eyes
- Simple eyes called Ocelli



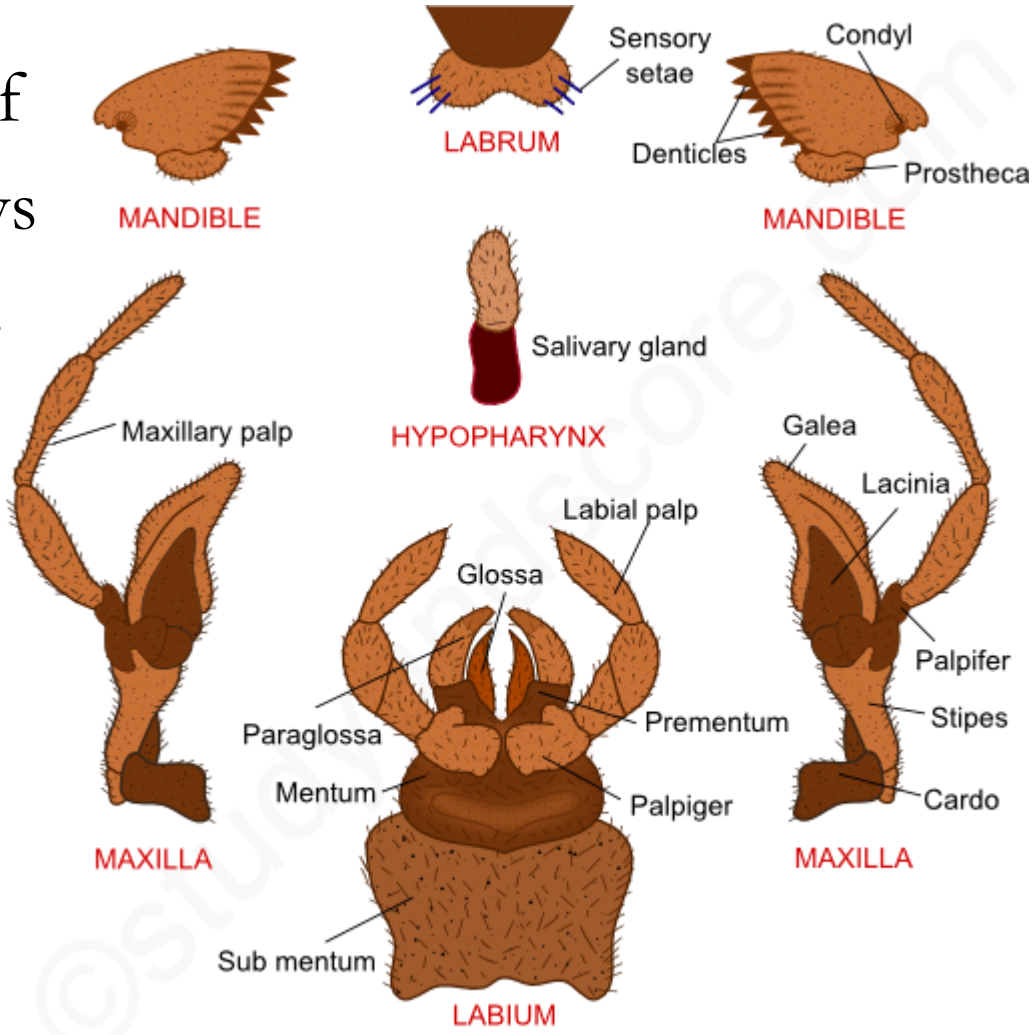


Vision~ Eye

- A compound eye has many facets, which are hexagonal in shape called Ommatidia. Each facet sees part of an image while the brain combines the images into a mosaic.
- The simple eyes is composed of 1 unit, often arranged in the shape of a triangle on adult insects .
- Larval insects, like caterpillars, do not have compound eyes.
- But they may have numerous ocelli with which they see reasonably.
- In a few adult insects and among some larval and pupal forms, eyes are completely absent.

The Mouthparts

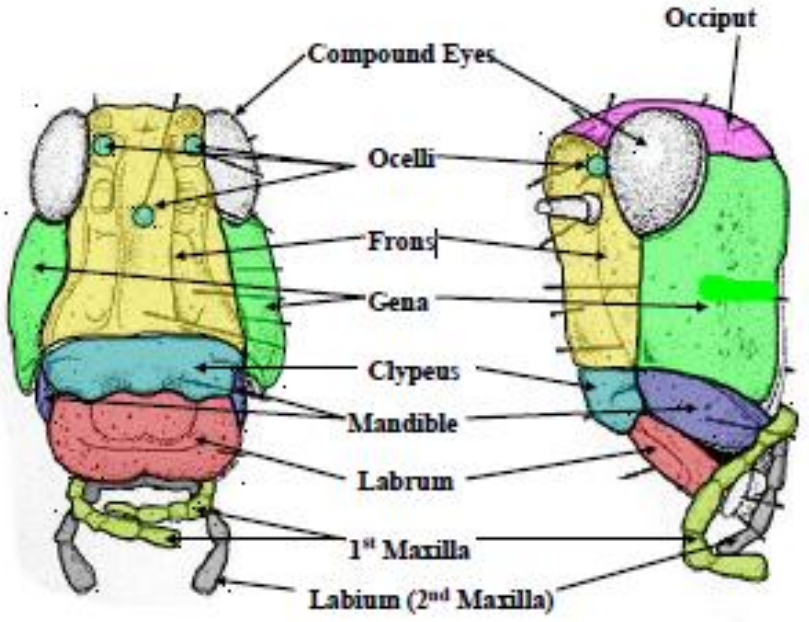
- An insect mouth consists of
  - Mandibles1st pair of jaws
  - Maxillae-2nd pair of jaws
  - Hypopharynx- tongue
  - Labrum - upper lip
  - Labium - lower lip



MOUTHPARTS OF COCKROACH - BITING AND CHEWING TYPE

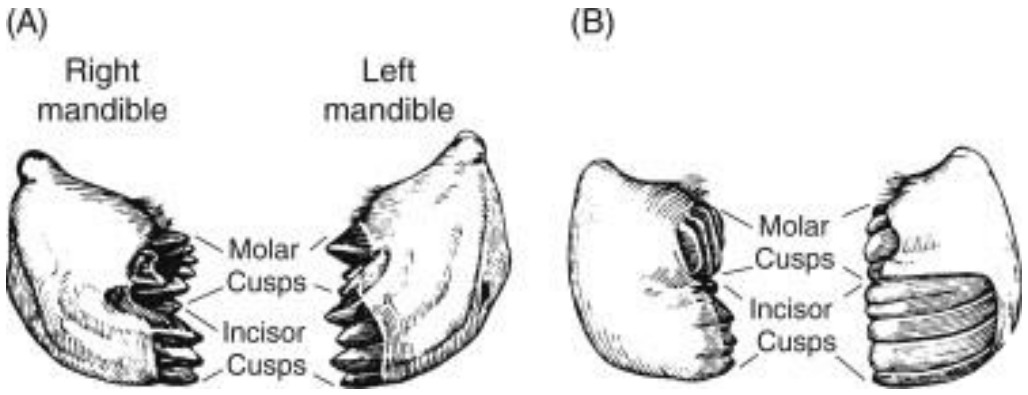
The Mouthparts ~ Labrum

- The Labrum is normally a sclerite or plate that is equivalent to the insect's upper lip and is generally moveable, it articulates with the clypeus by means of the 'clypeolabral suture.



The Mouthparts ~ Mandibles

- The mandibles and the maxillae are the equivalent of jaws with the exception that they move transversely.
- The mandibles show great variety within the insect orders and like our teeth they are hard and show variation in accordance with diet.



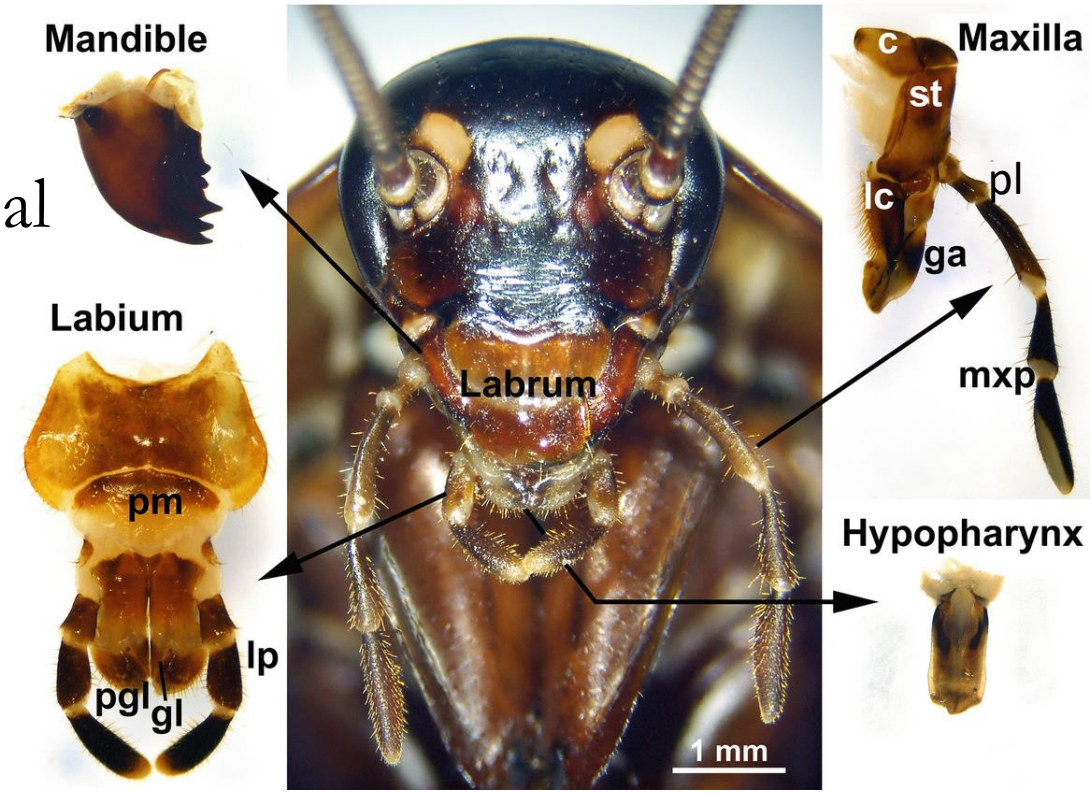
(A) grasshopper that feeds on soft, broad-leaved plants.
(B) grasshopper that feeds on grasses.

The Mouthparts ~ Mandibles

- They are sharp edged in carnivores, being extremely sickle like in the ant *Aceton burchelli*, whilst being adapted for crushing and chewing in herbivores.
- Mandibles are used not only for feeding but also for attack and defence, becoming extremely exaggerated in various species of termites.

The Mouthparts ~ Maxillae

- It forms the second pair of jaws and are located behind the mandibles in front of the labium.
- Each consists of a basal part composed of
  - cardo
  - stipes
  - lacinia
  - galea
  - lateral palpifer
  - maxillary pulp

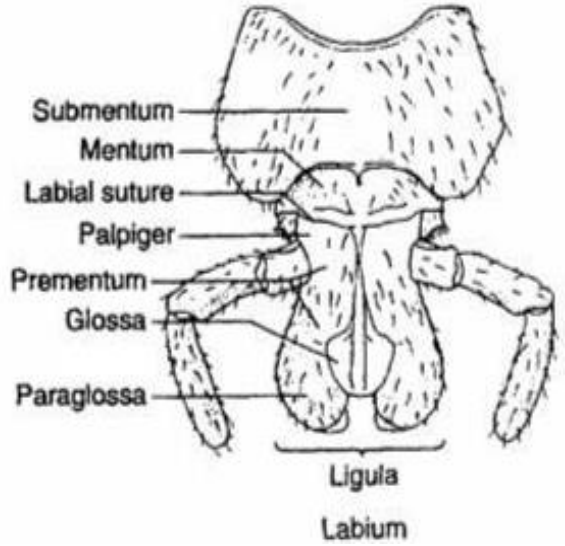


The Mouthparts ~ Maxillae

- The Cardo – this is the piece nearest the head capsule and in some species of insects it is the only part of the maxillae that is directly attached to the head.
- The Stipes-Articulates with the distal border of the cardo and bears a lateral sclerite or palpifer and sometimes an inner sclerite, the subgalea (parastipes).
- The palpifer carries the maxillary palp which has one to seven segments.
- Maxillary palps possess olfactory and gustatory sense receptors and function as sensory organs.
- At the distal end of the maxillae are two lobes; an inner one (mesal) lacinia and an outer (lateral) one, the galea.

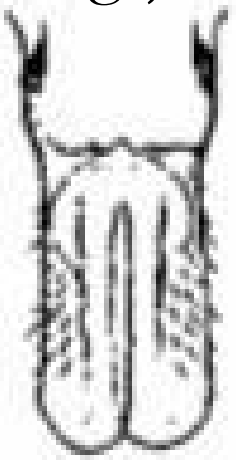
The Mouthparts ~ Labium

- The labium results from the fusion of a pair of limbs and serves a purpose similar to our lower lip for the insects.
- The labium is often regarded as the second maxilla as it evolved from paired maxillae-like structures which are fused along the centre line and closes the mouth cavity.
- Labium is divided into three parts
  - the proximal prementum,
  - central mentum
  - distal submentum



The Mouthparts ~ Hypopharynx

- The hypopharynx- a tongue-like structure situated between labrum and labium and has the salivary duct at its base.
- The salivary glands discharge saliva through it to assists swallowing.
- In most Diptera (true flies) and Hemiptera (true bugs), it has become highly modified and serves as the main feeding organ in many cases combining with the rest of the mouthparts to form a stylet or piercing organ.



Hypopharynx

Insect Mouthparts

Type of mouthpart	Siphoning	Sponging	Piercing/Sucking	Chewing
Example				
Function	Feeding tube is uncoiled and extended to suck liquids into the mouth.	Fleshy end of mouthpart acts like a sponge to mop up food.	A thin, needlelike tube pierces the skin or plant wall to suck liquids into the mouth.	Mandible pierces or cuts animal or plant tissue, and other mouthparts bring food to the mouth.
Insects with adaptation	Butterflies, moths	Houseflies, fruit flies	Mosquitoes, leaf-hoppers, stink bugs, fleas	Grasshoppers, beetles, ants, bees, earwigs

END

ENTOMOLOGY I

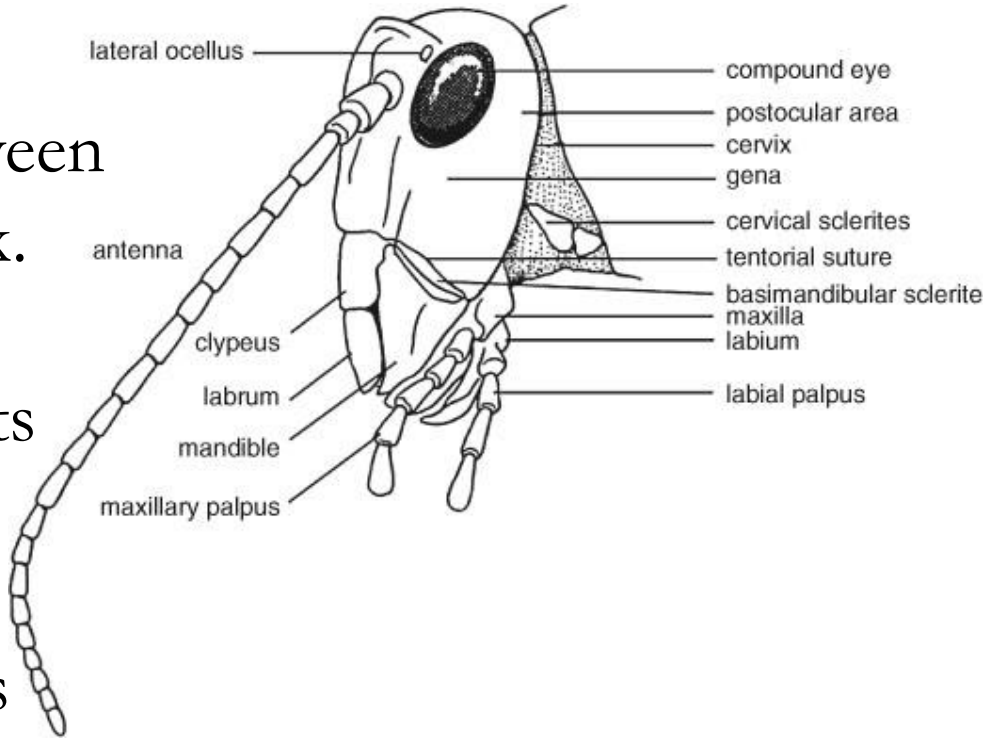
BODY DIVISIONS OF INSECTS

BIOL 355

Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

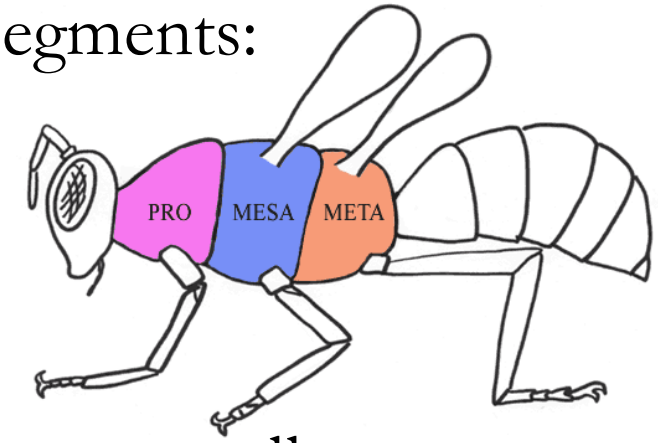
Neck Region/Cervix

- The cervix is the flexible intersegmental region between the head and the prothorax.
- Small plates called cervical sclerites are embedded in its membranes.
- In their least modified forms, the cervical sclerites consist of paired dorsal, lateral and ventral plates.



Thorax

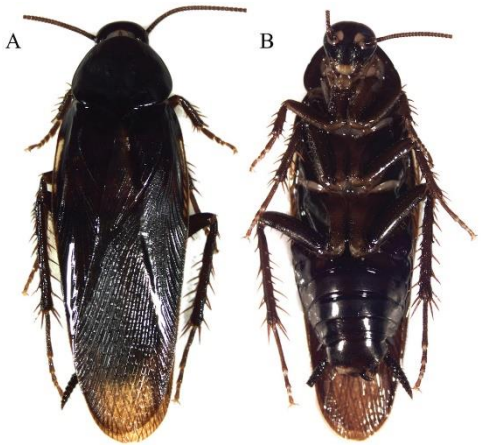
- This is the middle section of the body (between head and abdomen) and is divided into 3 segments:
  - Prothorax
  - Mesothorax
  - Metathorax



- Each segment bears a pair of legs lateroventrally
- The mesothorax and metathorax in addition to legs usually bears a pair of wings dorsolaterally
- Meso and meta thoracic segments together known as pterothorax

Prothorax

- Never bears wings and varies in its degree of development.
- Its dorsal region may be enlarged to form a shield as in the cricket, termites, cockroaches and bugs.
- Openings (spiracles) of gas exchange or tracheal system are mostly present laterally on the second and third thoracic segments at most with one pair per segment.



Mesothorax and Metathorax

- In most winged insects, the mesothorax and metathorax are enlarged relative to the prothorax.
- The absence of wings may be a primitive character as in the Apterogota.
- In Orders where the two wings are of equal area, these two (mesothorax and metathorax) bearing them are of equal size. E.g. termites, dragonfly.

Mesothorax and Metathorax

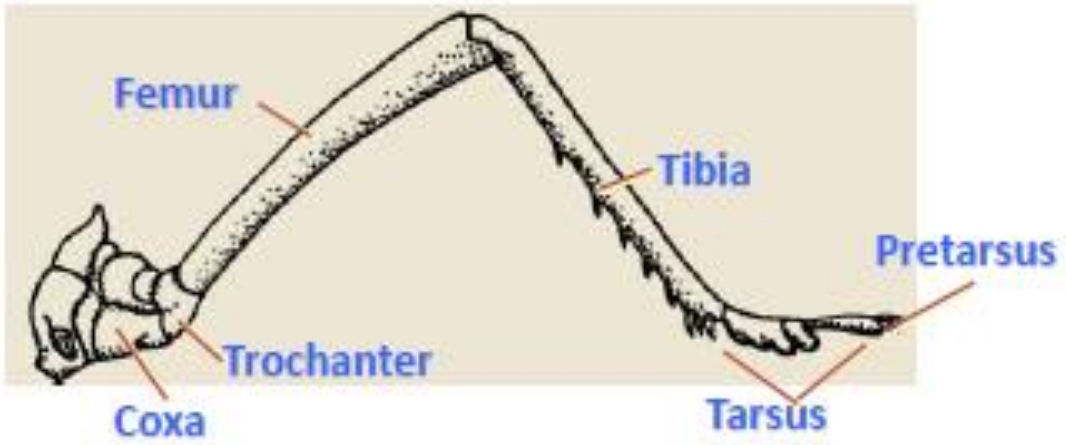
- Where the fore wings are markedly larger than the hind pair, there is a corresponding greater development of the mesothorax. E.g. Hymenoptera
- Where the fore wings are small or not used in flight there is a correlated reduction of the mesothorax. E.g. Coleoptera.

Hymenoptera

Coleoptera

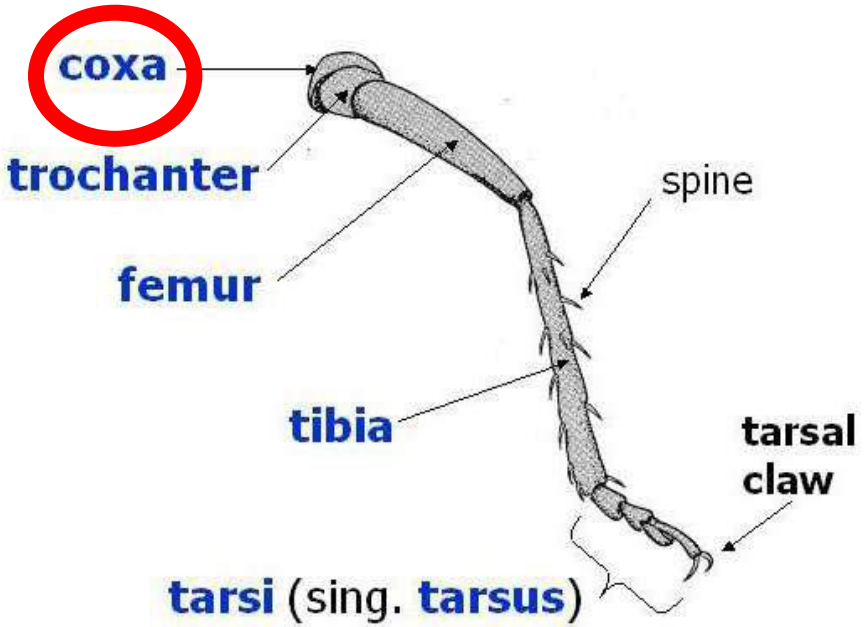
Insect legs

- Each leg consists of six segments
  - Coxa
  - Trochanter
  - Femur
  - Tibia
  - Tarsus
  - Pretarsus



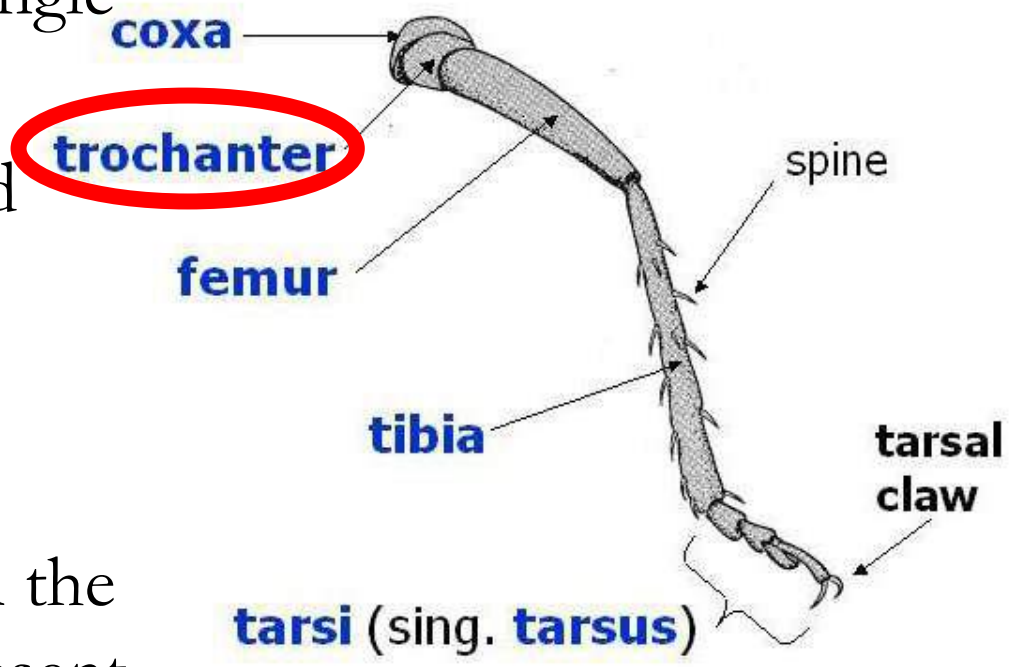
Coxa

- It is the first or proximal leg segment
- It is generally moves freely



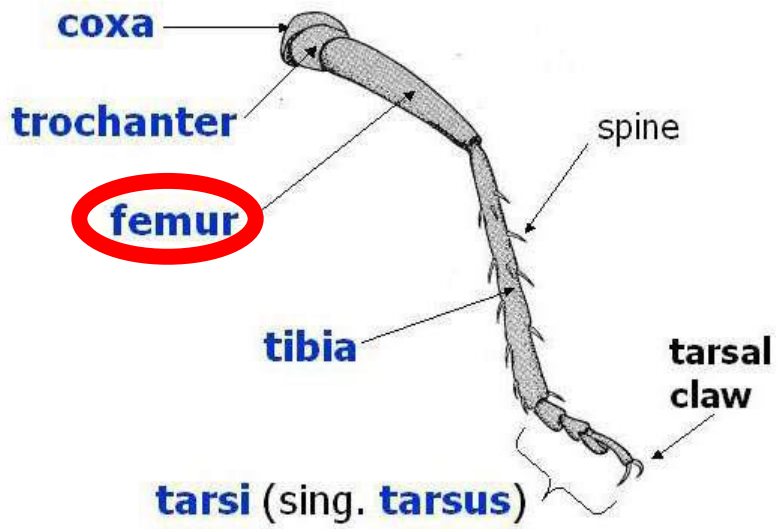
Trochanter

- It is the second leg segment
- It is usually small and single segmented
- In Odonata, it is divided into two subsegments
- In the parasitic Hymenoptera, a second trochanter derived from the base of the femur is present.



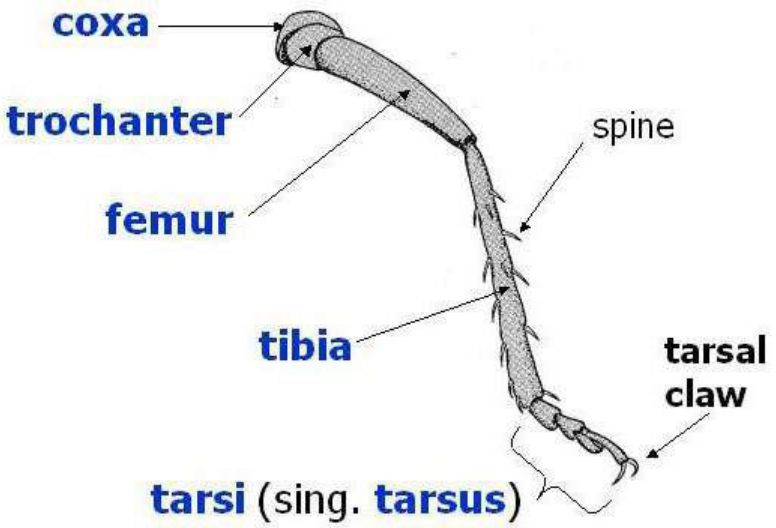
Femur

- It is the largest and strongest part of the leg
- It contains the main muscles used in running, jumping and digging.



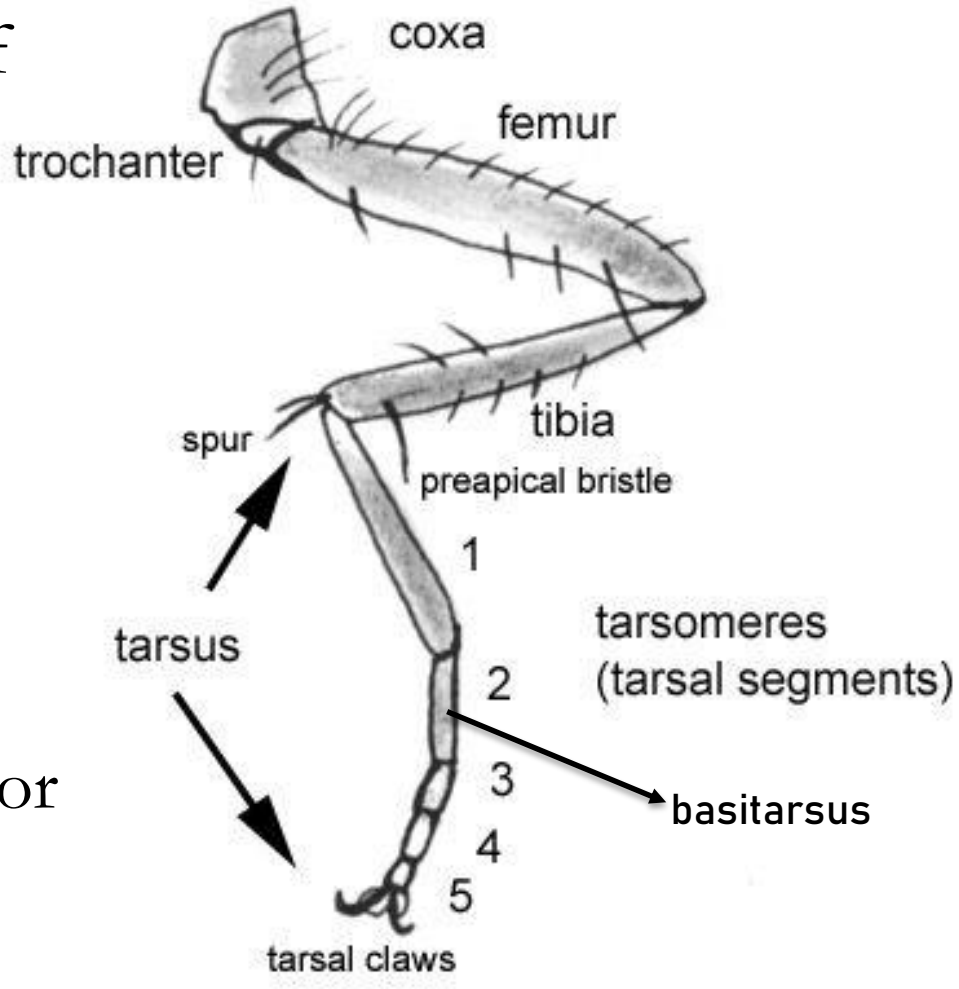
Tibia

- It is usually slender and often equals or exceeds the femur in length.
- Near its distal end it carries one or more tibial spurs.
- The femur and tibia may be modified with spines.



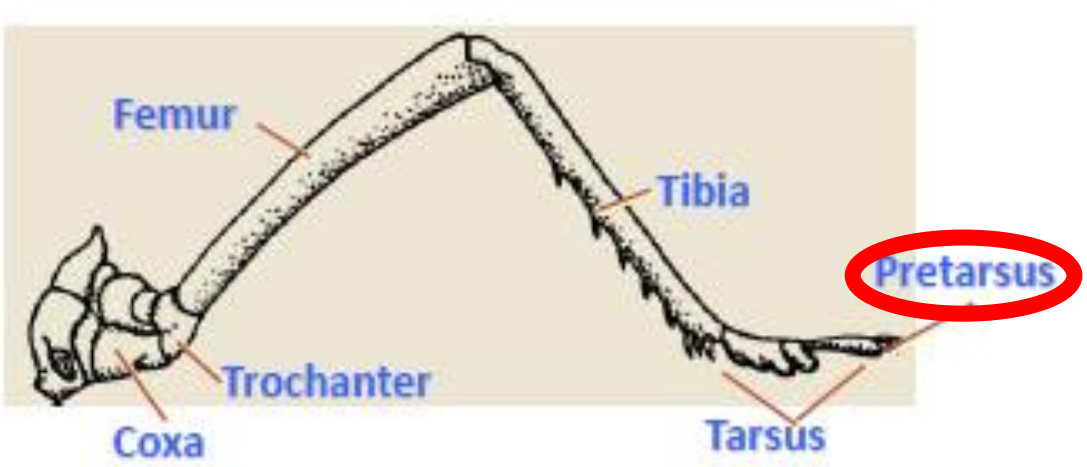
Tarsus

- It is the largest segment of the leg and consists primitively of a single segment which is usually divided into one to five "pseudosegments" called **tarsomeres** and are movable one on the other.
- First segment is large, big or broad in size known as basitarsus.



Pretarsus

- The tarsus at it's end consists of pretarsus which is in the form of a pair of claws.
- In most insects the claws are paired and between them on the ventral side the pretarsus is supported by a median plate.



Types or Modifications

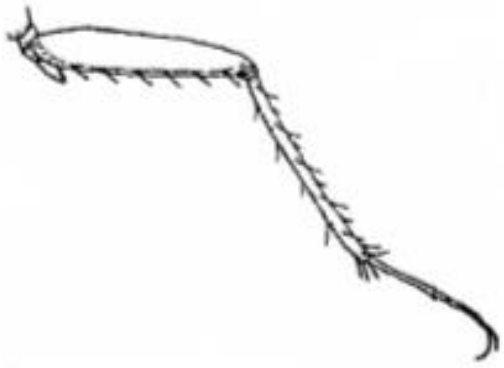
- Legs are modified into several types based on the habitat and food habit of insects and used for a wide variety of functions
  - Ambulatorial
  - Cursorial
  - Saltatorial
  - Scansorial
  - Fossorial
  - Raptorial
  - Natatorial
  - Pollen carrying type

Ambulatorial (Walking leg)

- Ambulatory legs are used for walking. This is the least specialized. All legs are normal.

- Examples: Bugs, some beetles.

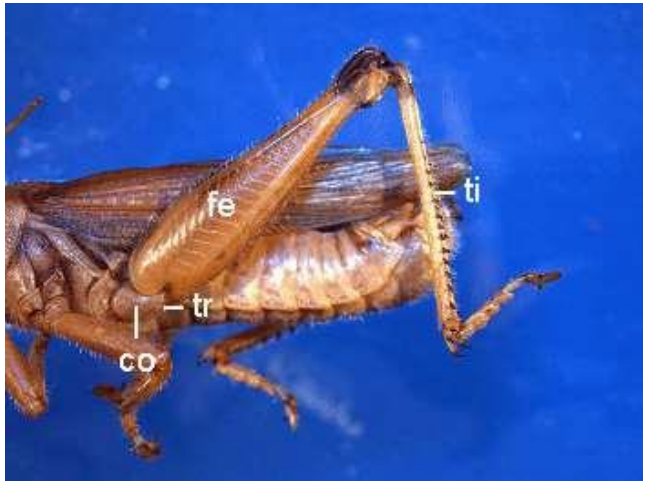
Cursorial (Running leg)



- Found in running insects.
- Their legs are slim and increased in length. Being elongated and slim helps it to reduce friction.
- Examples: Cockroaches, Wasp.

Saltatorial (Leaping/Jumping Legs)

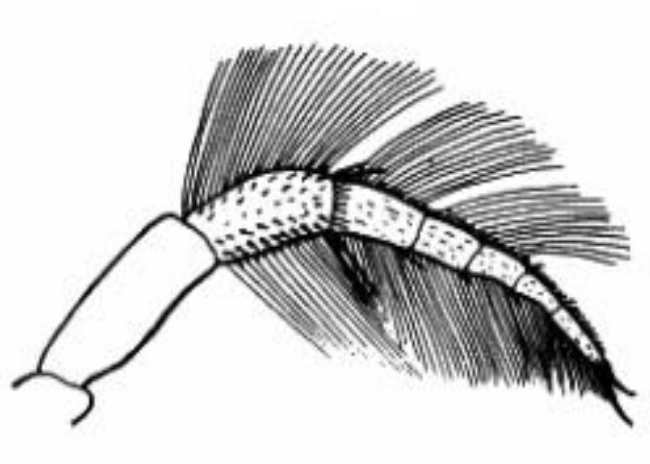
- Hind legs adapted for jumping.
- They have disproportionately developed hind femora (to accommodate the large extensor muscles) and tibiae.
- Examples: Grasshoppers, crickets.



Natatorial (Swimming Legs)

- Natatorial legs are modified for swimming.
- Tibia and tarsus short and broad having dense long marginal hairs for swimming.

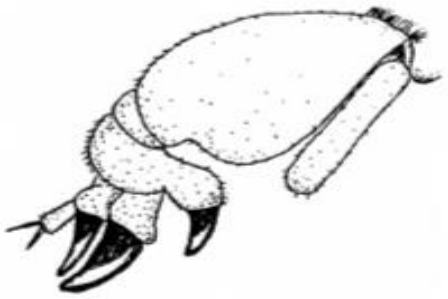
Examples: Aquatic beetles and bugs.



Fossorial (Digging/Burrowing leg)

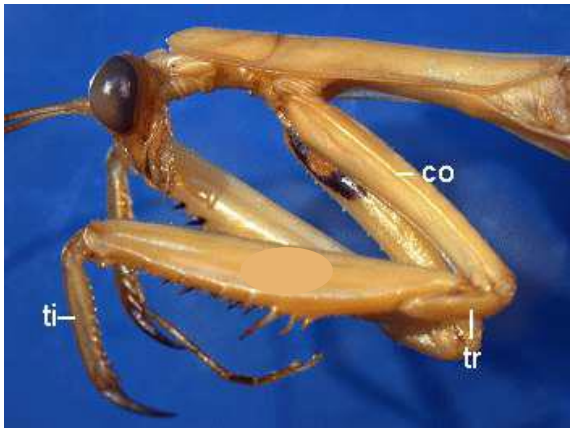
- Tibiae of forelegs are short and broad with projections, modified for digging.
- Large footed projections on the femur or tibia are used to dig through the soil to dislodge soil particles.
- The tarsi are reduced and usually fold out of the way during excavation.

Examples: Ground dwelling insects such as mole crickets and scarab beetles.



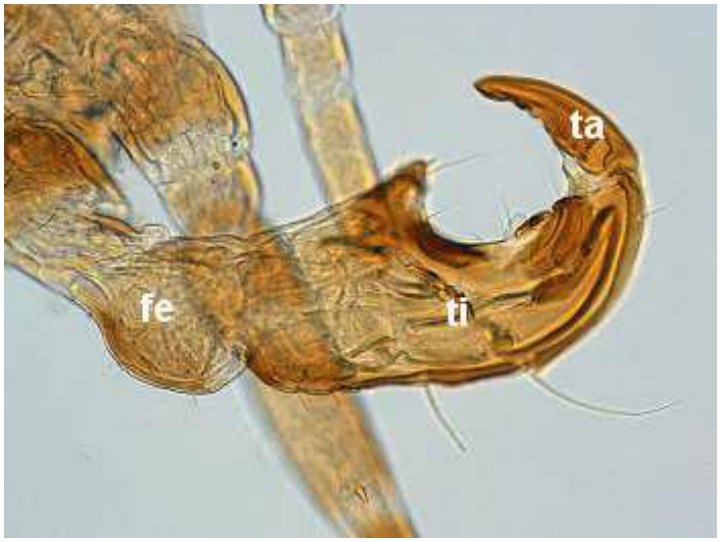
Raptorial (Predatory /Grasping leg)

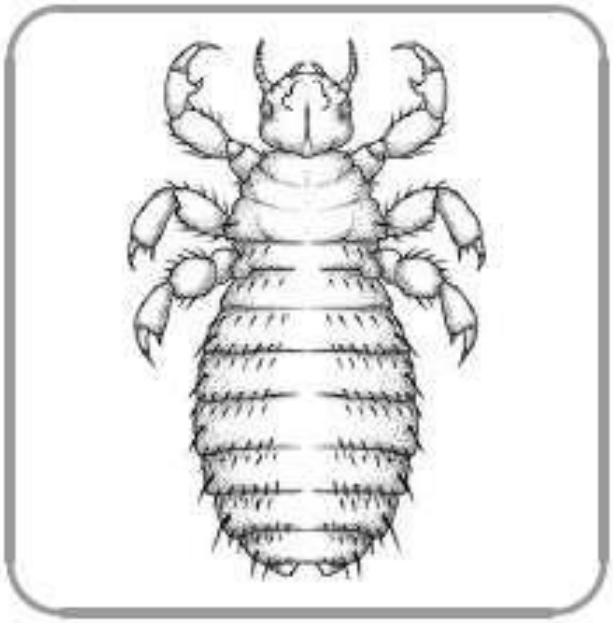
- Forelegs modified for grasping (catching prey).
- The large muscles are flexors and the tibia is pulled back against the femur when the muscles contract.
- Spines may be present in the tibia and femur to prevent the prey from escaping (as in the front leg of the mantid).
- Examples: Mantids, ambush bugs



Scansorial (Climbing/Clinging leg)

- It is seen in all the three pairs of legs of head louse



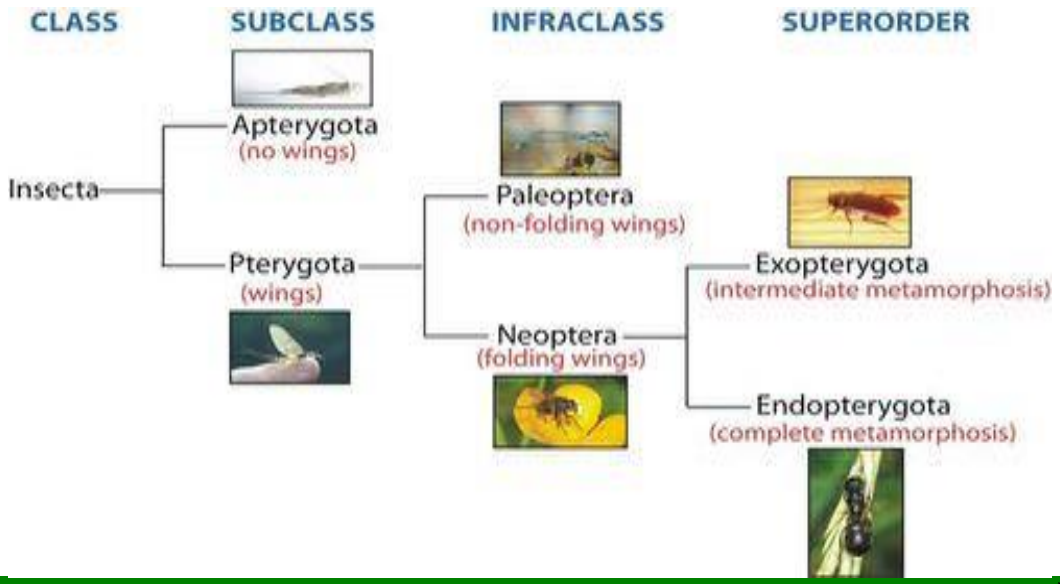


Sticking Leg : Pollen Carrying type

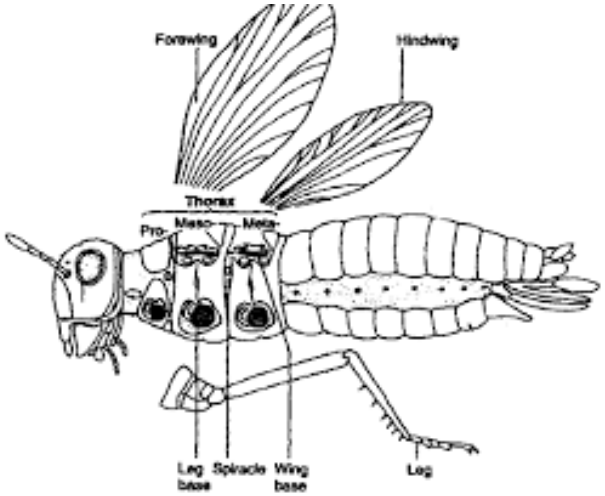
- The hind legs of worker honey bees are adapted for assembling and carrying pollen

Insect Wings

- Based on the presence or absence of wings, Class Insecta is divided into two subclasses.
  1. Apterygota
  2. Pterygota (Exoptera/external winged and Endoptera/internal winged)



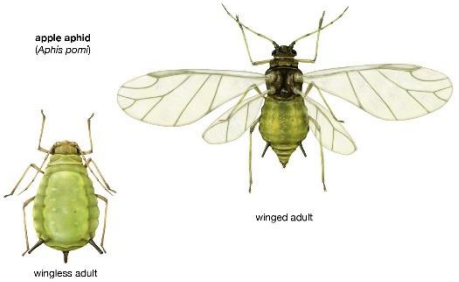
Insect Wings



- The wings are located dorsolaterally on the mesothorax and/or metathorax.
- Most of the muscles that move the wings are attached to the walls of the thorax rather than to the base of the wings.
- Insect wings vary in number, size, shape, texture, venation and in the position wings are held at rest.

Insect Wings

- Most insects have two pairs of wings but many have one pair and some are wingless.
  - Example of primitive apterygotes are silver fish and spring tails. In coccids, only males are winged. Aphids may or may not have the wings.
- Based on the degree of development or size of wings the insects may be Macroptera, having long or large wings or a Brachyptera, having short wings.




silver fish

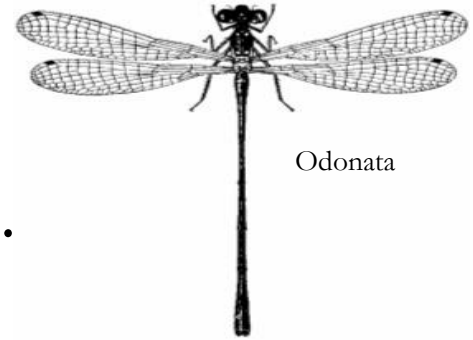

spring tails


Wings folded over abdomen

Insect Wings

Ephemeroptera

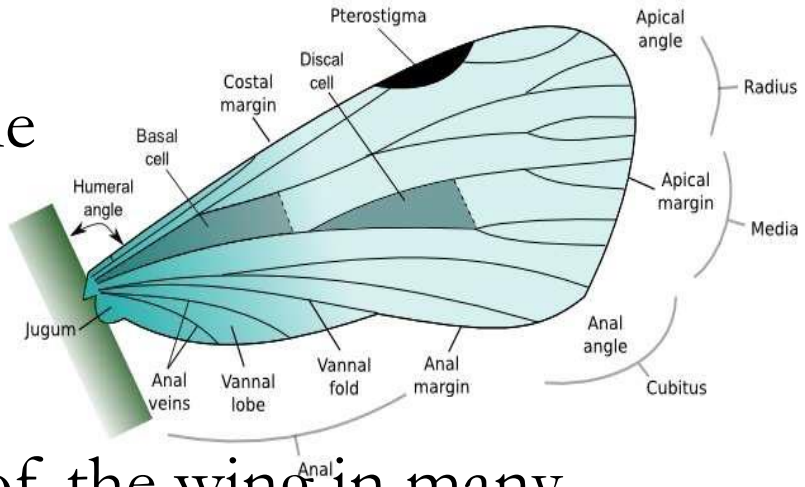
- Most insect wings are membranous, some are thickened or leathery. Many are covered with hair and some bear scales.
- Typically, insects fold the wings over the abdomen at rest.
- Primitive insects are unable to fold their wings. Instead, these insects carry their wings vertically or horizontally to their bodies. E.g. Ephemeroptera and Odonata.


Odonata

Wings held horizontally to body

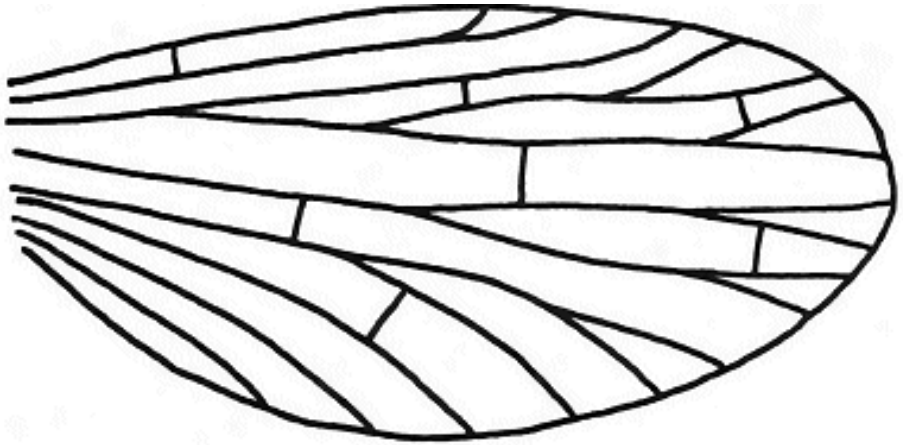
Insect Wings

- A typical insect wing is triangular with three margins and three angles.
- Three margins are Costal or anterior, Apical or outer and Anal or inner.
- The three angles are Humeral angle, Apical or outer angle and Anal angle or tornus
- There are one or two lobes in the anal area of the wing in some insects
- A conspicuous opaque spot is found near the coastal margin of the wing in many insects, and is termed the stigma or pterostigma



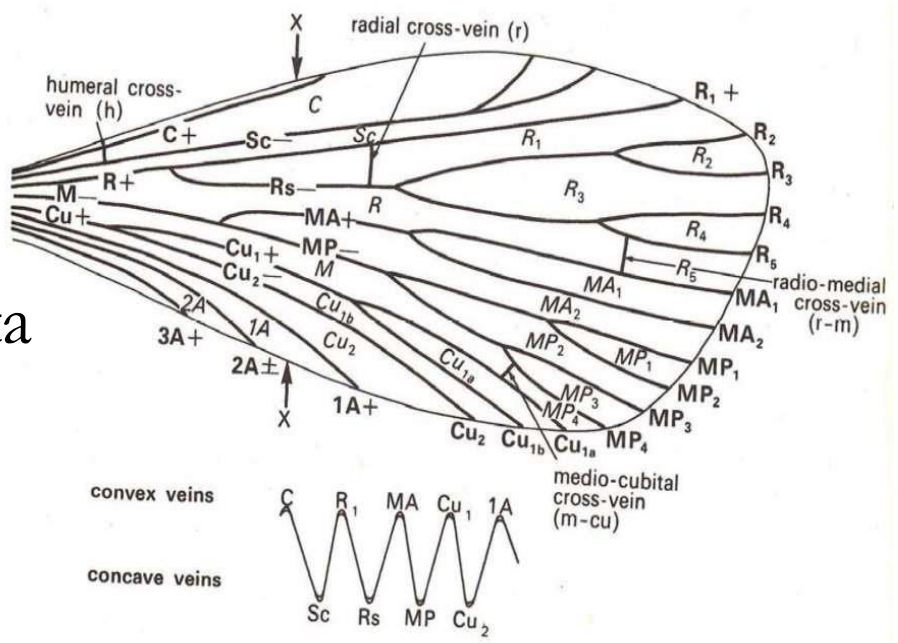
Wing Venation

- Wings are very thin broad leaf like structures strengthened by a number of hollow narrow tubular structures called veins.
- Arrangement of veins on wing surface is known as wing venation, which consists of two types of veins.
  1. Longitudinal veins : Extend from base of the wing to the margin.
  2. Cross veins : That interlink the longitudinal veins



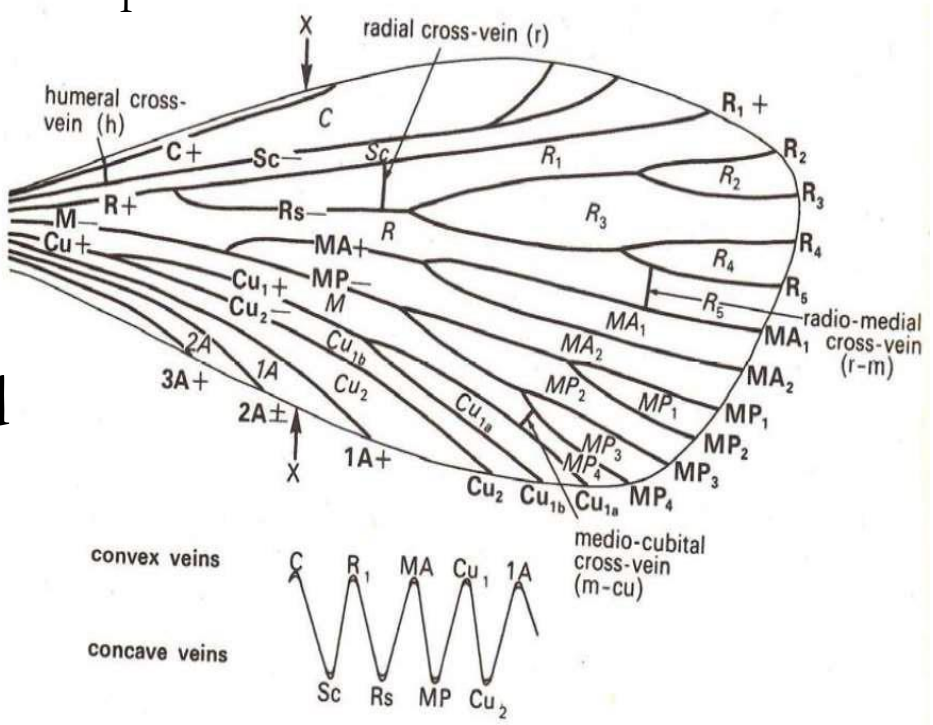
Longitudinal veins

1. Costa (C) is unbranched and convex.
2. Sub costa (Sc) runs immediately below the Costa which is concave and typically has two branches, Sc_1 and Sc_2.



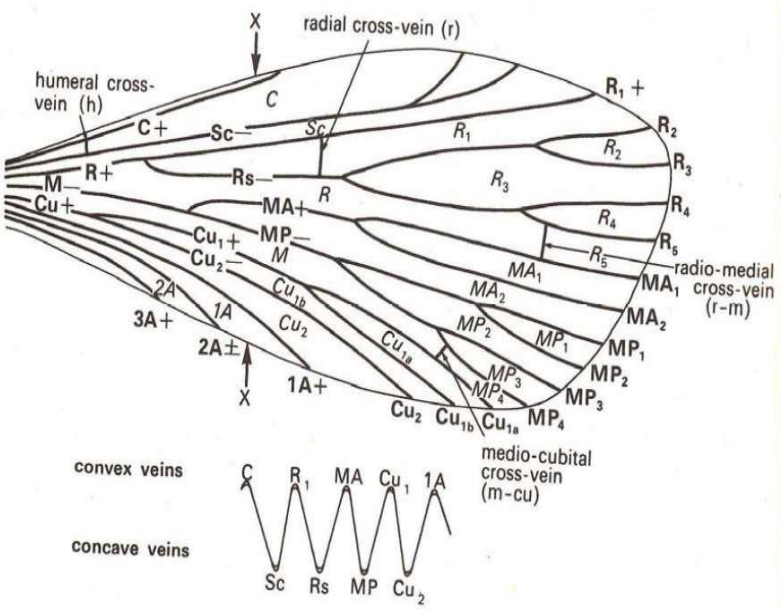
Longitudinal veins

3. Radial vein (R) is the next main vein, stout and connects at the base with second auxillary sclerite. It is divided in to two branches R_1 and Rs.
   - R_1 goes directly towards apical margin and is convex.
   - Rs is concave and divided in to 4 branches, R_2, R_3,R_4, R_5.



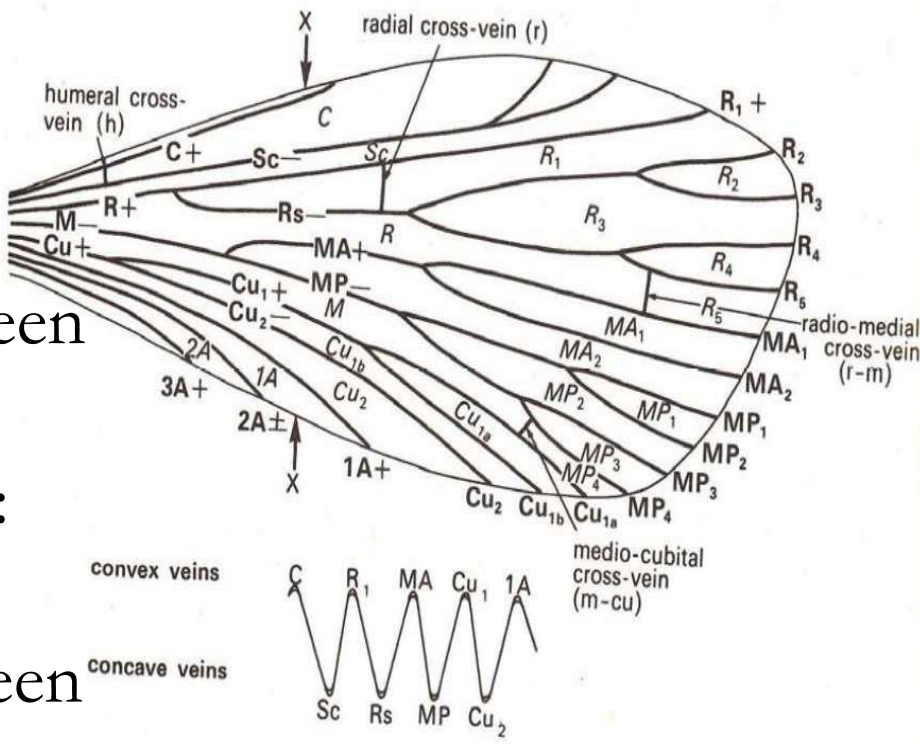
Longitudinal veins

4. Media (M) is divided in two branches, Media anterior (MA) and Media posterior(MP).
   Media anterior is again divided into MA_1 and MA_2.
   Median posterior is again divided in to MP_1, MP_2, MP_3, MP_4.
5. Cubitus (Cu) is divided into Cu_1 and Cu_2. Cu_1 is divided into $Cu1_a$ and Cu_{1b}.
6. Anal veins (A) are convex veins. They are individual un-branched, 1-3 in number



Cross Veins

1. Humeral cross vein (h) : between costa and subcosta.
2. Radial cross vein (r): between radius and radial sector.
3. Sectorial cross veins (s): between sub branches of radial sector
4. Radio medial cross vein (r-m): between radius and media.
5. Medial cross veins (m) : between branches of media.
6. Medio-cubital veins (m-Cu) : between media and cubitus.



Wing Modification

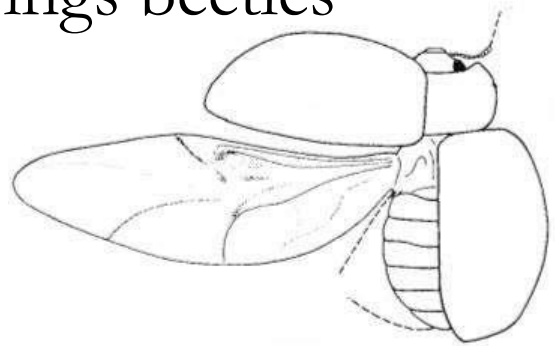
- Wings serve not only as organs of flight, but also may be adapted variously as
  - protective covers (Coleoptera and Dermaptera)
  - thermal collectors (Lepidoptera)
  - gyroscopic stabilizers (Diptera)
  - sound producers (Orthoptera)
  - visual cues for species recognition and sexual contact (Lepidoptera).

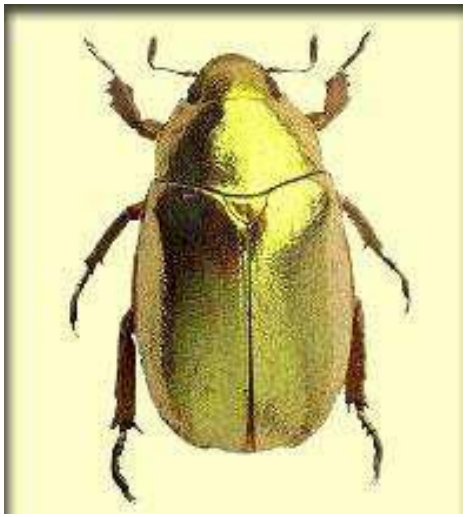
Wing Modifications

1. Tegmina :
   - Forewings are leathery and tough.
   - They protect the membranous hindwings.
   - e.g.: forewings of grasshopper

Wing modifications

2. Elytra :
   - Hard, shell like without clear venation
   - They form horny sheet and protect the membranous hind wings and abdomen.
   - e.g. Forewings beetles

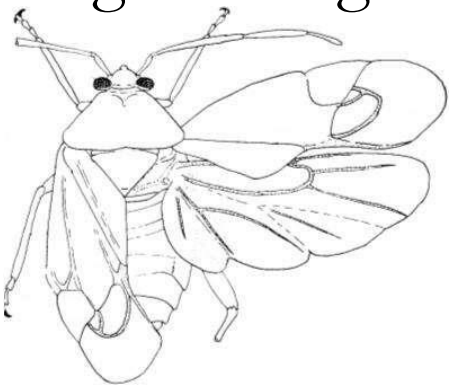


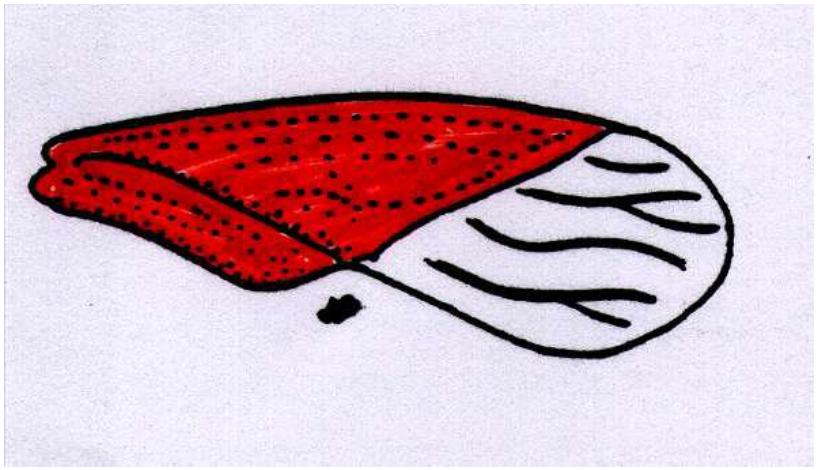


Wing modifications

3.Hemelytra :

- The base of the wing is thick like elytra and the remaining half is membranous
- They are useful for protection and flight
- e.g. Forewings of bugs





Wing Modifications

4. Membranous :
   - Naked thin with clear venation.
   - Always useful of flight
   - e.g. Both wings of Dragonflies, bees and wasps

Wing Modification

5. Scaly wings

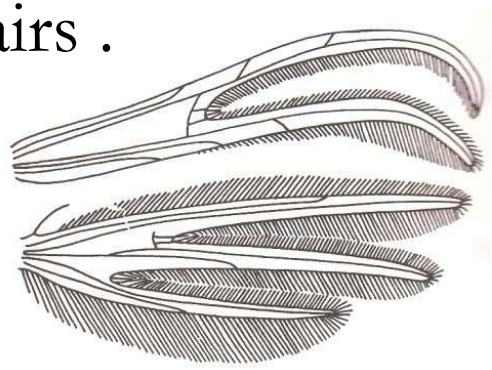
Wings thin and membranous but covered with unicellular scales all over the surface. Tiny scales gives butterflies their unique color and pattern variations.

These scales help them absorb sunlight and assist them in their flight.

e.g.: Both wings of moths and butterflies (Lepidoptera).

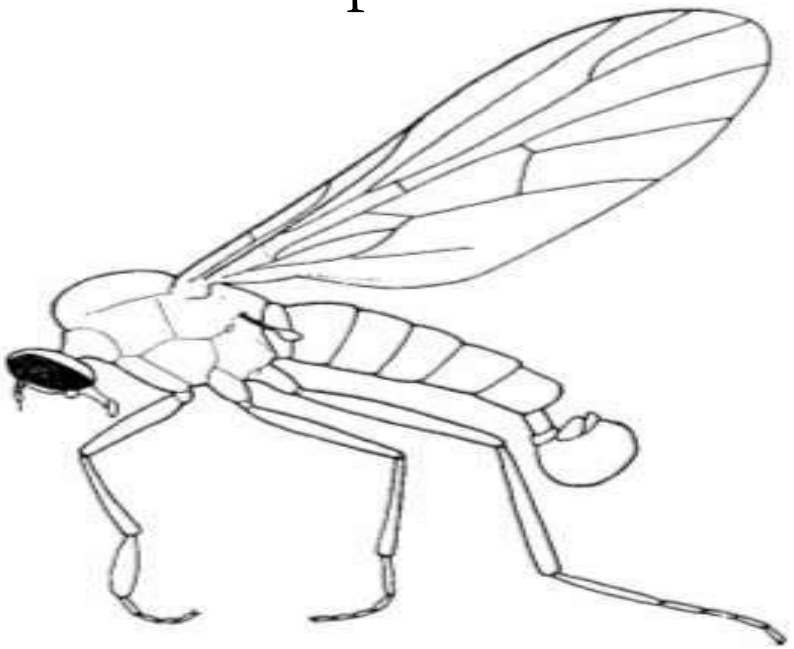
Wing Modification

6. Fissured wings
   - Forewings are longitudinally divided once forming a fork like structure whereas hindwings are divided twice in to three arms.
   - All the forks possess small marginal hairs .
   - They are useful for flight.
   - e.g.: Both the wings of plume moth



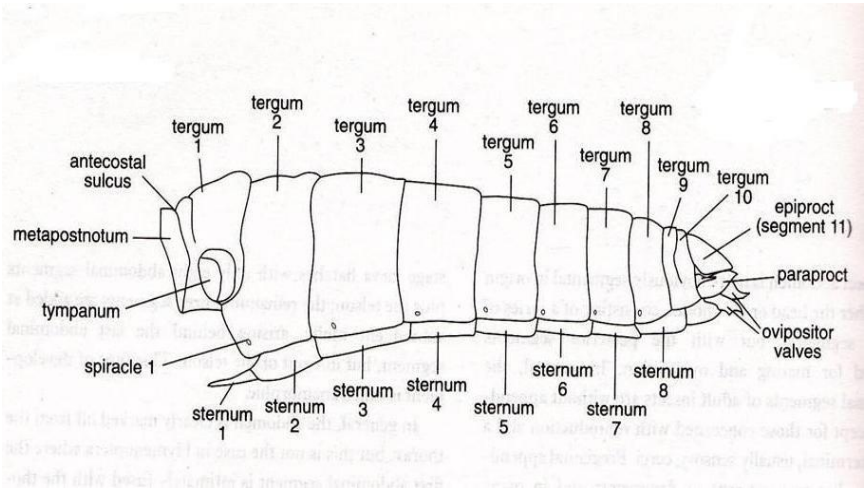
Wing Modification

7. Halteres
   - They are modified into small microscopic structures called halteres
   - They act as balancers.
   - eg. hind wings housefly



Abdomen

- The abdomen contains the insects digestive tract and reproductive organs and assists in respiration.
- It consist of a dorsal sclerite, the tergum and a ventral sclerite, the sternum, joined to one another laterally by a pleural membrane



Abdomen

- It consists of nine (9) to eleven (11) segments in most Orders of insects.
- The first seven abdominal segments of adults known as pregenital segments are similar in structure and lack appendages in pterygotes .
- Normally the eighth and ninth abdominal segments bears the female and male genital structure respectively. That is ovipositor in females and aedeagus or penis in males.
- Tenth and eleventh segments are known as postgenital segments.

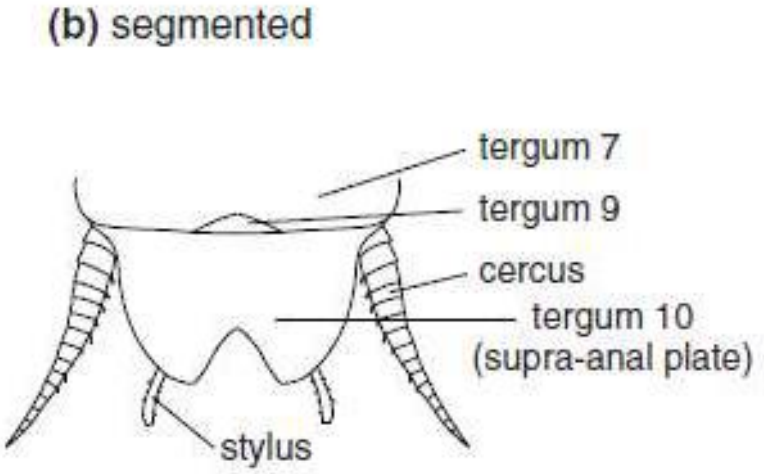
Abdomen

- Most insects lack appendages on the abdomen except the posterior end. The terminal appendages may be lacking or drawn into the body and hidden.
- When terminal appendages are present they usually consist of a pair of dorsolateral cerci, a median epiproct, a pair of lateroventral paraprocts.
- These structures are tactile (touch receptors).
- The anal opening is at the posterior end of the abdomen just below the epiproct if the later is present.

Some Appendages Of Winged Insect Abdomen

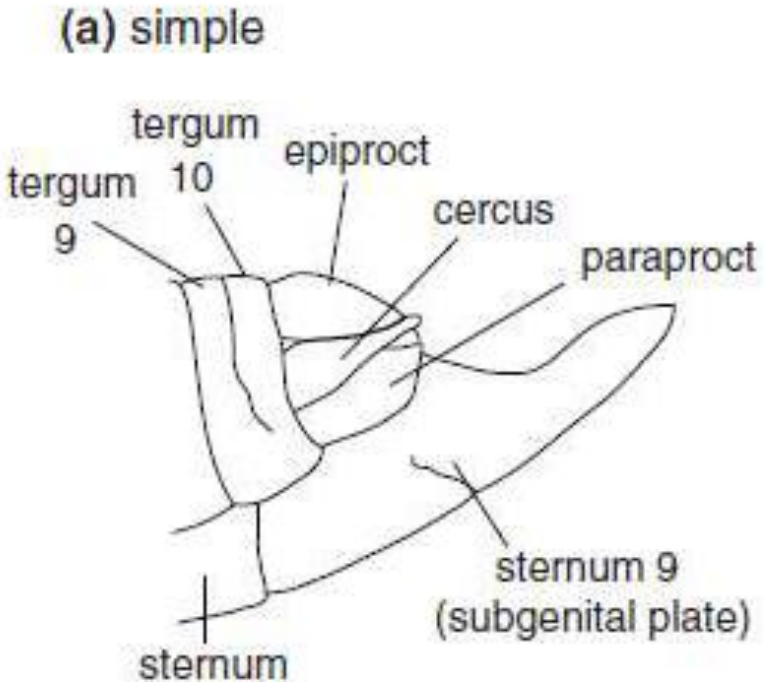
Cerci : (Cercus - Singular)

- They are the most conspicuous appendages associated normally with the eleventh (last) abdominal segment.
- They are sensory in function.
- They exhibit wide diversity and form.
- Long and many segmented :- e.g. Mayfly



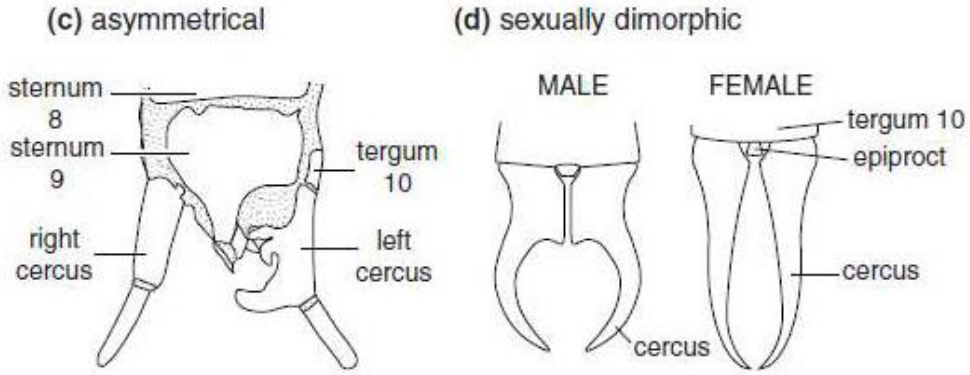
Cerci

- Long and unsegmented :- e.g. Cricket
- Short and many segmented :- e.g. Cockroach
- Short and unsegmented :- e.g. Grasshopper



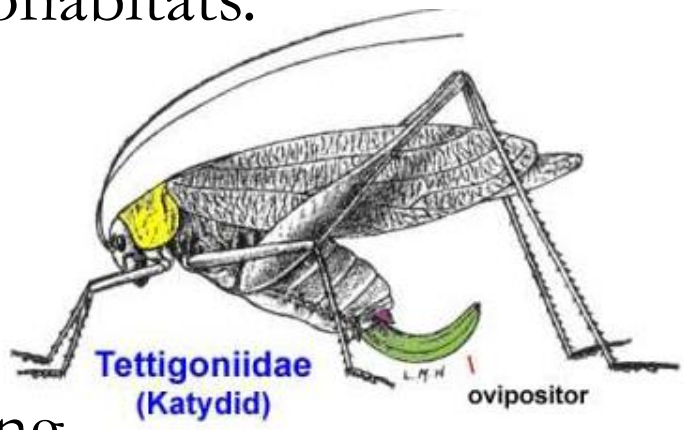
Cerci

- Sclerotised and forceps like : e.g. Earwig.
  - Cerci are useful in defense, prey capture, unfolding wings and courtship.
- Asymmetrical cerci : eg. Male embiid
- Left cercus is longer than right and functions as clasping organ during copulation.



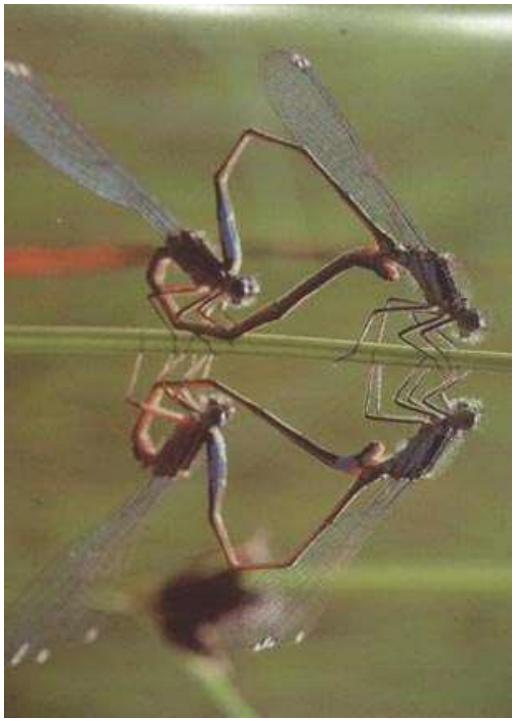
Ovipositor

- The egg laying organ found in female insect is called ovipositor.
- It is suited to lay eggs in precise microhabitats.
- It exhibits wide diversity and form.
- Short and horny : e.g. Short horned grasshopper.
- Long and sword like : e.g. Katydid, long horned grasshopper
- Needle like : e.g. Cricket
- Ovipositor modified into sting : e.g. Worker honey bee.



Male genitalia

- External sexual organs of male insects are confined to ninth abdominal segment.
- In dragonfly, the functional copulatory organ is present on the ventral of second abdominal segment



END

ENTOMOLOGY I

INSECT PHYSIOLOGY

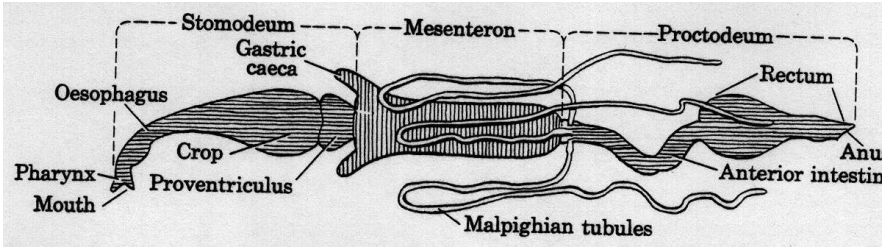
BIOL 355

Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

Insect Physiology

- Insect physiology is the study of how insects live and reproduce.
- The study of insect physiology is usually divided into a systems approach.
- These systems are the same required by all animals.
- The major systems are: digestive, muscular, excretory, respiratory, nervous, circulatory, immune and reproductive.

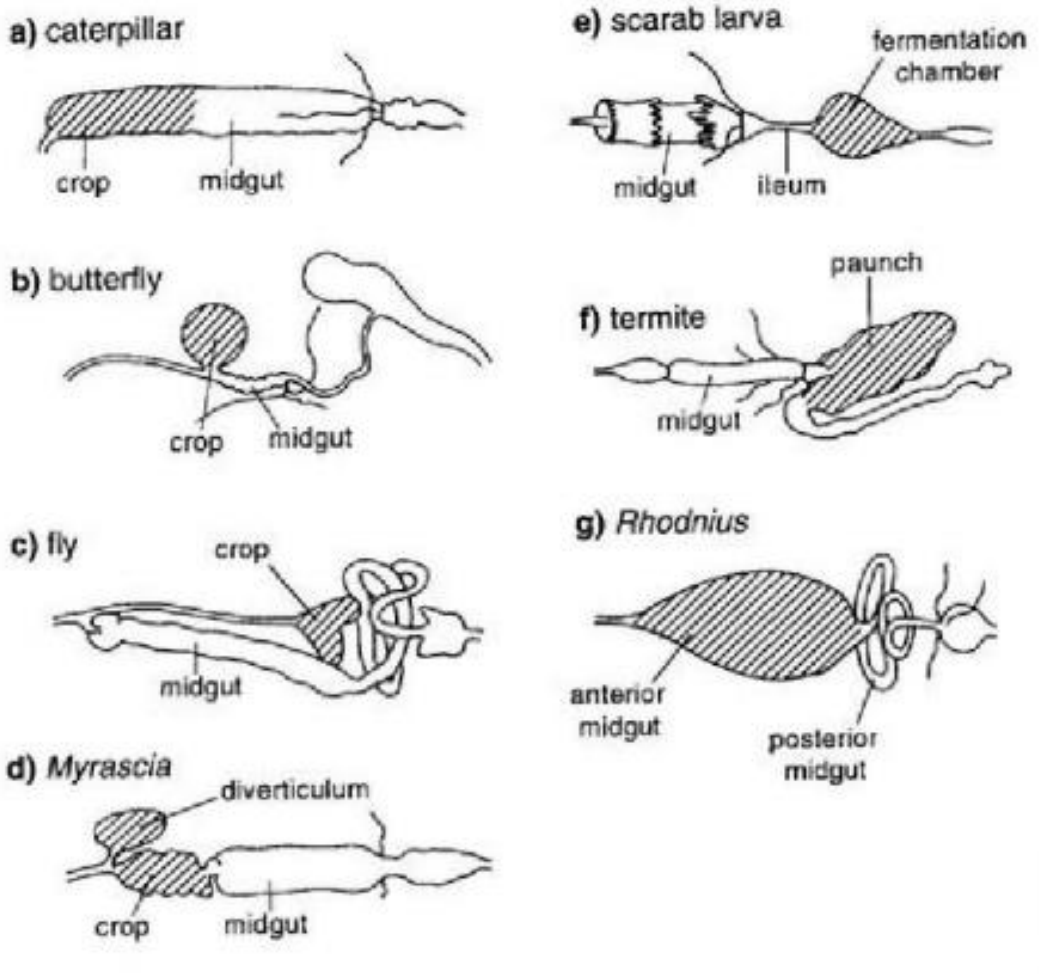
Digestive System



- The digestive system of an insect is usually long straight tube running from the mouth to the anus.
- Gut morphology and physiology per an insect depends on their life stage and what it eats.
- Insects of different groups consume variety of foods, including watery xylem sap (aphids and mealbug), vertebrate blood (bed bugs and female mosquitoes), dry wood (termites and wood wasps), bacteria and algae (blackfly and many caddisfly larvae) and the internal tissues of other insects (endoparasitic wasp larvae).

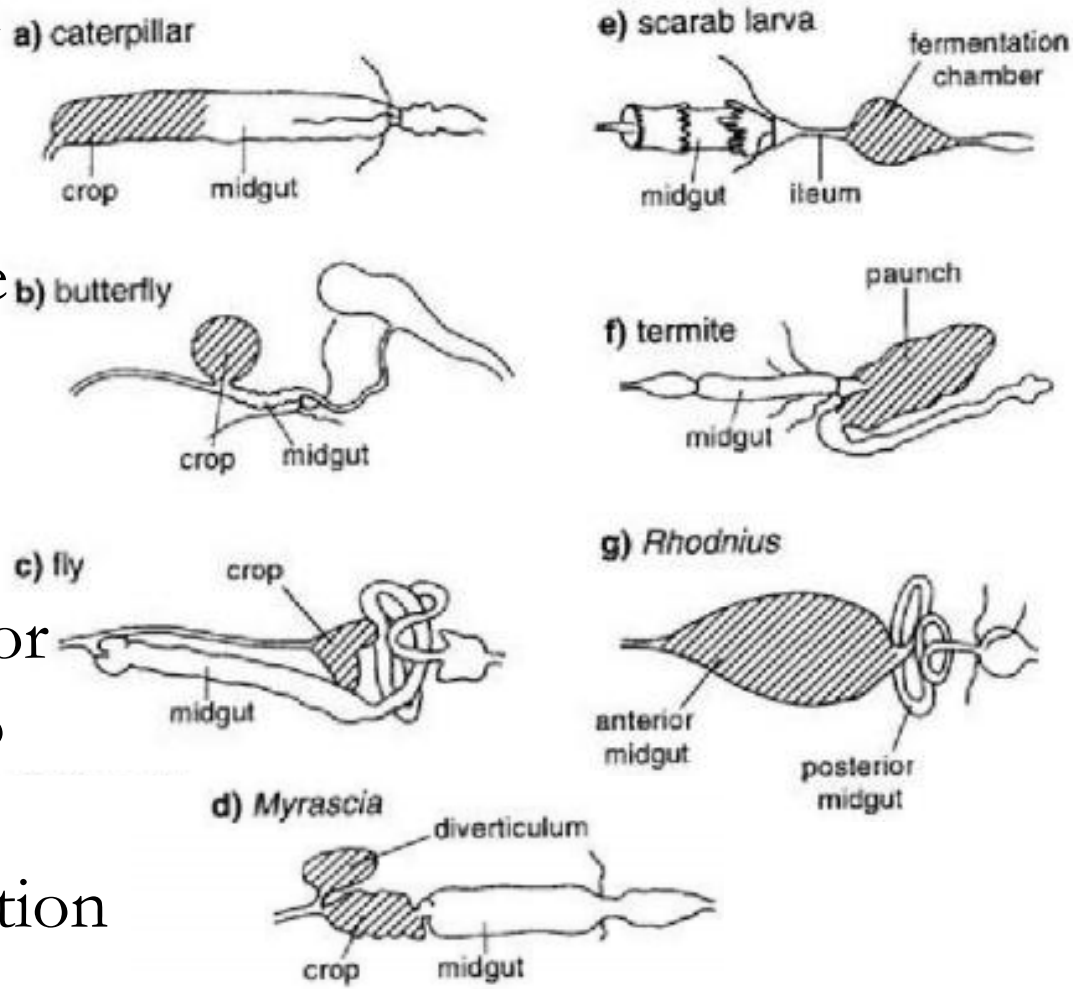
Digestive System

- Insects that take solid food typically have a wide, straight short gut with strong musculature; to give protection from abrasion e.g. plant eating caterpillars.



Digestive System

- Insects that take in liquid food have long, narrow, convoluted guts to allow maximal contact with the liquid food.
- The most obvious gut specialization of liquid-feeders is a mechanism for removing excess water to concentrate nutrient substances prior to digestion e.g. Homopterans.



Structure of the Gut

- There are three main regions to the insect gut (or alimentary canal) with sphincters (valves) controlling food/fluid movement between regions.
- It is often divided into the fore-gut (stomodeum), midgut (mesenteron), and hindgut (proctodeum).

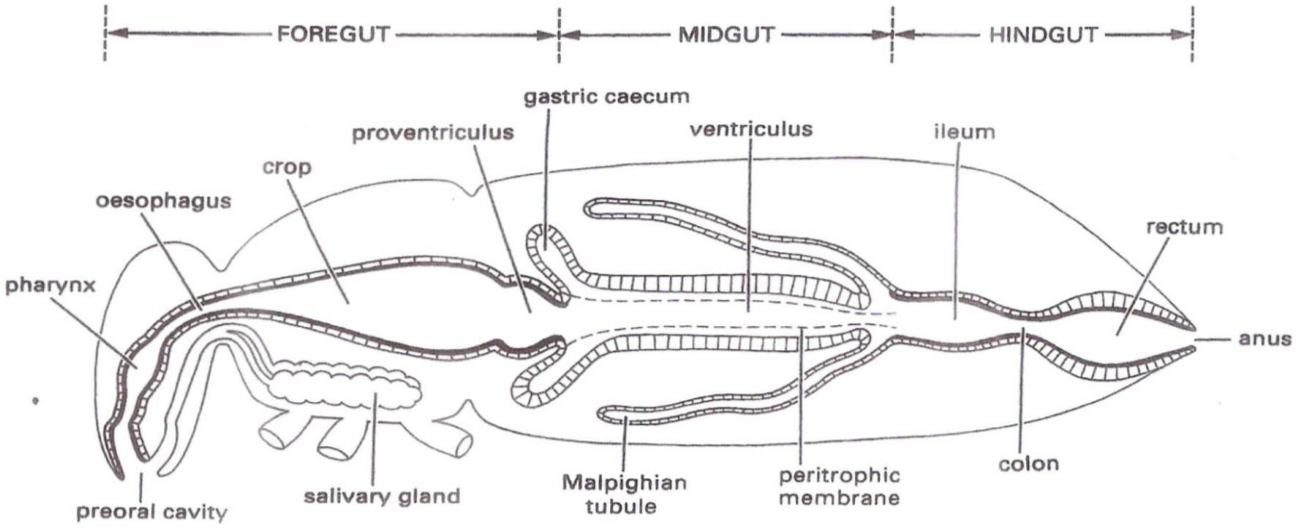
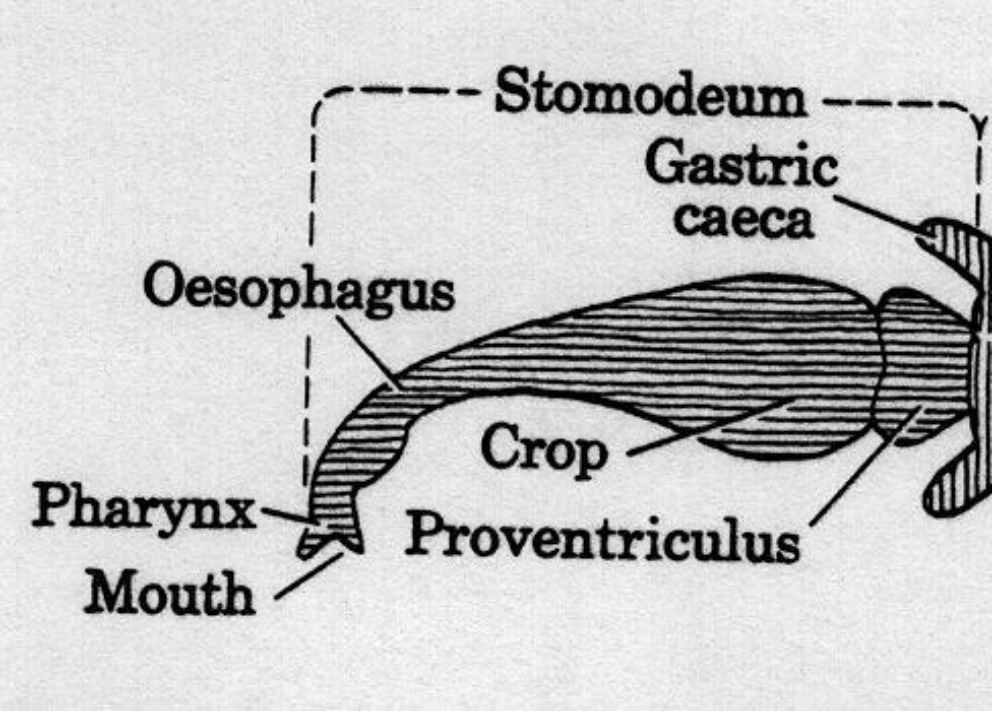


Fig. 3.13 Generalized insect alimentary canal showing division into three regions. The cuticular lining of

Foregut

- Food passes through
  - Mouth
  - Pharynx
  - Oesophagus
  - Crop
  - Proventriculus

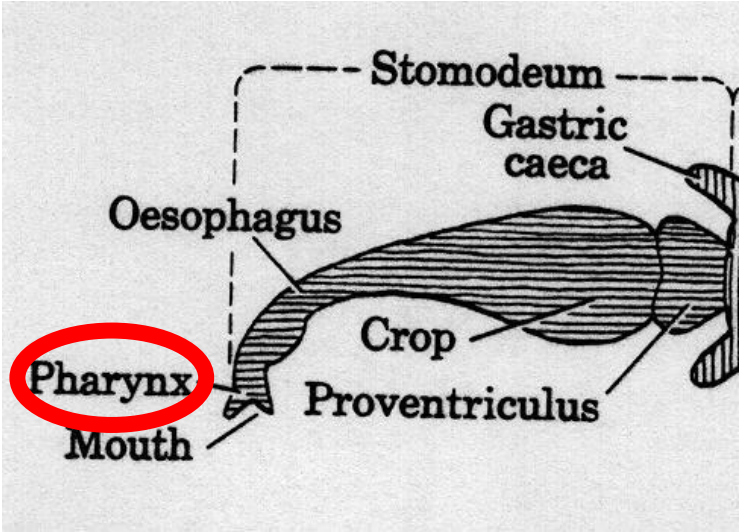


Foregut~Mouth

- The diverse range of mouthpart types correlates with the diets of different insects
- Immediately behind the mouth are the salivary glands. Secreted saliva lubricates food and contains enzymes to begin the process of digestion. It can be specialised eg. in Lepidoptera caterpillar they have been converted to the production of silk.

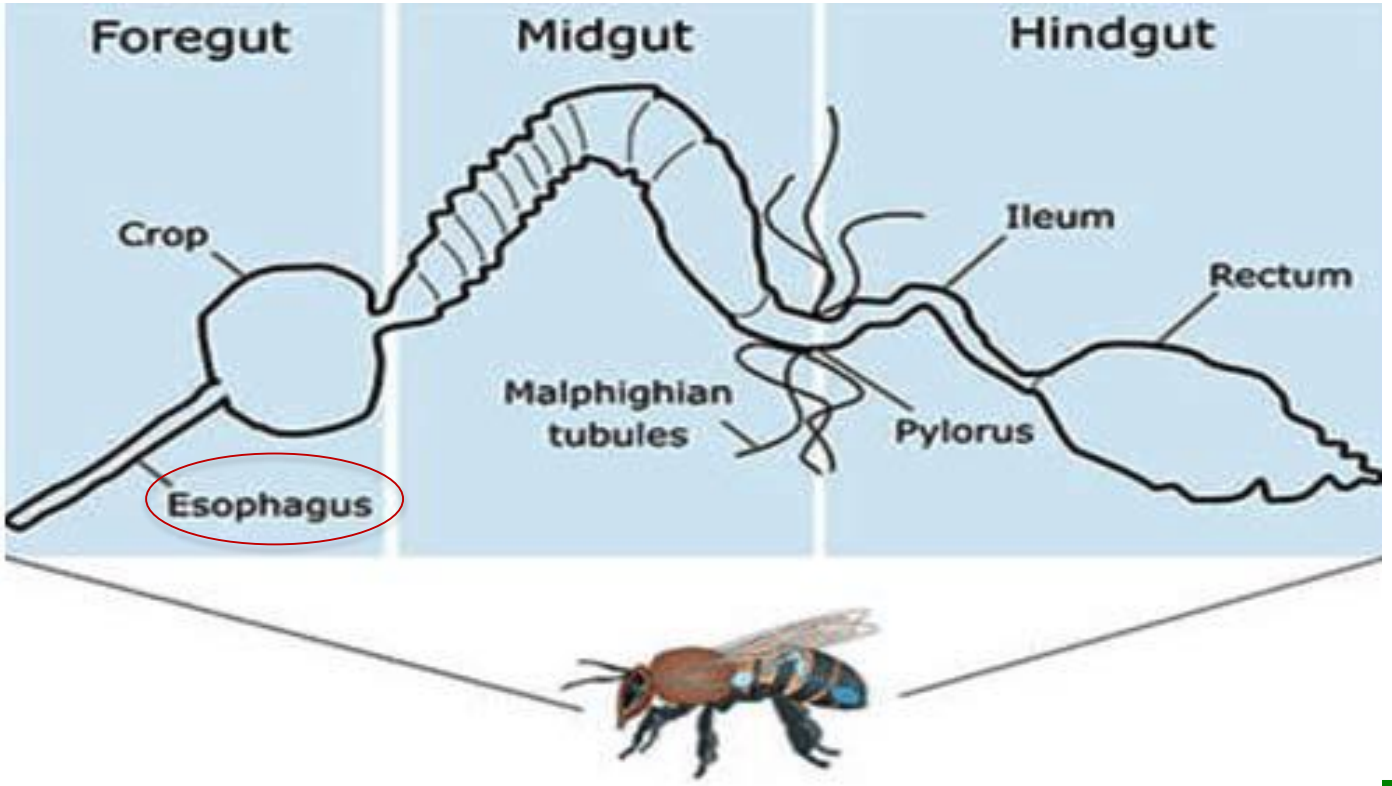
Foregut~Pharynx

- Food in the buccal cavity is sucked through the mouth opening and into the pharynx by the action of cibarial muscles.
- When the muscles contract, they create suction by enlarging the volume of the pharynx. This "suction pump" mechanism is called the cibarial pump.

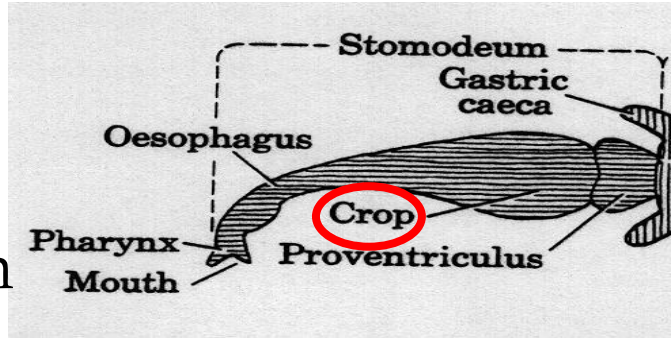


Foregut ~Oesophagus

- The oesophagus is a simple tube that assists the pharynx in transporting food.



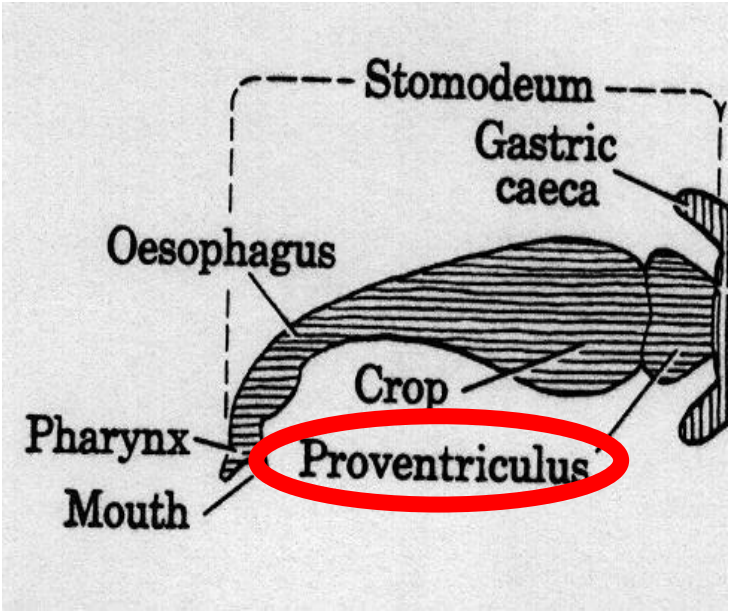
Foregut ~ Crop



- Storage area for food prior to digestion and absorption.
- Often the crop is folded longitudinally and transversely when it is empty with secretion and absorption not generally occuring in the crop.
- Digestion can occur, however, as a result of salivary enzymes passing to the crop with the food and midgut enzymes being regurgitated from the midgut.
- Although the proventriculus acts as a valve limiting the backward movement of food, it does not prevent the regurgitation of fluid.

Foregut ~Proventriculus

- This organ contains tooth-like denticles that grind and pulverize food particles.
- The proventriculus serves much the same function as a gizzard in birds.
- The stomodeal/cardiac valve, a sphincter muscle located just behind the proventriculus, regulates the flow of food from the stomodeum to the mesenteron.



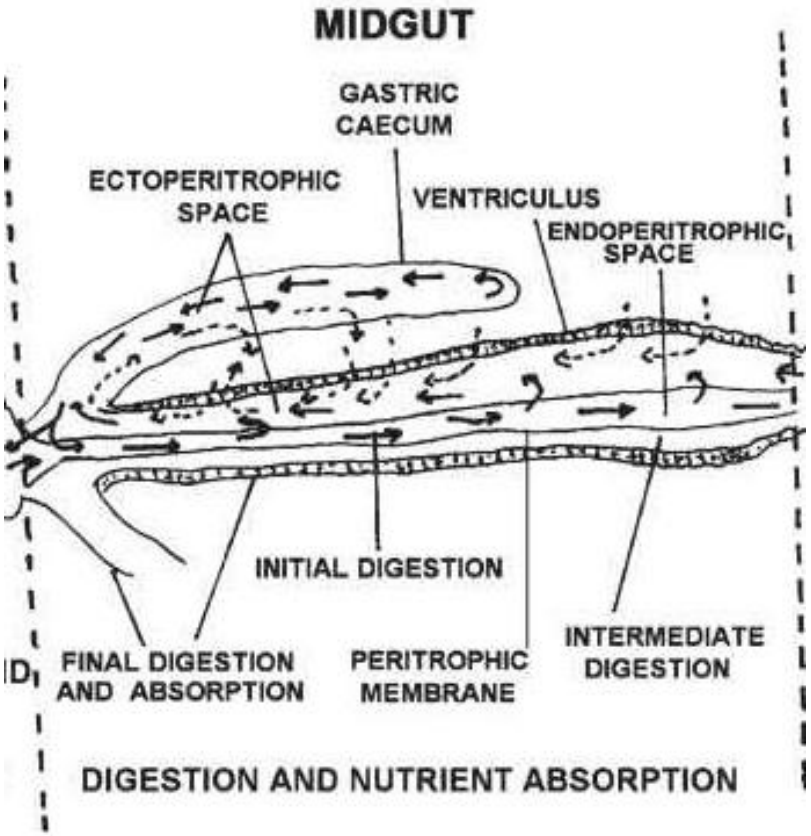
Midgut

- Midgut is made up of three types of epithelial cells.

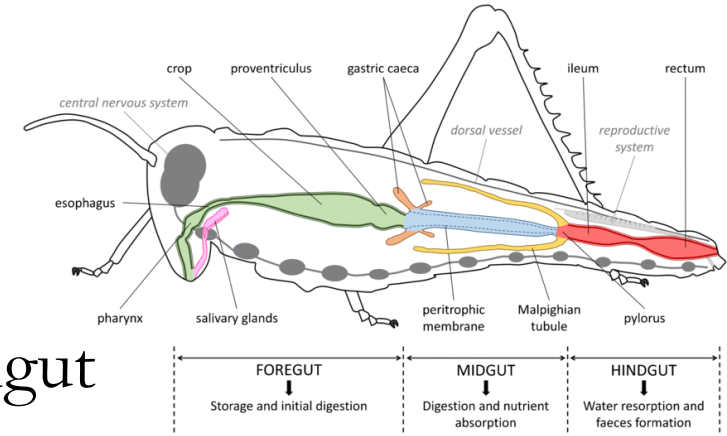
(i) Secretory cells (Columnar cells)

(ii) Goblet cells (aged secretory cells)

(iii) Regenerative cells which replaces secretory cells.



Midgut



- Important structures present in midgut

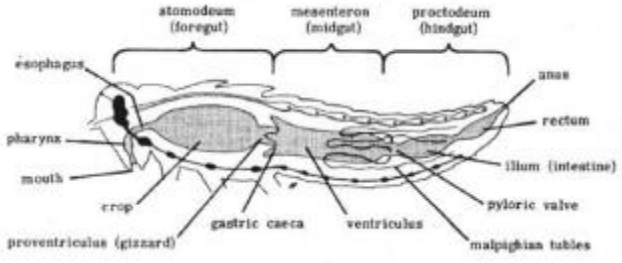
(i) Peritrophic membrane

- It is the internal lining of midgut, secreted by anterior or entire layer of midgut epithelial cells.
- Present in solid feeders and absent in sap feeders.
- Its functions are

(a) Lubricate and facilitate food movement

(b) Envelops the food and protects the midgut epithelial cells against abrasion from harder food .

Midgut

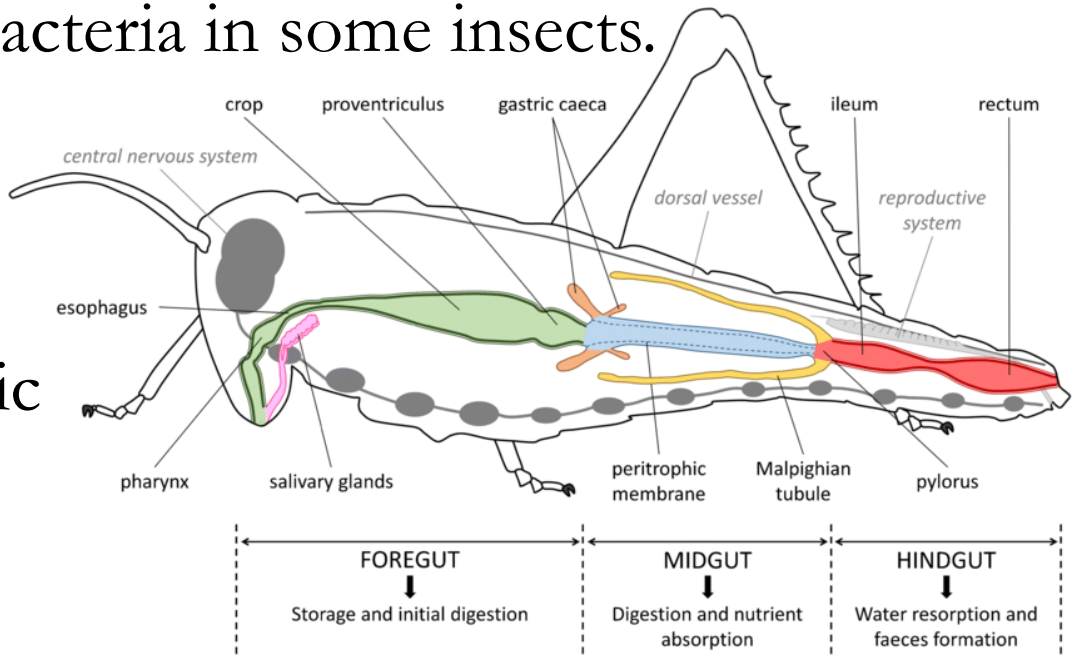


(ii) Gastric caecae:

- Finger like outgrowths found in anterior or posterior ends of midgut.
- This structure increases the functional area of midgut and shelter symbiotic bacteria in some insects.

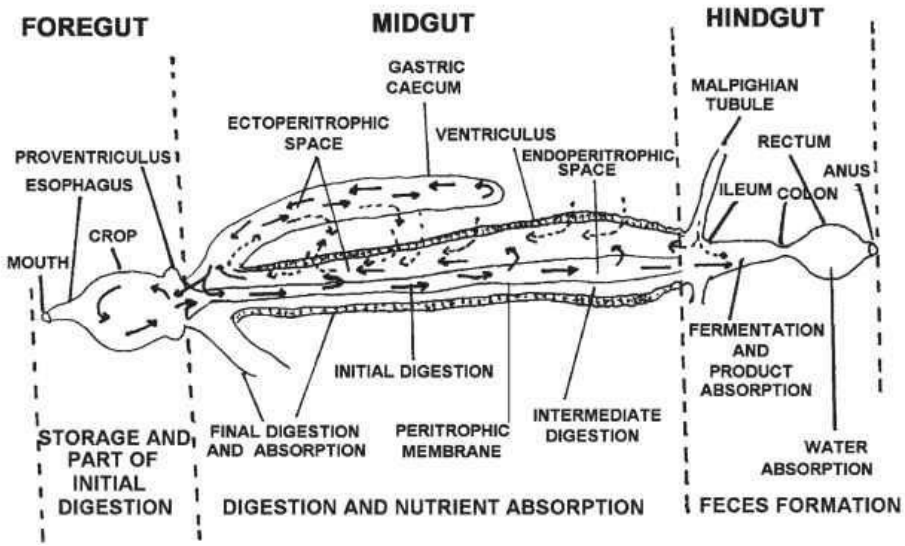
(iii) Pyloric valve:

- Midgut opens into hindgut through pyloric valve, which regulate food flow.



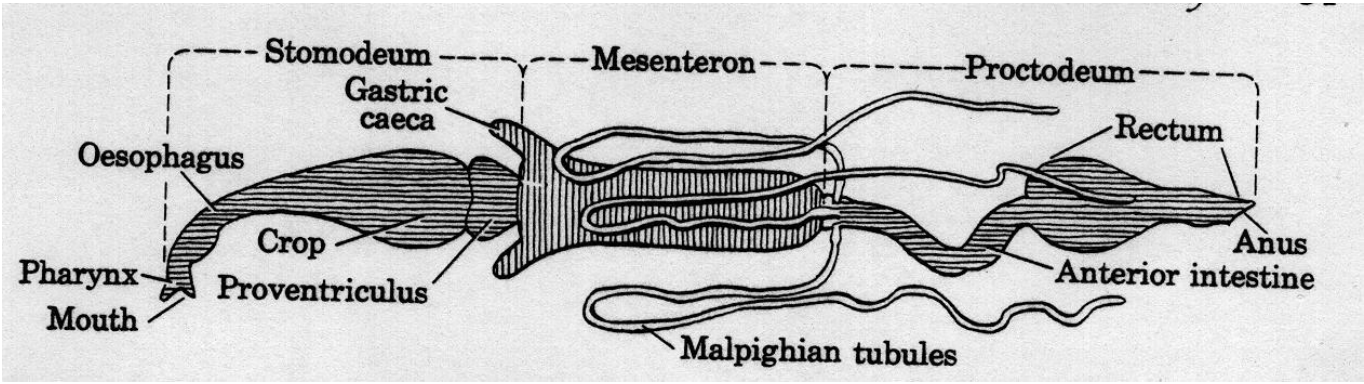
Hindgut

- The main functions of hindgut are the absorption of water, salt and other useful substances from the faeces and urine.
- Hindgut is differentiated into three regions viz., ileum, colon and rectum.
- In the larva of scarabids and termites, illeum is for housing symbionts and acts as fermentation chamber. Rectum contains rectal pads helping in dehydration of faeces and it opens out through anus.



Excretory System

- The typical insect excretory system consists of the Malpighian tubules, intestine, and rectum.
- The malpighian tubules, vary in number from 2-100, ending blindly in the body cavity (which is a blood space) and open to the alimentary canal at the junction between midgut and hindgut.
- The malpighian tubules which eliminate nitrogenous waste from blood.

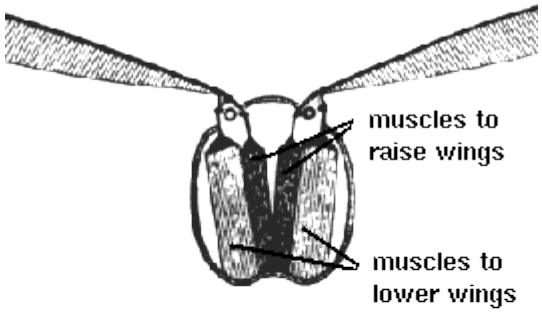


Muscular System

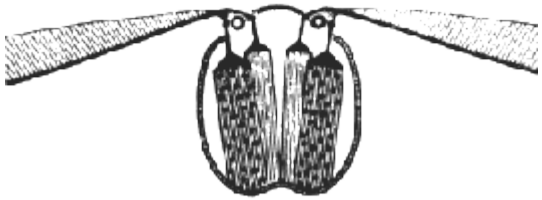
- Muscles powers all the movements, external and internal in insects.
- Muscles can be divided into four categories
  - Visceral: these muscles surround the tubes and ducts of insects and produce peristalsis.
  - Segmental: required for moulting and locomotion in legless larvae.

Muscular System

- Appendicular: Originating from either the sternum or the tergum on the coxae and these muscles move appendages as one unit. These are arranged segmentally and usually in antagonistic pairs.

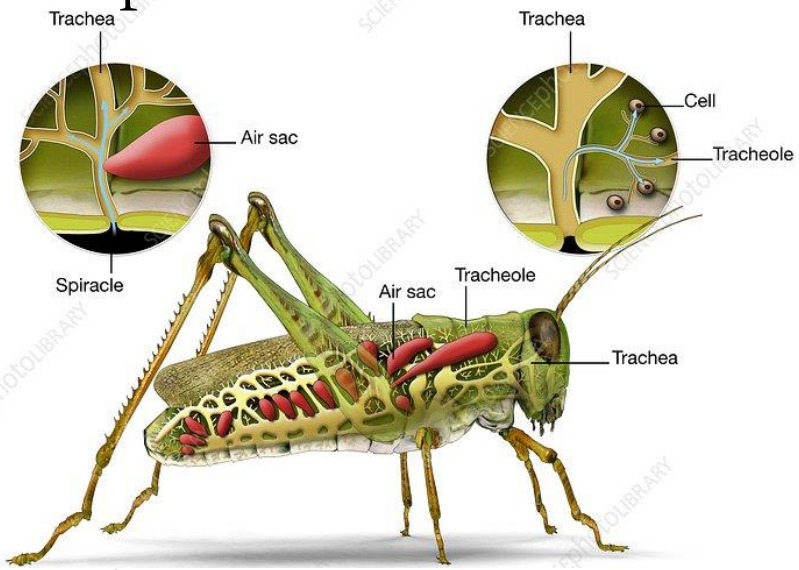


- Flight: Flight muscles are the most specialised category of muscle and are capable of rapid contractions.

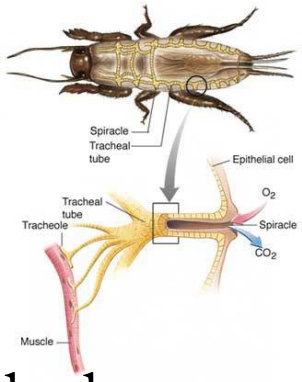


Respiration System

- All insects are aerobic organisms – they must obtain oxygen from their environment in order to survive.
- The respiratory system is responsible for delivering sufficient oxygen to all cells of the body and for removing carbon dioxide that is produced as a waste product of cellular respiration.
- The respiratory system of insects is separate from the circulatory system. Oxygen is delivered to the cells directly through respiration, and not carried by blood as in vertebrates.



Respiratory System

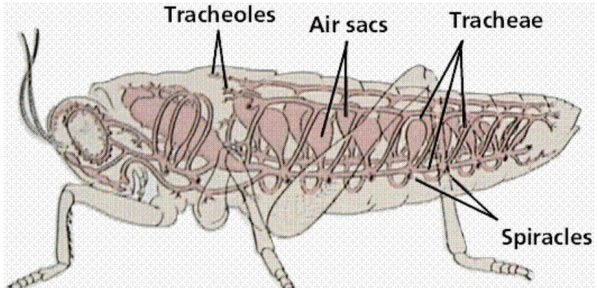


- There are three parts to the Tracheal System:

  1)Spiracles: external openings of the tubes

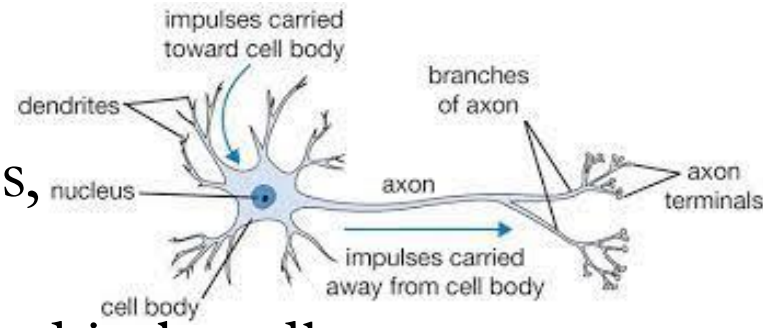
  2)Tracheae: These tubes branch and ramify through the body. The finest branches (tracheoles) contact all internal organs and tissues and are especially numerous in tissues with high oxygen requirements.

  3)Taenida: spiral bands of the exoskeleton in the wall of trachea. It adds strength. Where there are no taenidia, the tube functions as an air sac capable of storing air. Air sacs may assist flight by increasing buoyancy.



Nervous System

- An insect's nervous system is a network of specialized cells (called neurons) that serve as an "information highway" within the body. These cells generate electrical impulses (action potential) that travel as waves along the cell's membrane. Every neuron has a nerve cell body and filament-like processes (dendrites, axons, or collaterals) that propagate the action potential.
- Individual nerve cells connect with one another through special junctions, called synapses.

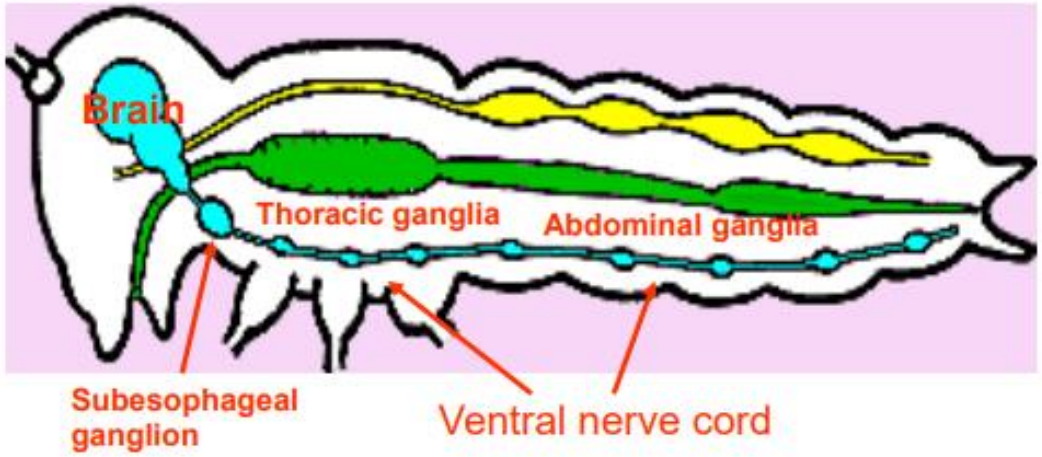


- Nerve cells are typically found grouped in bundles.
- A ganglion is a dense cluster of interconnected neurons that process sensory information or control motor outputs.

Nervous System

- Nervous System is composed of
  – Central nerve system (CNS)
  Most ganglia included: Brain+ventral nerve cord

  – Peripheral nervous system (PNS)
  All sensory neurons; not bundled in ganglia; located in integument.



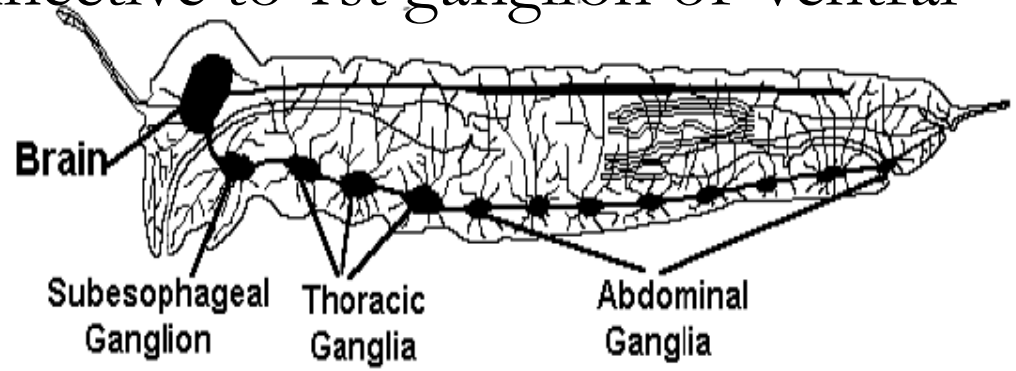
Nervous System ~ Brain

- Nerve cord to the head is the brain
- 3 pairs of ganglia region:

  1)protocerebrum: associated with vision; they stimulate the compound eyes and ocelli.

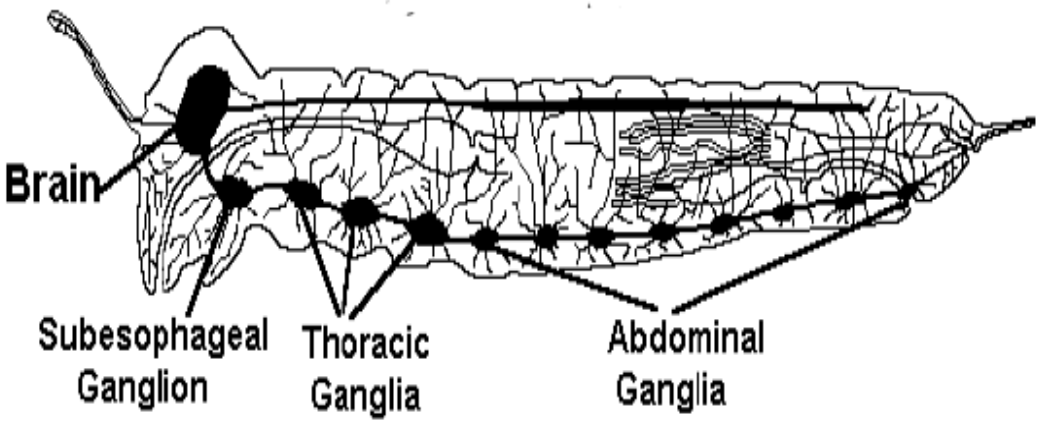
  2)deotocerebrum: pair lobes with sensory pathway to antennae.

  3)tritocerebrum: connective to 1st ganglion of ventral nerve cord.



Nervous System ~ Ventral Cord

- 1) Subesophageal ganglion
  - stimulates mandibles, maxillae, and labium, hypopharynx, salivary glands, and neck muscles.
- 2)Thoracic ganglia
  - control locomotion by stimulating the legs and wings.
- 3) Abdominal ganglia
  - control movements of abdominal muscles.

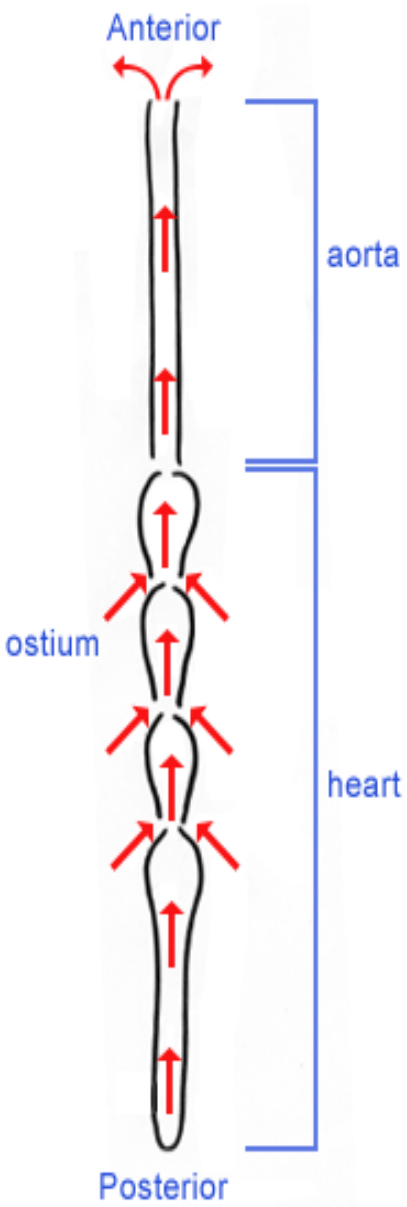


Circulatory System

- It is made up of an open circulatory system which differs in both structure and function from the closed circulatory system found in humans and other vertebrates.
- The hemolymph spends much of its time flowing freely within body cavities (haemocoel) where it makes direct contact with all internal tissues and organs.
  - It consists of:
    - 90% plasma, a watery fluid usually clear, sometimes greenish or yellowish with high concentrations of amino acids, proteins, sugars, and inorganic ions.
    - 10% haemocytes, various cell types involved in the clotting reaction, phagocytosis for encapsulation of foreign bodies.
- Insect have no arteries, veins or capillaries in the haemocoel

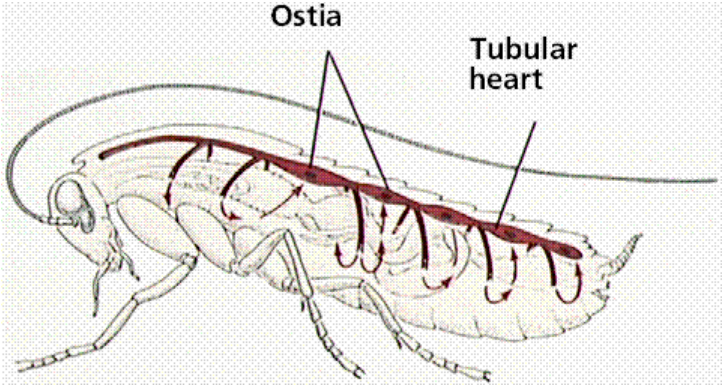
Circulatory System

- The circulatory system has a dorsal vessel running the length of the body.
- The dorsal vessel is divided into a posterior heart containing valves called ostia and an anterior aorta. Ostia are one-way valves that allow blood to enter heart. It is then forced out via the aorta.



Circulatory System ~ Function

- Transport of nutrients and hormones.
- Storage for substance like acid amino.
- Water reservoir.
- Carry waste products to the excretory systems
- Protection from foreign organism which invades the insect.



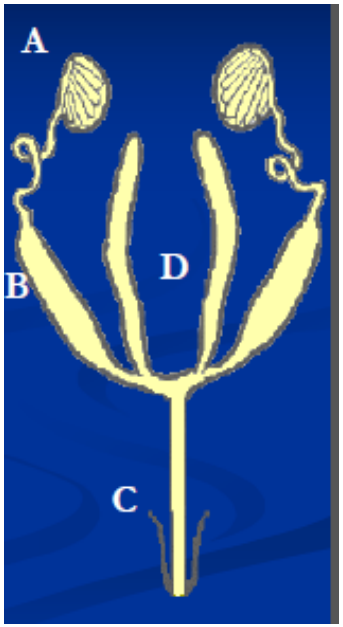
Reproductive System

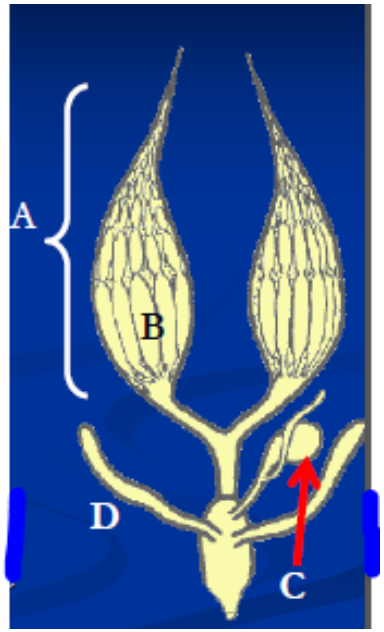
- Most insects reproduce oviparously.
- The eggs are produced by the female in a pair of ovaries. Sperm produced by the male in one testis or more is transmitted to the female during mating by means of external genitalia. The sperm is stored within the female in one or more spermathecae.
- At the time of fertilization, the eggs travel along oviducts to be fertilized by the sperm and are then expelled from the body, in most cases via an ovipositor.

Reproductive System

- Reproduce are by sexually and asexually means
- They are mostly sexually with 2 sex cells

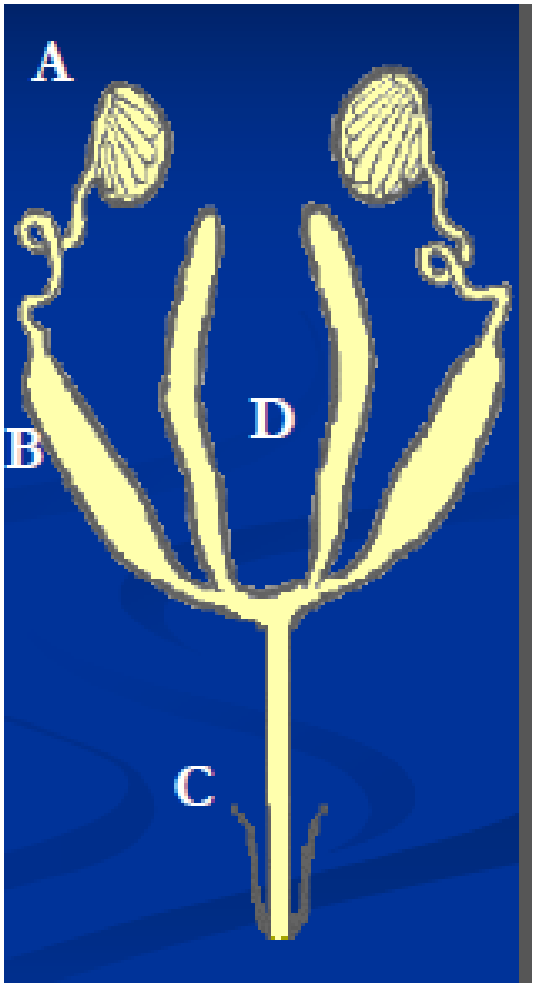
1) sperm
2) ovum

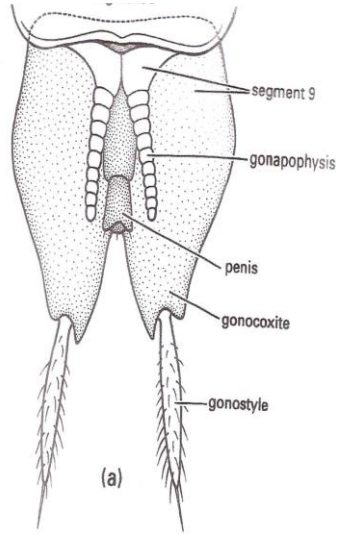




Male Reproductive System

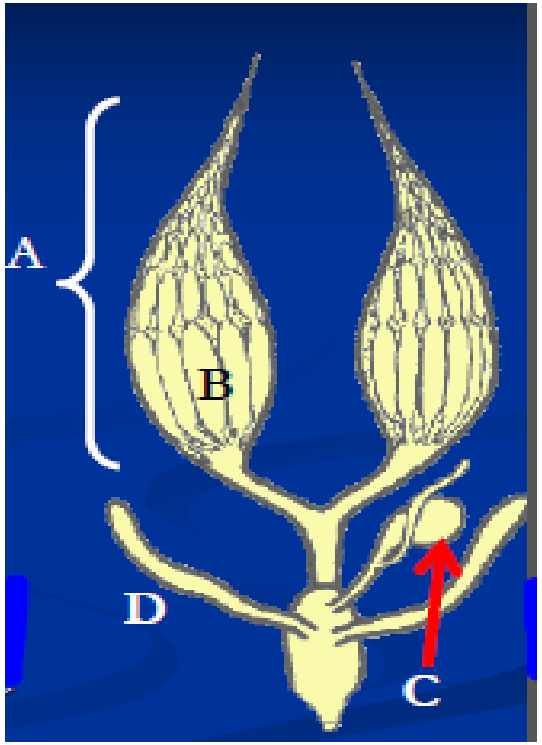
- Sperm produce by testes (A).
- From testes sperm stored in seminal vesicle (B).
- During copulation discharge through aedeagus (C) (penis)
- Along with secretion from accessory glands (D).

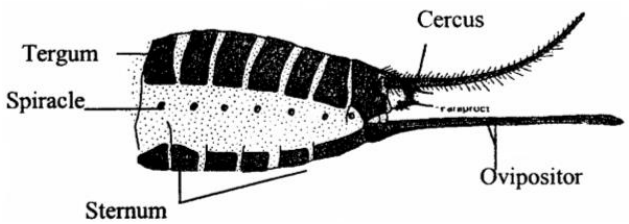




Female Reproductive System

- Ovum produce by ovary (A)
- Inside ovaries: ovarioles (B) egg producing tubules
- Spermatheca (C): storing sperm –
- Species that mate once stored sperm for months/years
- Accessory glands (D): provide materials for egg to attach to substrate





END

ENTOMOLOGY I

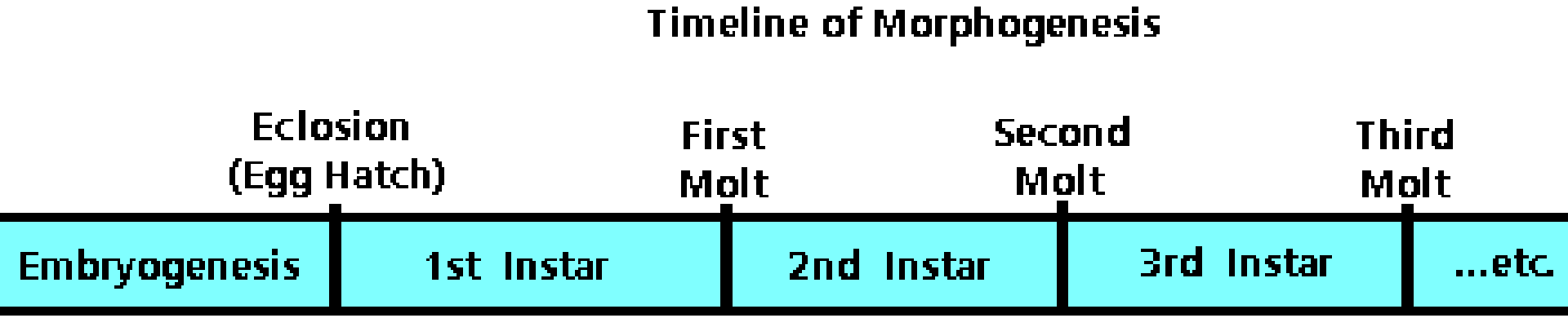
GROWTH AND DEVELOPMENT

BIOL 355

Dr. (Mrs.) Sandra Abankwa Kwarteng
Department Theoretical and Applied Biology
College of Science

Morphogenesis

- Morphogenesis is the origin and development of morphological characteristics in an organism. All changes that involve growth, molting, and maturation.



Growth

- In vast majority of insects, growth is determinate since there is a distinctive instar that marks the cessation of growth and molting.
- All insects with determinate growth become reproductively matured in this final instar. This reproductively matured individual is called an adult or imago.
- In Collembolans, Diplurans and Apterygote insects, growth is indeterminate. The animals continue to molt until they die. However, they do not continue to increase in size throughout their adult life.

Molting

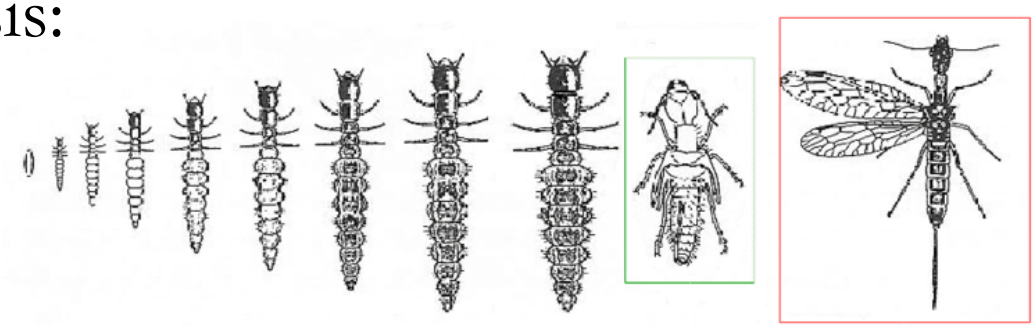
- The growth of an insect is accompanied by shedding its exoskeleton (skin) one or more times.
- This shedding process is called molting, or ecdysis. The cast skin is called the exuviae.
- The growth stage form of the insect between two successive molts is called an instar. When an insect emerges from the egg it is said to be in its first instar; the first ecdysis occurs and the insect then assumes its second instar and so on.
- The number of molts is generally 4 to 8, but may be as many as 20 in some insects.

Metamorphosis

- Each time an insect molts, it gets a little larger.
- In most cases, the appearance of a given species changes drastically in each successive stage.
- The process by which one stage transforms into another is called metamorphosis.
- Types of metamorphosis:
  - Ametabola
  - Hemimetabola
  - Holometabola

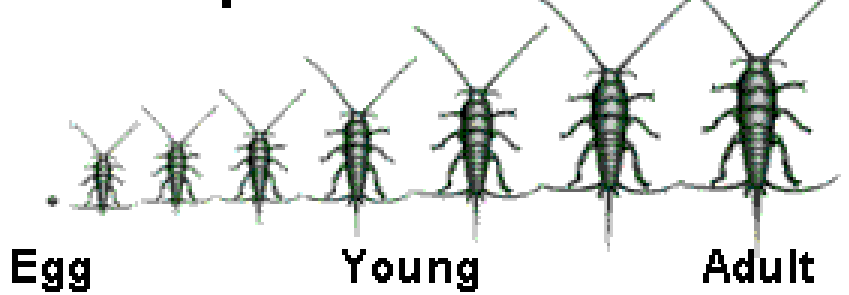
Ametabolan mode (Example: Archaeognatha)

Hemimetabolan mode (Example: Orthoptera)



Holometabolan mode (Example: Raphidoptera)

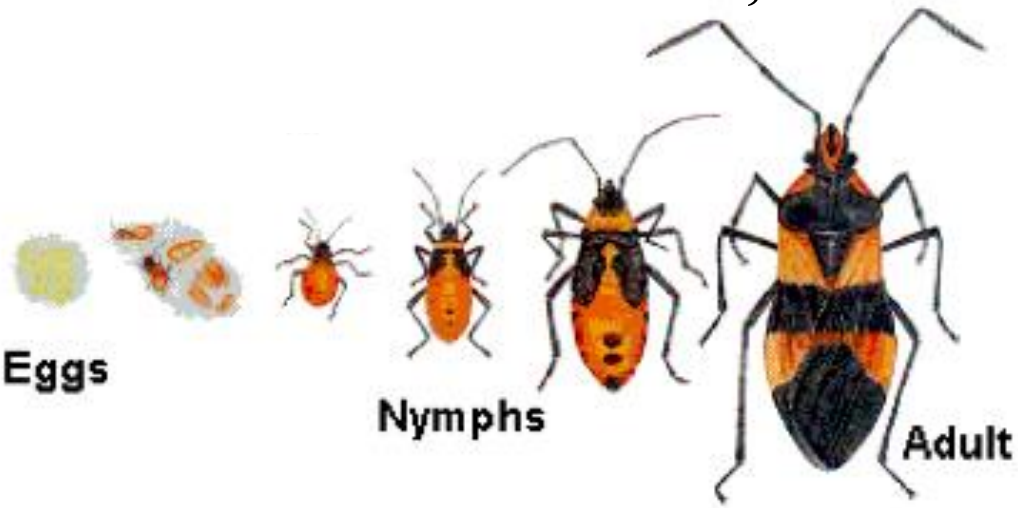
Ametaboly



- In the primitive developmental pattern, ametaboly, the insect hatches from the egg in a form essentially resembling a miniature adult but lacking genitalia.
- This pattern is retained by the primitively wingless orders, the silverfish and bristle tails in which the adults continue to molts after they become sexually mature.
- In contrasts, all pterygote insects undergo a more or less marked change in form between the immature phase of development and the winged adult.

Hemimetaboly

- The immature instars of insects with this type of metamorphosis are called nymphs.
- Nymphs usually resemble the adult except in size and the development of wings and genitalia.
- They generally live in the same habitat as the adult, and feed on the same foods.
- The term exopterygote has been applied to this type of wing growth.



Hemimetaboly

- Compound eyes are present in the early instars if they are present in the adult with no prolonged resting stage before the last molt. Examples: Cockroach, Grasshopper, Mantid and Bug nymphs.
- The immature of mayflies, stoneflies, damselflies and dragonflies differ from adult slightly more than in other insects with simple metamorphosis. They live in water and have gills, and when fully-grown come to the surface of the water or crawl out of the water for their final molt.


immature of mayfly

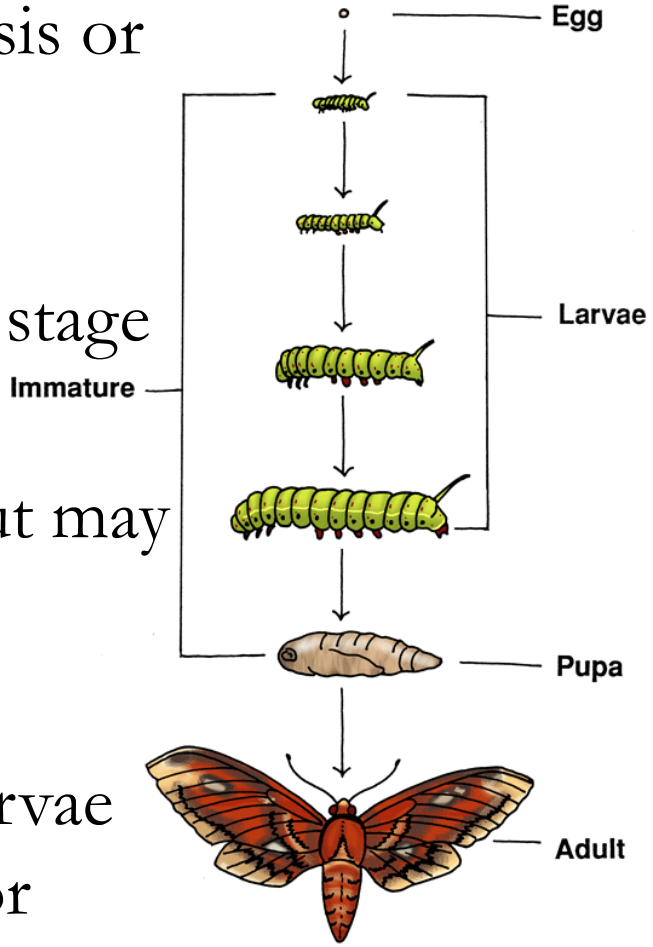

mayfly


stonefly


dragonfly

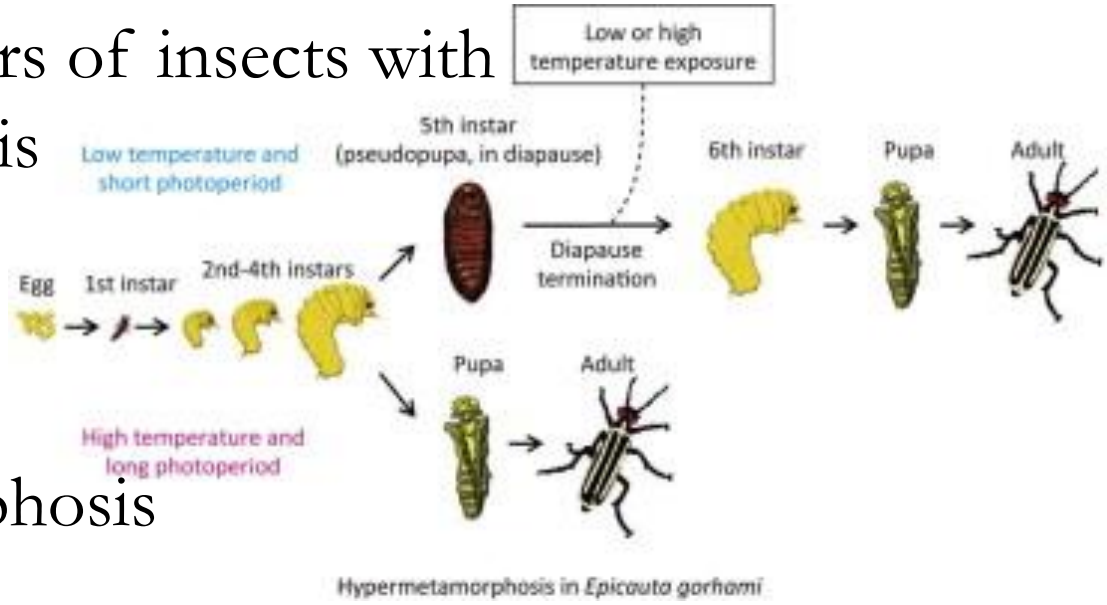
Holometaboly

- Also known as complete metamorphosis or endopterygotes.
- The eggs of insects with complete metamorphosis hatch into a worm-like stage called the larva.
- Larvae do not have compound eyes (but may have ocelli).
- Structures unique to adults; wings and genitalia, are present internally in the larvae as group of cells called imaginal discs or buds which are scarcely visible until the pupal instar.



Holometaboly

- The larval stage lasts from a few to several instars increasing in size and sometimes changing in color or other character. The last larval instar molts into a pupa.
- The diet and lifestyles of larvae are very different to those of their adults.
- The different larval instars of insects with complete metamorphosis are not always of the same type. This development is called larval heteromorphosis or hypermetamorphosis.



Hypermetamorphosis in *Epicauta gorhami*

Hypermetamorphosis

1. Protopod larvae

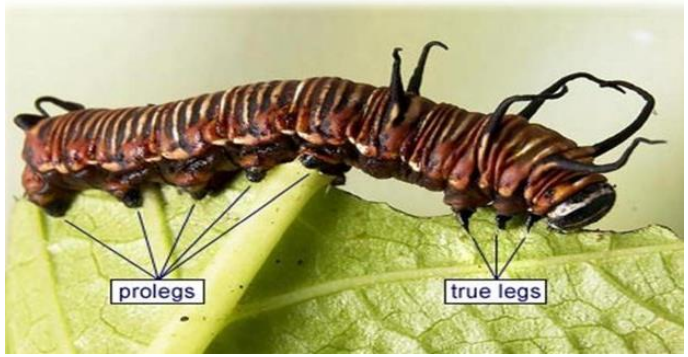
- Found in the larvae of certain parasitic Hymenoptera (parasitoids).
- The eggs of such insect species contain little yolk. The larvae emerge while still in the early embryonic phase.
- Their survival is made possible from the fact that they occur in the eggs or in the bodies of other insects where they develop immersed in a highly nutritive medium.

- They lack abdominal segmentation and possessing only rudimentary cephalic and thoracic appendages but no abdominal appendage.

Hypermetamorphosis

2. Polypod (eruciform) Larvae

- Characterized by cylindrical bodies with short thoracic legs and abdominal prolegs (pseudopods).
- Have well defined segmentation.
- Antennae are present but little developed.
- Examples are larvae of Mecoptera, Hymenoptera and Trichoptera.
- Such larvae are inactive and are mostly phytophagous.

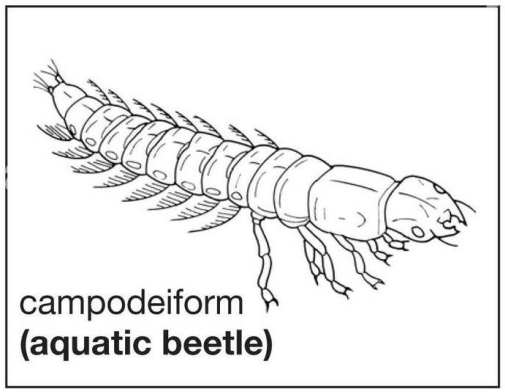


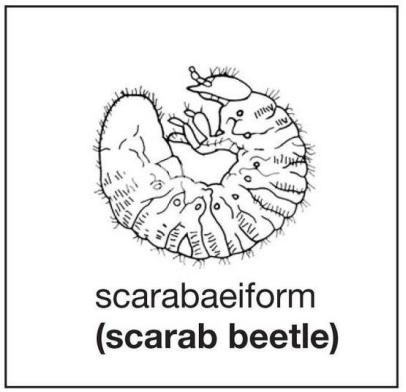
Hypermetamorphosis

3. Oligopod Larvae

- Have well developed head capsule with its appendages.
- Have functional thoracic legs but lack abdominal prolegs.

- Two types can be distinguished
    a. Campodeiform
    b. Scarabaeiform

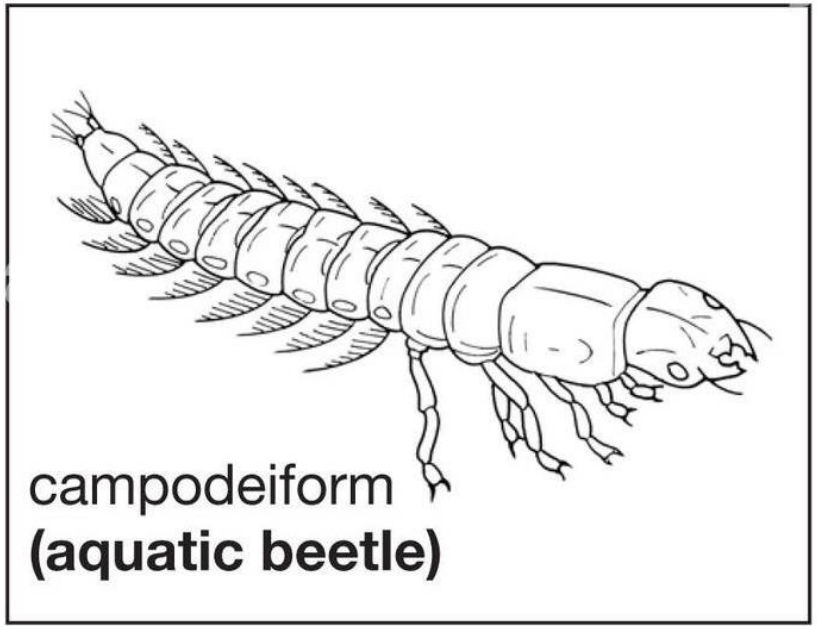




Hypermetamorphosis

a. Campodeiform

- Is well scleroterized, dorso-ventrally flattened with the antennae, cerci and thoracic legs well developed and generally active predators.
- Found in Neuroptera and Coleoptera.



Hypermetamorphosis

b. Scarabaeiform

- Are grub-like, with thoracic legs and poorly sclerotized.
- They are slow- moving detritivores living in soil or are phytophages.
- They occur in certain Coleoptera (example scarabaeidae)

Types of Pupae

- Several pupal types are recognized in the holometabola and these appear to have arisen convergently in different orders.
- Pupae are usually inactive.
- They do not feed, and are sometimes enclosed in a protective covering which may be a cocoon formed by the last larval instar before it molted

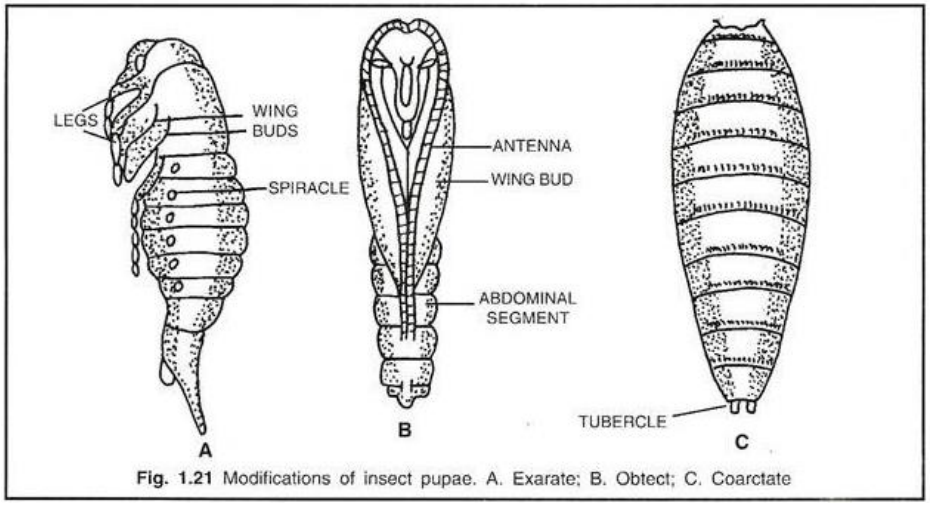
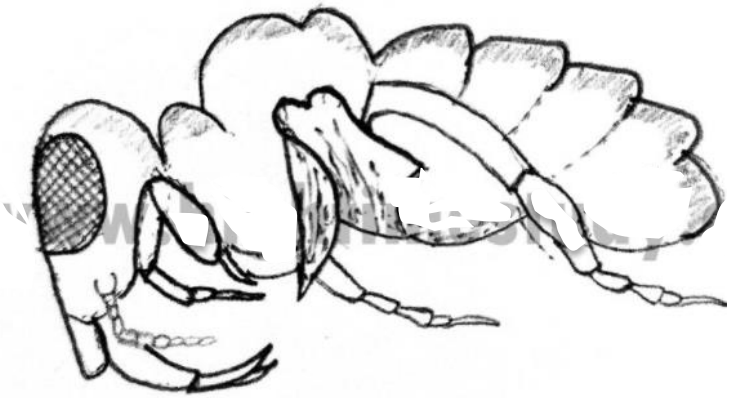


Fig. 1.21 Modifications of insect pupae. A. Exarate; B. Obtect; C. Coarctate

Exarate

- Their appendages are free and visible.
- Their appendages (example legs, wings, mouthparts and antennae) are not closely appressed to the body.
- Occur in most insects with complete metamorphosis except the Diptera and most Lepidoptera.



Obtect

- Their appendages are glued or cemented to the body and the cuticle is often heavily chitinized.
- Look much less like the adults.
- Occur in almost all Lepidoptera and some Diptera.

Coarctate

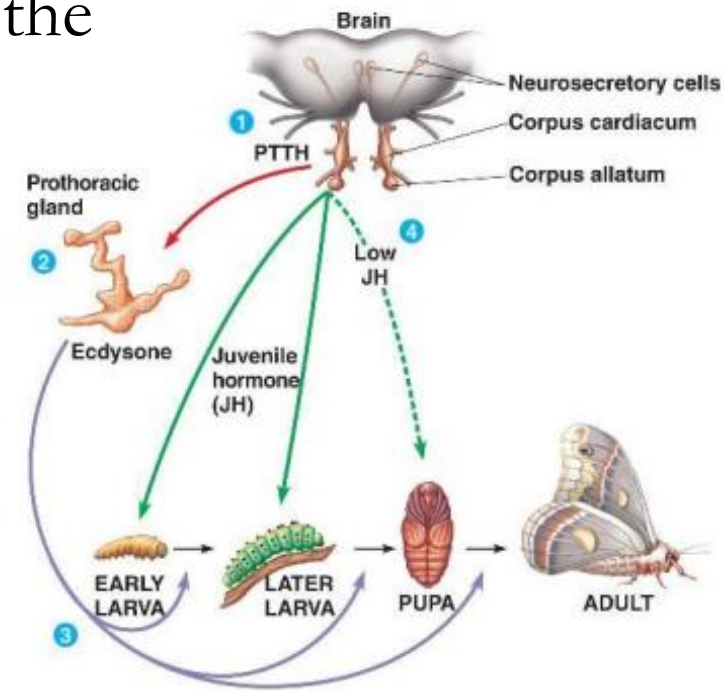
- The pupa of many Diptera (Brachycera and Cyclorrhapha) is enclosed in a puparium.
- The puparia are oval and brownish.

Endocrine Control of Insect Metamorphosis/Molting

- Hormones are chemicals produced by an organism which circulate in blood to regulate its long term physiological, developmental and behavioral activities.
- Growth and development in insects are controlled by series of hormones which are secreted in a predetermined sequence.
- Two types of hormones are involved in inducing each molting cycle in insects:
  - the activation hormone
  - the actual molting hormone

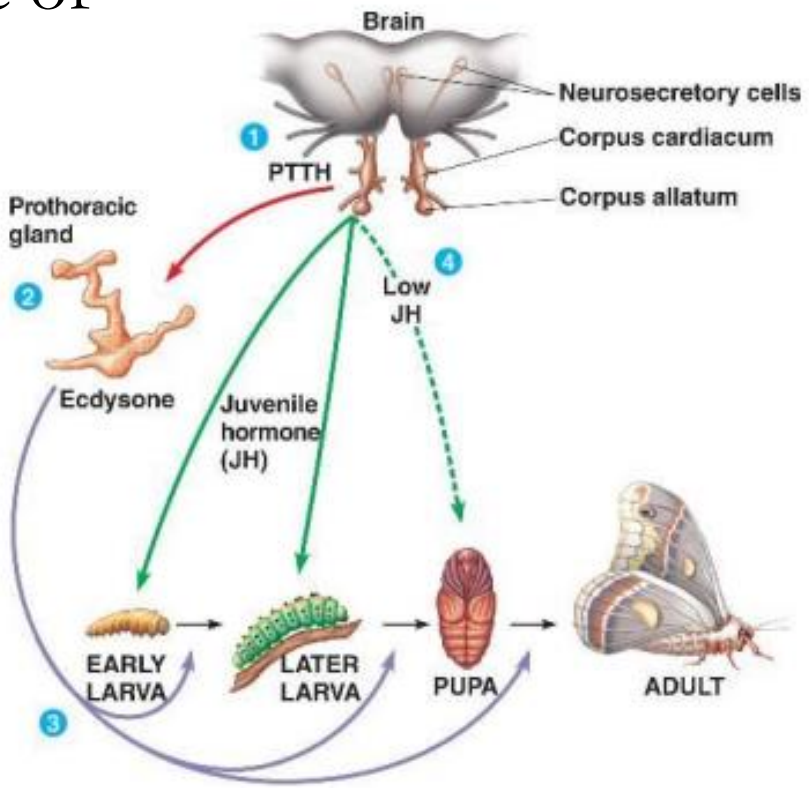
Activation Hormone

- The brain hormones, prothoracicotrophic (PTTH) and some adipokinetic hormone are secreted by the corpora cardiaca.
- The PTTH is essential for molting and pupation.
- The molting process is initiated in the brain, where neurosecretory cells release PTTH in response to neural, hormonal or environmental signals.



Actual Molting Hormone

- They include juvenile hormones (JH), ecdysone, eclosion hormone and various type of peptides produced by the neurosecretory cells; corpora allata, prothracic glands, epitrachael glands and midgut endocrine cells respectively.



Juvenile Hormones (JH),

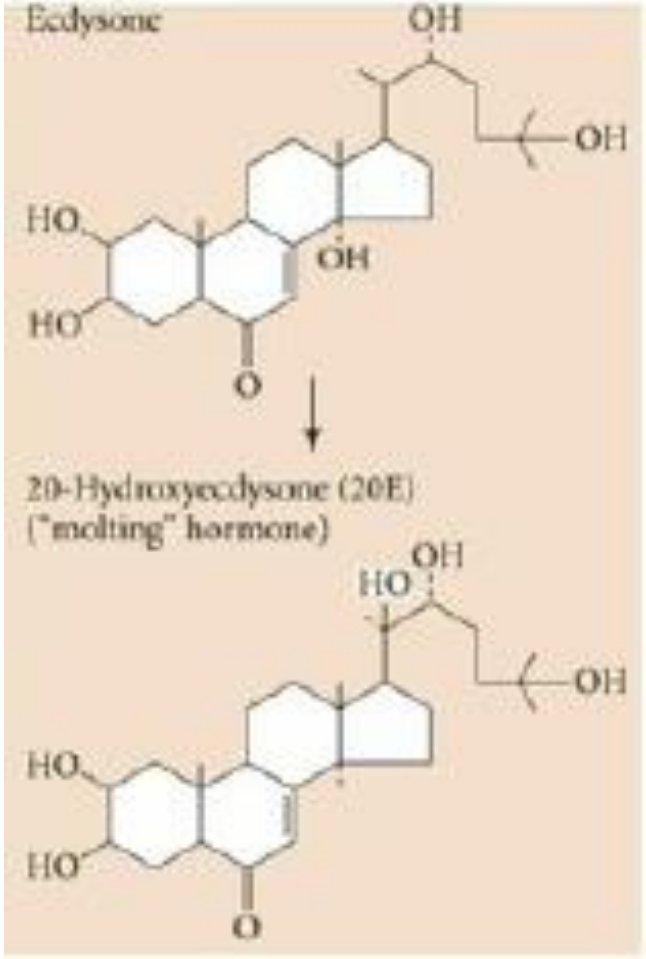
- The JH is secreted by corpora allata. The secretory cells of corpora allata are active during larval molts but inactive during late stage of larval molt or nymph stage where JH production is stopped.
- The JH inhibits the genes that promote development of adult characteristics (eg. Wings, reproductive organs) causing the insect to remain immature (larvae or nymph).
- At sexual maturity however JH production is stimulated. This hormone stimulate the production of yolk for the eggs.

Ecdysone/ Molting Hormone

- Molting hormone affect many cells throughout the body but its principle function is to stimulate a series of physiological events that leads to the synthesis of a new exoskeleton.
- Ecdysone is modified in periphery tissues to become the active molting hormone 20E (20-hydroxyecdysone).
- It initiates the molting process, breaking larval and pupal diapauses and renew growth and deposition of new cuticle in insects.
- It inhabits the function of corpora allata.
- As long as ecdysteroid levels remain above a critical threshold in the hemolymph, other endocrine structures remain inactive.

Ecdysone/ Molting Hormone

- Towards the end of apolysis, ecdysteroid concentration falls and neurosecretory cells in the ventral ganglia begin secreting eclosion hormone.
- This hormone triggers ecdysis, the physical process of shedding the old exoskeleton.



ENTOMOLOGY I

INSECT CLASSIFICATION

BIOL 355

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Insects Classification

- Insects with similar characteristics, number of wings, mouthparts, etc. are placed in a group with other insects that possess the same characteristics.
- Identification of insect orders aids in prevention and management of insect pest and vectors.

Classification of Class Insecta

Class Insecta

Sub-Class

Pterygota (Winged insects)

Sub-Class

Apterygota (Wingless insects)

Orders:

1. Thysanura - Silver Fish
2. Collembola - Spring tails
3. Diplura - Campoda silver fish
4. Protura - Proturon

Endopterygota:

1. Lepidoptera - Butterflies, moths
2. Coleoptera - Beetles
3. Hymenoptera - Bees, ants, wasps
4. Diptera - Ture flies, mosquitoes
5. Siphonoptera - Fleas
6. Neuroptera - Lace wings, ant lions
7. Mecoptera - Scorpion flies
8. Tricoptera - Caddis flies

Exopterygota

1. Orthoptera - Grass hopper, cricket
2. Dictyoptera - Cockroaches, Mantids
3. Hemiptera - Bugs
4. Homoptera - Aphids, Plant hoppers
5. Odonata - Dragon flies
6. Isaptera - Termites
7. Thysanoptera - Thrips
8. Anaplura - Sucking lice
9. Plecoptera - Stone flies
10. Dermoptera - Earwigs
11. Phasmida - Stick and leaf insects
12. Ephimeroptera - May flies
13. Malophaga - Chewing lice

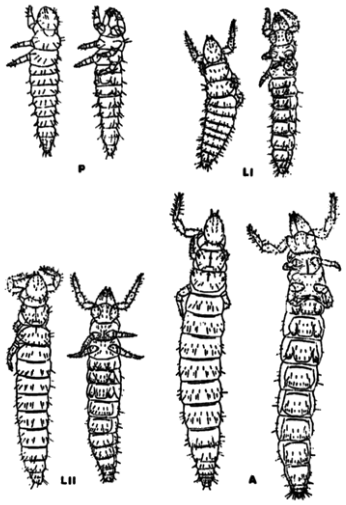
Apterygota

Proturans (proturon)

- Ametabolous, no wings, no eyes with some breathing through their cuticle.
- No antennae, has a sucking mouthparts, they are normally very small (are almost impossible to spot with a hand lens due to their slender profile and almost see-through body), found in moist habitats.

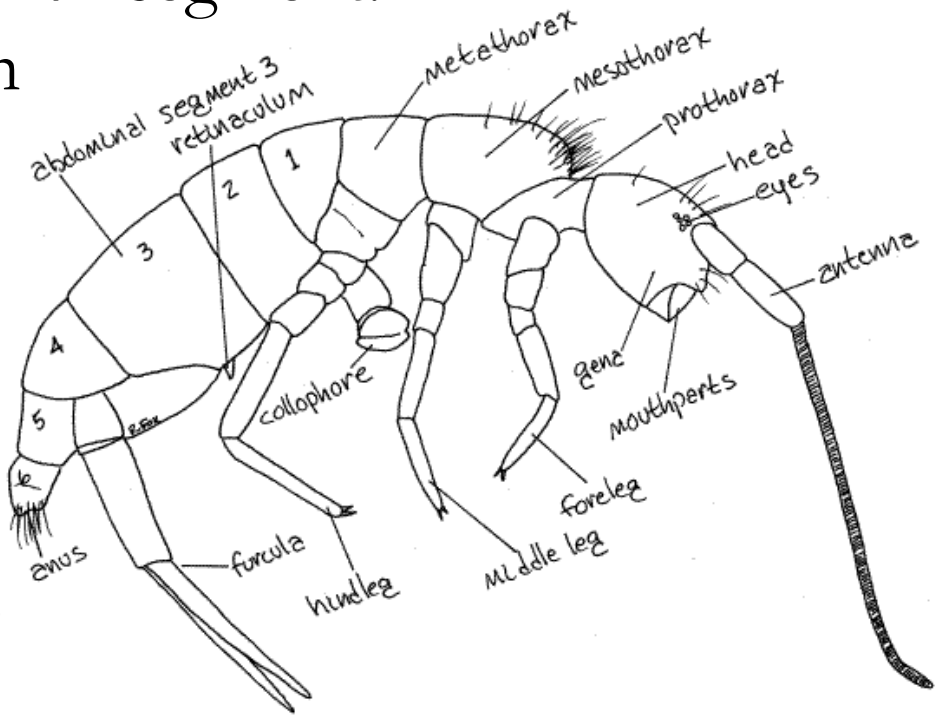
Diplurans (campoda silver fish, *Japyx*)

- Ametabolous, no wings, no eyes with some breathing through their cuticle.
- Their antennae have internal muscles, they have chewing mouthparts, they are normally small, also and found in moist habitats.
- Their abdomen has 11 segments and 2 cerci.



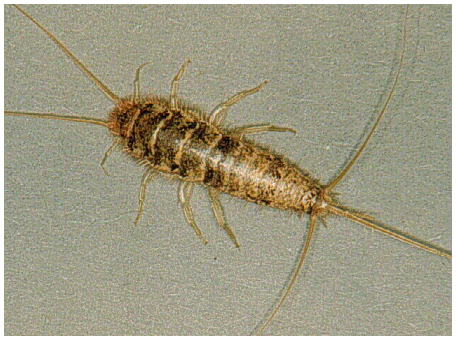
Collembola (spring tails)

- Ametabolous, no wings, some species have eyes
- Their antennae have internal muscles.
- Abdomen has scales, collophore on 1st segment, retinaculum on 3rd segment and furcula on 4th segment.
- Extremely abundant in certain soil habitats (moist and with much organic debris)
- Occasional pests in potted plants, greenhouses.
- Important food source for many arachnids and other insects.



Thysanura (silverfish, bristletails)

- They are ametabolous with no wings.
- Their antennae are very long without internal muscles but have well-developed eyes and breath through spiracles.
- Their abdomen has 11 segments with 3 bristly cerci.
- Habitats include moist, shady locations outdoors and hot, dry locations indoors.
- They feed on starchy substances and can be indoor pests on wallpaper, books, cereals etc.



Pterygota

Exopterygota

Ephemeroptera = "Short Lived Wings"

(mayflies)

- Adults are short lived (vestigial mouthparts).
- Nymphs are call 'naiads'. Penultimate nymphs are called 'subimagos'
- Fragile bodies, weak legs, body curved upward at the head and tip of the abdomen, when at rest.
- Three caudal filaments at the end of the abdomen.
- Adult swarms can be a nuisance.

Ephemeroptera = "Short Lived Wings"

Naiad Characteristics

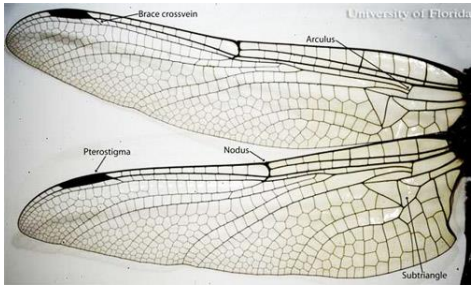
- Naiads emerge as adults in large swarms, for a short mating period.
- Naiad antennae are short, bristle-like and live 1-2 years in the water, with many molts.
- They normally have 7 pair of abdominal gills.

Odonata = 'tooth wing'

Adult Characteristics

(Dragonflies and damselflies)

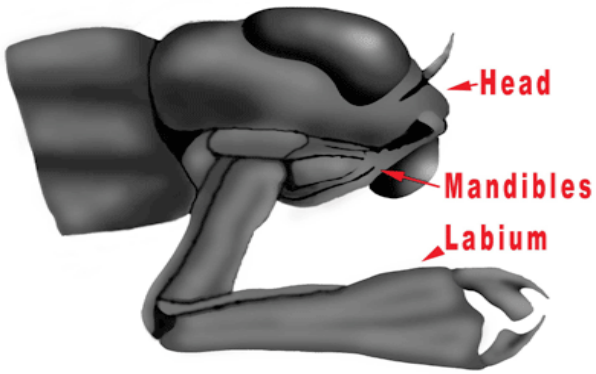
- Adults have 2 pair of membranous, elongate wings, with many cross veins.
- Chewing mouthparts.
- Dragonflies hold wings horizontal, at rest. Damselfly wings are folded over abdomen, upright, when at rest. The abdomen is long and thin.
- Adults patrol over stream, ponds, and other aquatic habitats.
- All are predaceous.

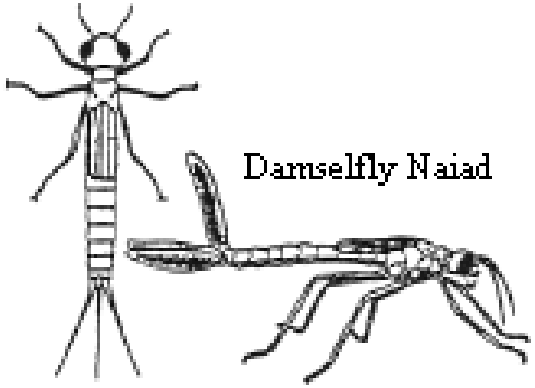


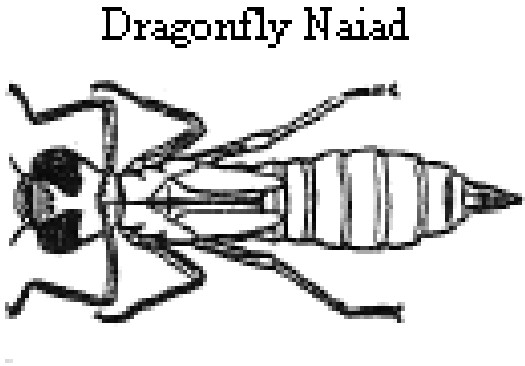
Odonata = 'tooth wing'

Naiad Characteristics

- Highly modified and hinged labium and are highly predaceous.
- Dragonflies have rectal gills and tracheal gills.



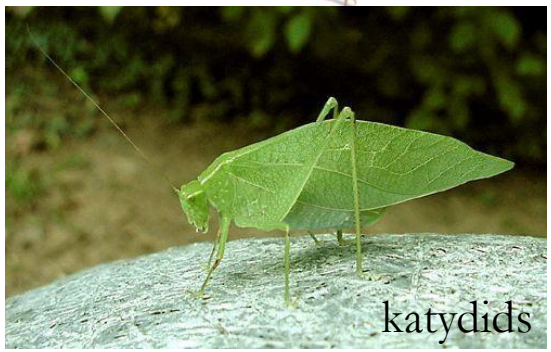




Orthoptera = 'Straight wing'

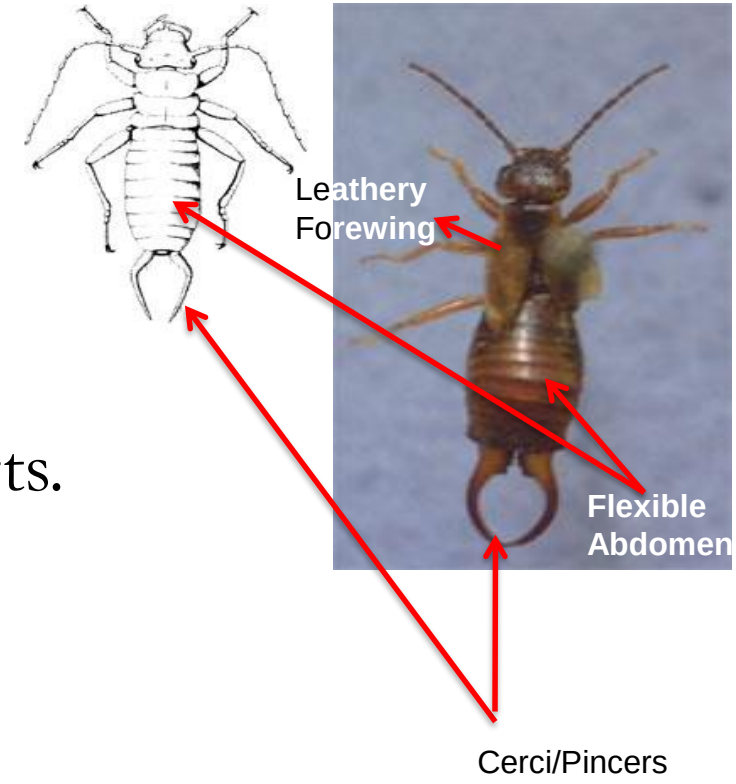
(Grasshoppers, katydids, crickets)

- Two pair of wings.
  - First pair is a leathery tegmina.
  - Second pair is membranous and fanlike.
- Chewing mouthparts.
- Can be found in a variety of habitats – old fields, woodland, households.
- Some are extremely destructive pests to cultivated crops.



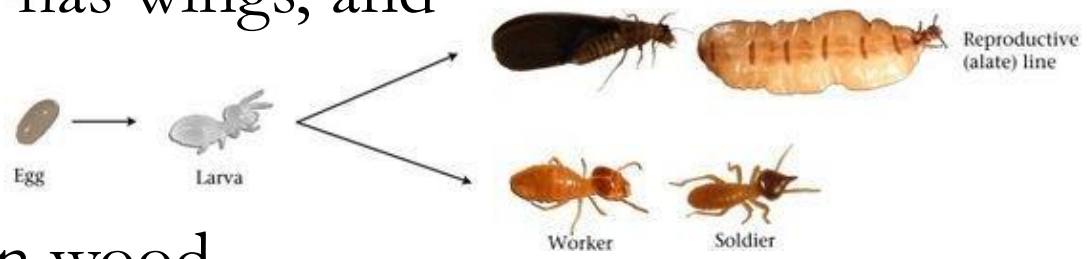
Dermoptera = "Skin Wing" (Earwigs)

- They possess two pairs of wings
  - Short, square, and veinless, leathery tegmina forewings
  - Fanlike hindwings
- They undergo the hemimetabolous development with biting mouthparts.
- They feed by scavenging plant and animal matter.
- Their cerci form pincers.
- Abdomen is uncovered and very flexible and distribution world-wide dwelling in the ground crevices.



Isoptera = 'Same Wing' (Termites)

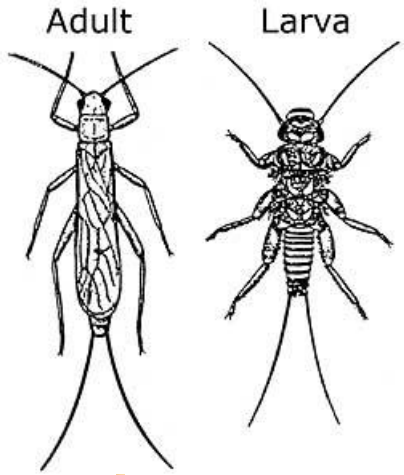
- Two pair of wings with few cross veins.
- Their wings are longer than their body.
- They are eusocial, showing an advanced level of social organization, in which a single female or caste produces the offspring and non-reproductive individuals cooperate in caring for the young.
- Only reproductive caste has wings, and only near the time of nuptial flight.



- They live in ground or in wood.
- Many are pests of buildings. Most are beneficial, because they recycle nutrients from dead trees and other plant materials.

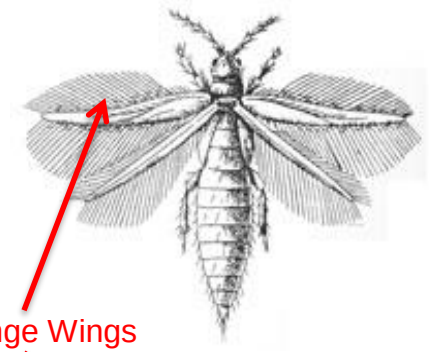
Plecoptera = 'Folded wing' (Stoneflies)

- Two pair of wings. Both membraneous. Hind pair folds fan like under front wings.
- They possess chewing mouthparts although they are reduced in some species.
- Stoneflies have long, slender antennae.
- Adults and naiads have 2 cerci at apex of abdomen.
- Adults live on vegetation near water while naiads prefer cold, well-oxygenated, water habitats.
- Naiads are an important prey and predator component of aquatic food chains.



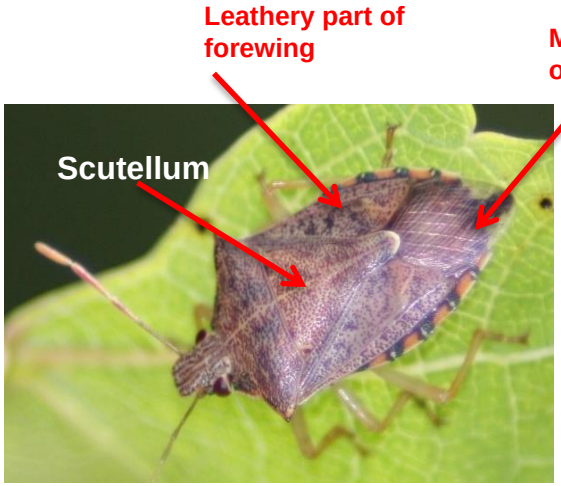
Thysanoptera = 'fringe wings' (Thrips)

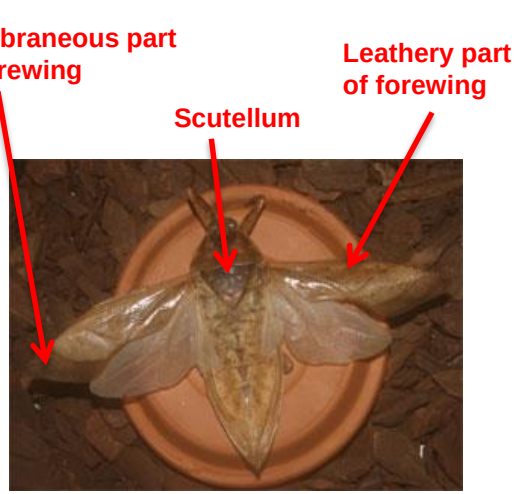
- They are 2 pairs of tiny, feather-like wings.
- They are usually small 0.5 - 15mm long.
- Their mouthparts are adapted for piercing and have very narrow body with prominent compound eyes.



Hemiptera = 'Half Wing' (True Bugs-assassin bugs, kissing bugs, leaf-footed bug, lygus bug, stink bug, big-eyed bug)

- 2 pairs of wings (some species wingless) with their forewings generally hardened to some extent.
- They are 1mm - 100mm long with a suctorial mouthparts.
- They possess cibarial pump. Mostly vegetarian or omnivorous.
- Some however are strictly carnivorous species.
- A few families are aquatic and a few too predaceous.

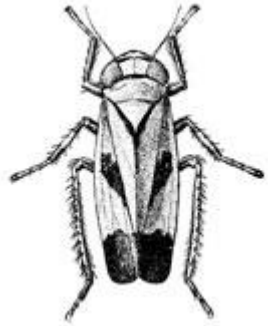




Homoptera = 'Full wing' (cicadas, aphids, leaf hoppers, and whiteflies)

- They possess two sets of wings
  - Forewings are of uniform texture (all membraneous or leathery).
  - Hindwings are membraneous
- Their heads deflected backwards with piercing/sucking mouthparts.


aphid

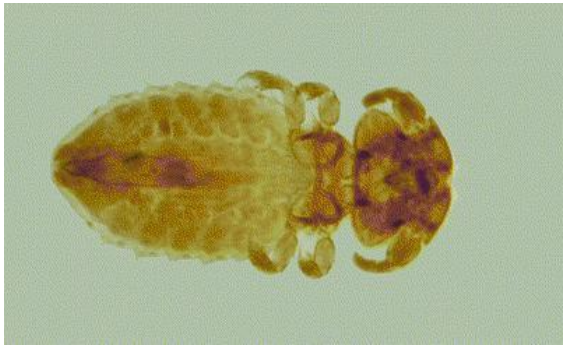


Psocoptera (Book and Bark Lice)

- Wings present or absent.
- If, present, 2 pair of membraneous wings, with reduced venation.
- Forewing larger than hindwing, and held roof like over body at rest.
- Small (<5mm in length)
- Some species are pests that damage books (feed on starchy bindings).

Malophaga / Anoplura (Lice)

- Malophaga = chewing mouthparts
  - Head wider than thorax.
  - Many are important pests of livestock.



- Anoplura = sucking mouthparts.
  - Head is usually narrower than thorax.
  - Includes species that are parasitic to humans.
- Minute (<4mm in length).
- Body dorso-ventrally flattened.
- Tarsal claws.

Blattodea

- About 4,600 species of insects
- The cockroach is characterized by a flattened oval body, long threadlike antennae, and a shining black or brown leathery integument

- The female produces eggs in egg cases called oothecae.
- The diet of the roach, which includes both plant and animal products, ranges from paper, clothing and books to dead insects such as bedbugs.

- Egs. American cockroach (species *Periplaneta americana*), german_cockroach (*Blattella germanica*), brown-banded cockroach (*Supella longipalpa*).

Endoterygota

Neuroptera = 'Nerve Wing'

(Antlions, Owlflies, Lacewings)


Antlion Adult

- Adults possess two pairs of membranous wings made up of dense network of cross veins on wings.


Antlion Larva

- The chewing mouthparts of the larvae enable them predate on smaller insects and pollen-eaters by mostly trapping them in their dug out pits. Most of their lives are spent in larval stage.


Antlion Larval Pits

- Distribution: 6,000 species world-wide, found in ground debris, in woodlands, sandy soils.

Coleoptera = “sheath wing”

- They possess two pairs of wings; forewings (elytra) are veinless, toughened and horny, covering the entire abdomen and meeting at the midline and hindwings which are membranous.
- Prothorax is large, and covered by the pronotum.
- They possess chewing mouthparts.
- Distribution, more than 300,000 species world-wide and from deserts to tropical regions, mainly ground dwelling and in vegetation, others aquatic
- Feed on most solids, including crops, timber, dry bone etc.

Raphidioptera (snakeflies)

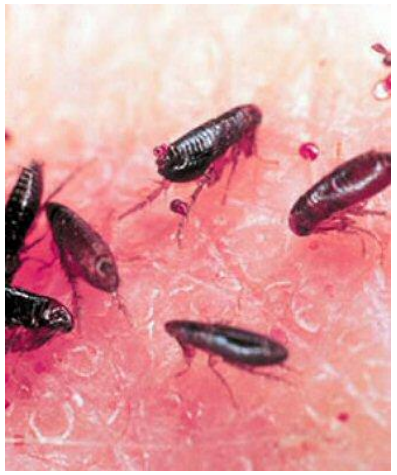
- Two pairs of membranous wings which are mostly cross veins (forming a nerve network). There are numerous cross veins between costa and subcosta veins.
- Chewing mouthparts.
- Possess elongated prothorax.
- Front legs rise from the posterior end of the prothorax, and are similar to the other legs.

Lepidoptera = 'Scale Wing'

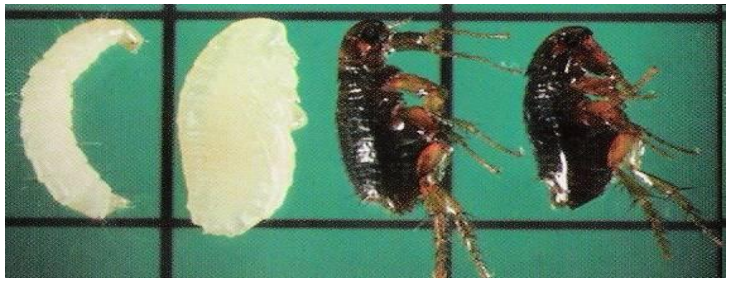
(Butterflies, Moth)

- Two pairs of membranous wings
  - Both pairs covered in minute scales of various colours
- Adult mouthparts mainly suctorial, with proboscis for feeding on liquids, usually nectar.
- Chewing mouthpart– Caterpillars
- Distribution
  - 20,000 species
  - Associated with higher plants, especially angiosperms.

Siphonaptera (Fleas)



- Wingless
- Piercing and sucking mouthparts (obligate blood feeders).
- Laterally flattened
- Hindlegs adapted for jumping.
- Larvae worm-like.
- Can jump 100 times their own length.
- Females can consume more than 15 times their body weight daily.



Hymenoptera = 'Membraneous Wing'

(Bees, Wasps, Ants)

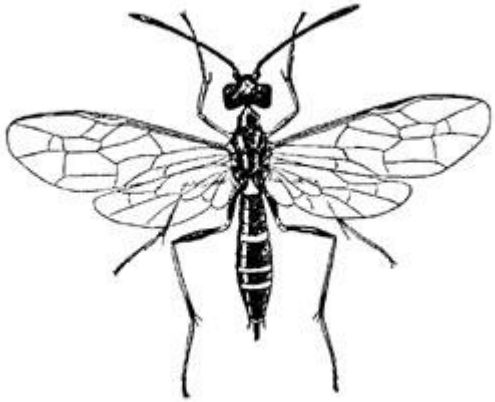
- Two pairs of membranous wings
  - Hind wings much smaller than forewings.
- Chewing-Lapping mouthparts presenting as predators, herbivores and nectar feeders
- Distribution: Over 100,000 species.
  Habitats: from woodland to desert
- There exist social systems in Hymenoptera:
  - They create their own nests with their young ones provided for by varying levels of parenting.

Hymenoptera = 'Membraneous Wing'

- Suborder Symphyta

(sawfly, horntail, and wood wasp)

  - The most primitive members of the order.
  - No typical wasp-waist
  - Hold wings flat over the body

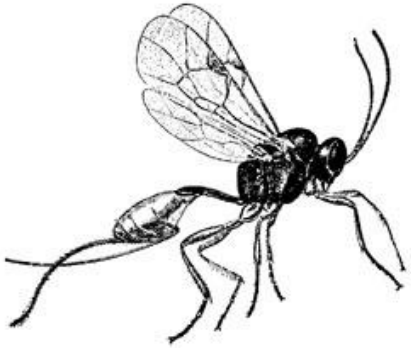


Hymenoptera = 'Membraneous Wing'

- Suborder Apocrita

(ants, bees, wasps, braconids,, nearly all parasitic Hymenopterans)

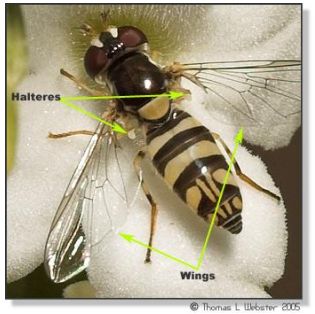
  - The suborder includes the most highly evolved members of the order
  - Wasp waist
  - Have wingless castes



Diptera = 'two wings'

(Flies, Midges, Mosquitoes, House fly, Crane fly)

- One pair of wings
  - Membranous forewings used for flight
  - Hindwings form small stick-like halteres
- No cerci on the abdomen
- Distribution
  - Mainly associated with flowers and decaying organic matter .
  - Feed on vegetation and organic matter, some are blood feeders and ectoparasites. Are common vectors of diseases.
  - Over 100,000 species,



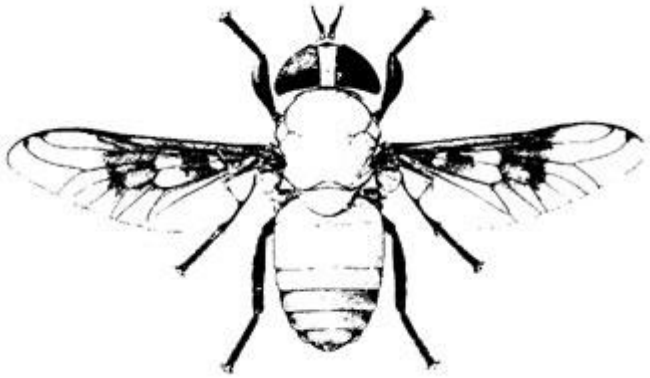
Diptera = ‘two wings’

Suborder Nematocera

(mosquitoes, crane flies, gnats)

- Small, delicate insects
- Slender, many segmented antennae, with no arista
- No distal cell in the wing, open anal cell widens towards the wing margin
- Larvae have prominent, biting jaws

Diptera = 'two wings'



Suborder Brachycera

(e.g., horse flies, robber flies, bee flies)

- Stout flies
- Their most distinguishing characteristic is reduced antenna segmentation. Antennae 3-segmented, shorter than the thorax, may have terminal arista
- Discal cell not always present
- Larvae have reduced jaws which can be retracted into the head

Diptera = ‘two wings’

Suborder Cyclorrapha

(Hoverflies and the Coffin flies)

- Stout flies.
- Antennae non-prominent, 3 segmented and pendulous, bristle from dorsal surface
- Circular seam on head
- Larvae are maggot-like, with no visible jaws

Mecoptera='long wings'

(Scorpionflies, hangingflies)

- Panorpidae - The males have enlarged genitals raised over the body that looks similar to the stingers of scorpions.

- Bittacidae - Known for their elaborate mating rituals, in which femals females choose mates based on the quality of gift prey offered to them by the males

Trichoptera (caddisflies)

- They are a group of insects with aquatic larvae and terrestrial adults.
- The larvae use silk to make protective cases strengthened with sand, gravels and twigs and are predators or leaf-shredders, algae grazers etc.
- Most adults are short lived during which they do not feed.
- There are about 14,500 described species.
- Caddisfly are useful bioindicators as they are sensitive to water pollution.