LABORATORY MANUAL & WORK BOOK

Fundamentals of Entomology
(BSAC-207)

For B.Sc.(Hons.) Agriculture Semester-II

Dr.Hitendra Kumar
Associate Professor & Head

DEPARTMENT OF ENTOMOLOGY
School of Agricultural Sciences
Shri Guru Ram Rai University,
Dehradun 248001 (Uttarakhand)

SHRI GURU RAM RAI UNIVERSITY

(Estd. By Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act No. 03 of 2017)

New Campus Pathri bagh, Dehradun-248001, Uttarakhand

Certificate

This is to certify that the practical work recorded herein is a bona fide account of the work carried out by Mr./Ms. _____ (Enrollment No. _____) as part of the B.Sc. (Hons.) Agriculture degree programme, Course No. BSAC-207, titled "Fundamentals of Entomology," during the 2nd Semester of the Academic Year _____.

The work documented in this work book cum manual has been performed sincerely and diligently, in accordance with the prescribed syllabus and under proper guidance and supervision.

Date: _____
Faculty In-charge: _____
Department of Entomology
School of Agricultural Sciences
Shri Guru Ram Rai University, Pathribagh
Dehradun 248 001 (Uttarakhand)

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Department of Entomology
School of Agricultural Sciences
B.Sc.(Hons.)Agriculture Semester-II
Subject: Fundamentals of Entomology (BSAC-207)

LAB EXERCISE NUMBER -01

TITTLE: Methods for the Collection and Preservation of Insects

MATERIAL REQUIRED : Insect collecting net, Insect store box, Setting board, Aspirator, Killing bottle, Entomological pins, Glass Vials containing 70% alcohol, Forceps, Camel hair brush, Hand lens, Insect labels.

METHODOLOGY:

A.Look at following plant parts and habitats for insects

Plant Parts /habitat	Insect
Leaves	Plant bugs,caterpillars,leaf hoppers,plant hoppers,mealybugs, Leaf weevils,aphids,grasshoppers,beetles
Stem and branches	Stem borer,bark borers,Mealy bugs
Buds and flowers	Caterpillars,thrips,flower beetles,honey bees
Fruits	Fruit borers,fruitfly maggots,
Roots	Termites,white grub larvae
Litter and debris	Scavenger and saprophytic insects.
Light source	Different varity of insects specially nocturnal moths
Water reservoirs	Naiads of dragonfly,damselfly,mayfly,caddishfly,stonefly ,beetles and bugs
Flying	Adults butterfly,dragonfly,damselfly etc.

B.Use below listed equipments for insect collection ,setting and preservation

Materials	Use
Insect collection net	Use to trap flying insects. Made up of an aluminium or iron handle with metal frame fitted with net cloth bag.After trapping the insect handle is rotated at 90 degree to prevent escape of insect from net.
Killing jar	A wide mouth glass jar or bottle ,cotton and ethyl acetate is used to make temporary insect killing bottle.Cotton is placed at the bottom of jar and little volume of ethyl acetate is poured on to it until cotton get saturated.After trapping insect is placed in to the bottle for a few minutes to kill.
Setting board	The spreading boards or setting boards is used for spreading the wings of a butterfly and moth. It is a simple board made up of plywood lined by cork sheet on the top. It is provided with central longitudinal groove to fit the abdomen of the

	insect.
Insect storage box	Insects are stored permanently for longer time in store boxes. Insect boxes are made up of wood lined with cork sheet inside for easy pinning of insects. The standard size of insect store box is 45 cm x 30 cm x15 cm.
Aspirator	Aspirator is useful to collect small insects from a net or directly from foliage. Aspirator bottle may be prepared with any small bottle fitted with a lid containing two holes. Two plastic tubes are fitted in the holes of the lid. One tube is kept opened at both ends while the other is closed at its inner end with a piece of muslin cloth held by a rubber band. The outer end of the second tube is used for suction.
Insect pins	Rust proof nickel pins of different sizes are used to pin different types of insects.Pinning body regins have been listed in a separate table for ease of students.

C. Methods of insect collection

Type of insect	**Method of collection**
Medium to large flying	With insect net
Small active	Aspirator
Large sedentary	Foreceps
Small sedentary	Camel hair brush
Aquatic	Aquatic net
Soil insects	Berlese funnel

D. Method of pinning the insects

Pinning is the best way to preserve hard bodied insects. Pinned specimens keep well, retain their normal appearance, and can be easily handled and studied. Insects are usually pinned vertically through their body. About 1/3 of the pin length should be seen above the body. The place of pinning on the insect body varies according to the group of insect as listed in the following table.

Insect	**Pinning region**
Grasshopper and Praying mantids	Pronotum (slightly right to the middle)
Bugs	Scutellum (slightly right to the middle)
Beetles and weevils	Right elytron (at 1/3 length of wing from its base)
Dragonflies, Damselflies,moths and butterflies	Thorax (central point)
Bees, wasps and true flies	Thorax (slightly right to the middle)

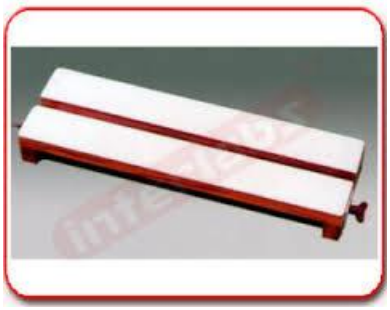
E. Methods of mounting and preservation:

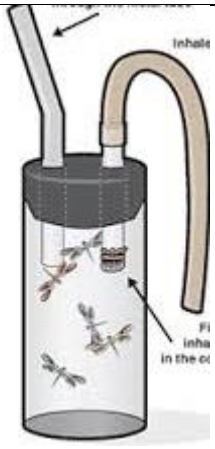
Particular	**Description**
Direct Pinning	Large insects can be directly pinned with insect pins and stored in the insect boxes.
Staging	A stage is made up of narrow rectangular piece of cork. Small insect is pinned with a micropin to the stage.this stage is then pinned in to insect

	box.
Carding	Insect specimen is stuck on a rectangular card (5 x 8 mm) with glue.This card is then pinned in to insect box.
Pointing	Specimens too small to be pinned can be mounted on a triangular card (10x5 mm) with glue and then stored in insect box.
Liquid preservation	Immature stages of insect such as eggs, larve and nymphs and soft bodied adult forms are stored in 70-80% ethyl alcohol or 4% formalin in glass vials.
Repellents	Naphthalene balls are placed in insect boxes to keep scavangers and ants away from specimens.

G. LAB WORK FOR STUDENTS

Draw diagrams of each equipment in given box separately:

 Insect setting box	
 Insect collection net	
 Insect setting board	



Aspirator

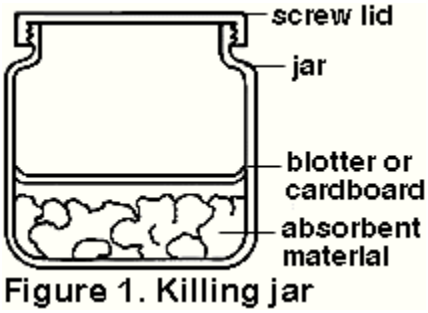
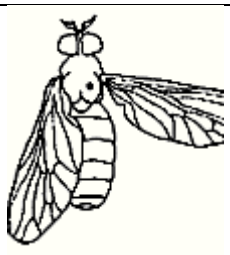


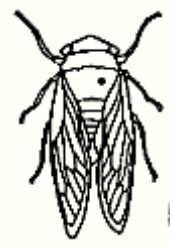
Figure 1. Killing jar

Insect killing jar

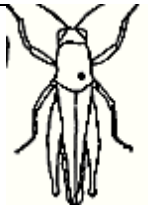
Draw diagrams of each insect with pinning region in given box separately:



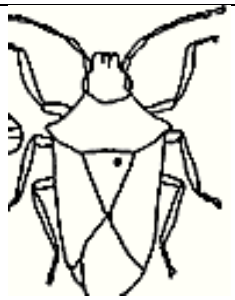
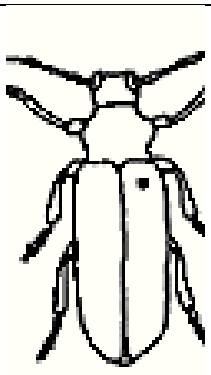
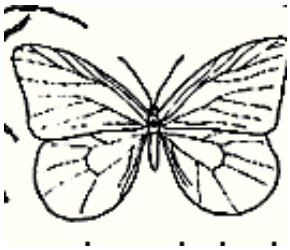
Pinning region of true fly



Pinning region of cicada



Pinning region of grasshopper

 Pinning region of plant bugs	
 Pinning region of beetles	
 Pinning region of butterfly	

Name & roll number of student: **Signature of Course Instructor:**

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LAB EXERCISE NUMBER -02

TITLE: **External Morphology of a Grasshopper**

OBJECTIVE:
To study the external morphology of a grasshopper, including its body segmentation and structural adaptations.

MATERIAL REQUIRED:

- Insect collecting net
- Insect store box
- Setting board
- Aspirator
- Killing bottle
- Entomological pins
- Glass vials containing 70% alcohol
- Forceps
- Camel hair brush
- Hand lens
- Insect labels

INTRODUCTION:
Grasshoppers belong to the order *Orthoptera* and are known for their jumping ability. They are commonly found in grasslands, lowland tropical forests, and semiarid regions. Their body coloration varies from green to olive or brown with yellow or red markings. Grasshoppers are widely used in entomological studies due to their generalized insect body structure, which consists of three distinct regions: head, thorax, and abdomen. The grouping of body segments into these regions is termed tagmosis, and these regions are called tagmata.

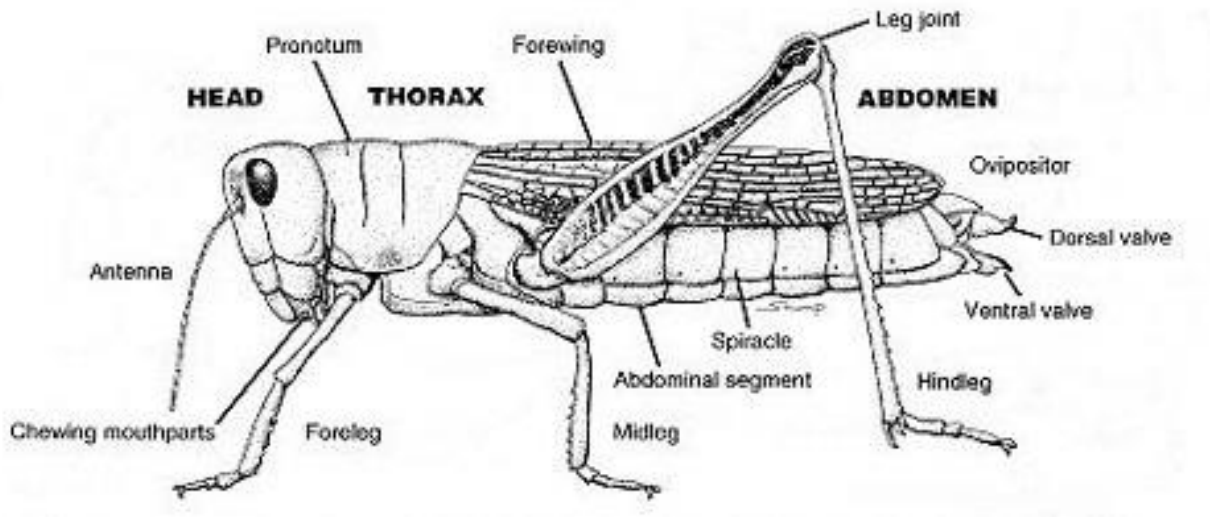
EXTERNAL MORPHOLOGY

1. Head

- The head is a hard capsule housing large muscles that control the mouthparts.
- It has a pair of threadlike (*filiform*) antennae.
- The compound eyes are large, and three simple eyes (*ocelli*) are present.
- The head capsule is divided into several regions:
    - **Vertex**: The top of the head between the compound eyes.
    - **Frons**: The front region extending to the clypeus.
    - **Gena (Cheek)**: The lateral side of the head.

2. Thorax

- The thorax consists of three segments:
    1. **Prothorax**: Bears the first pair of legs.
    2. **Mesothorax**: Bears the second pair of legs and forewings (*tegmina*).
    3. **Metathorax**: Bears the third pair of legs and hindwings.
- The **pronotum**, a saddle-shaped structure behind the head, is used in species identification.
- The **notum** (top), **sternum** (bottom), and **pleura** (sides) make up the thoracic exoskeleton.



3. Legs

- The three pairs of legs have the same basic structure, but the hind legs are enlarged for jumping.
- The femur and tibia of the hind legs are well-developed, with rows of spines and stridulatory pegs for sound production.

4. Wings

- The forewings (*tegmina*) are leathery and narrow, providing protection.
- The hindwings are membranous and fan-shaped, aiding in flight.

5. Abdomen

- Composed of 11 segments, the first segment contains the tympanum (hearing organ).
- The remaining segments are flexible, allowing for respiration, copulation, and egg-laying.

6. Genitalia

- Males possess cerci, furcula, epiproct, and a subgenital plate, which vary in shape among species.
- Females have an ovipositor with dorsal and ventral valves for laying eggs.

PROCEDURE:

1. Collect a grasshopper specimen using the insect collecting net.
2. Preserve the specimen in a glass vial containing 70% alcohol.

3. Observe the external features under a hand lens or dissecting microscope.
4. Identify and label the body parts.
5. Note the structural adaptations related to their function.
6. Draw a well-labeled diagram of the grasshopper in the lab notebook.

OBSERVATIONS:

- Record the body segmentation and structural modifications.
- Note the color, size, and special features such as spines, carinae, and sulci.

CONCLUSION:

Grasshoppers exhibit a well-developed external morphology with distinct head, thorax, and abdomen regions. Their specialized legs and wings contribute to locomotion and survival in various habitats. Understanding their morphology is fundamental apect in entomology.

INSTRUCTIONS FOR STUDENTS:

- Draw a well-labeled diagram of the grasshopper in space provided below.
- Identify and label all external features clearly.
- Submit your lab report with observations and conclusions.

Lab Work for students: Draw well labeled diagram of grasshopper in the box given below:-

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LAB EXERCISE NUMBER -03

TITTLE: Structure and Modifications of Insect Antennae

MATERIAL REQUIRED: Collected insects, dissecting trey, dissecting microscope, Insect pins, Forceps, Camel hair brush, cotton.

Methodology:

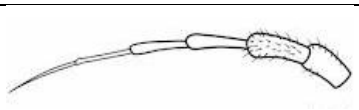
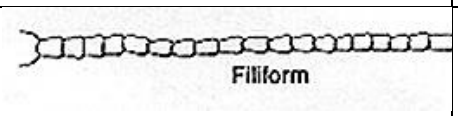
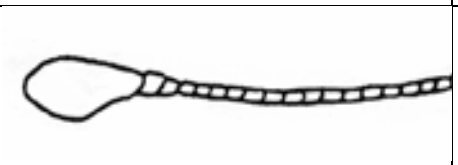
1.Bring adult insects of different orders to the laboratory immediately after collection and killing.
2. Pull out antenna with the help of forcep by holding the head in fingers.
3. Put the antenna on slide and mount if size is appropriate for this procedure.
4. Observe each antenna under the streo-zoom microscope to study structure of flagellum.
5. Study the characteristics of each antenna and sketch it on lab note book.
6. Take the help of information provided in lab manual in identification of different modifications of antennae.

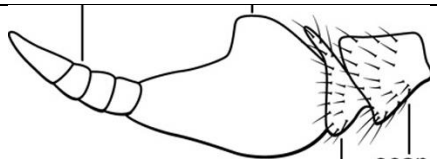
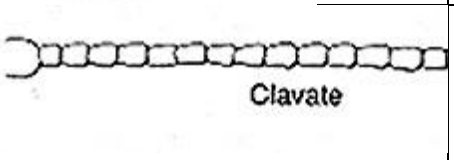
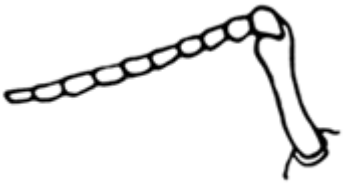
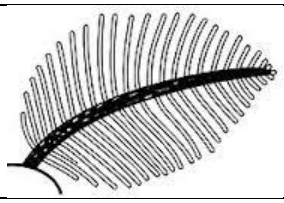
Insect antennae are paired, segmented sensory appendages located on the head, usually between the compound eyes. They play a crucial role in perceiving various environmental stimuli such as smell, touch, humidity, temperature, and sound vibrations. Each antenna is inserted into a depression or socket on the cranium known as the antennal socket, which allows for flexible movement. The base of the antenna is connected to the antennal socket by an articulatory membrane, providing mobility and facilitating free movement in multiple directions.

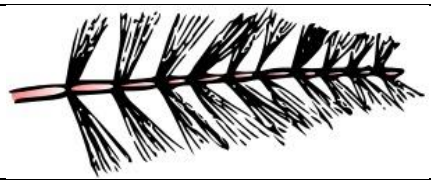
Structurally, an insect antenna consists of three main parts — the scape, pedicel, and flagellum:

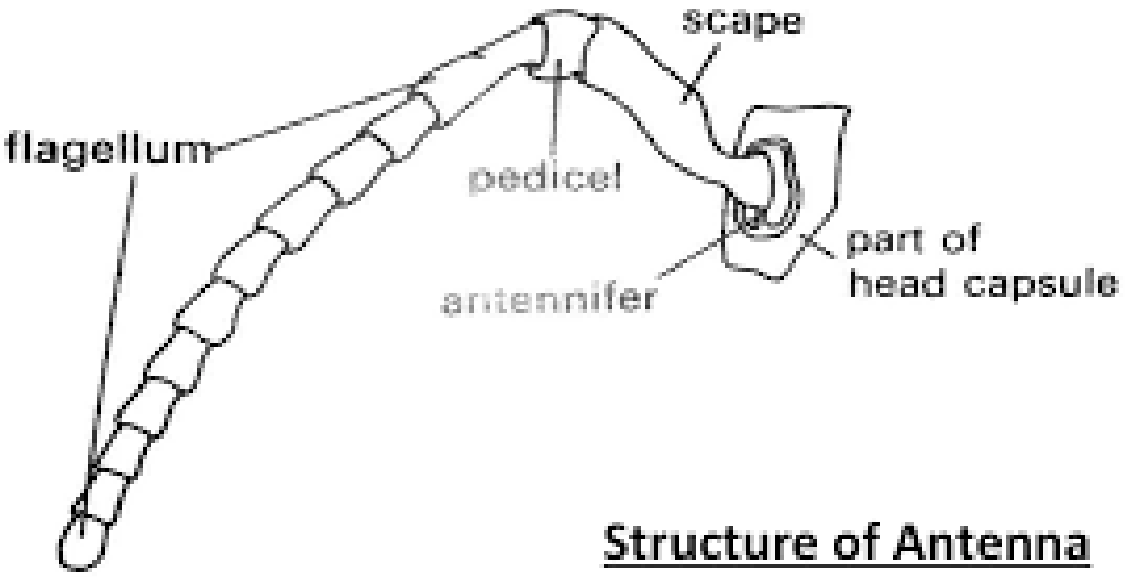
1. **Scape:**
   The scape is the basal and generally the largest segment of the antenna. It articulates with the head capsule at a small point called the antennifer, allowing movement in different directions. The scape functions as the main supportive base that connects the antenna to the head and assists in overall mobility.
2. **Pedicel:**
   The pedicel is the second segment of the antenna, located between the scape and the flagellum. It houses a specialized sensory structure known as Johnston's organ, which is a type of chordotonal organ. This organ is sensitive to movement and vibration and helps the insect detect sound waves, flight speed, and position of the antenna.
3. **Flagellum:**
   The flagellum forms the terminal and usually the longest part of the antenna. It is composed of numerous small segments known as annuli (singular: annulus), the number of which varies among insect groups. Unlike the scape and pedicel, the flagellum lacks intrinsic muscles; its movement is controlled by the basal segments. The terminal annulus of the flagellum is referred to as the meriston. The flagellum bears a variety of sensilla (sensory organs) responsible for detecting chemical and mechanical stimuli.

Table 1. : Different modifications of insect antennae

MODIFICATION	EXAMPLE	DIAGRAM	Description
Setaceous	**Cockroach**		
Filiform	**Grasshopper**		
Moniliform	**Termite**		
Capitate	**Khapra Beetle**		
Lamellate	**Ber beetle**		

Stylate	**Snip fly**		
Flabellate	**Cedar beetle**		
Clavate	**Cabbage butterfly**		
Geniculate	**Honey bee**		
Serrate	**Dhora beetle**		
Unipectinate	**Sawfly**		
Bipectinate	**Silkworm moth**		
Plumose	**Male mosquito**		

			
Pilose	**Female mosquito**		
Aristate	**House fly**		



Structure of Antenna

Lab Work for students: Draw well labeled diagrams of insect antennae you have observed during lab work in the box given below:-

Name & roll number of student:

Signature of course Instructor:

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LAB EXERCISE NUMBER -04

Title: Preparation of Permanent Mounts of Different Types of Insect Heads

Learning objectives

By the end of this exercise students will be able to:

1. Identify and describe the three principal head orientations in insects: **hypognathous** (mouthparts directed downwards), **prognathous** (mouthparts directed forwards), and **opisthognathous** (mouthparts directed backwards).
2. Dissect insect heads safely and obtain the desired view (dorsal/ventral/lateral) for mounting.
3. Clear, stain (when required), dehydrate and mount small insect heads or dissected mouthparts to produce permanent mounts suitable for microscopy.
4. Properly label, document and critically evaluate the mounted slides for morphological study.

Head orientations & example taxa

- **Hypognathous**: mouthparts directed downwards — e.g., many Lepidoptera (adult butterflies/moths), Hemipteran nymphs when feeding orientation appears downward.

- **Prognathous**: mouthparts projecting forward — e.g., many Coleoptera (ground beetles), Orthoptera (grasshoppers) for dissected mandibles and maxillae.

- **Opisthognathous**: mouthparts directed posteriorly — e.g., many Hemiptera (true bugs) including pentatomids and aphids in some descriptions.

Materials and reagents

Specimens (choose small/medium specimens appropriate for slide mounts):

- Aphid or small hemipteran (ideal for whole-head slide mounts)
- Adult butterfly/pupa head sections (for hypognathous preparations or seta/scale study)
- Grasshopper or small beetle (for dissecting mouthparts — prognathous example)

Reagents & consumables

- 70%, 80%, 90%, 95%, and 100% ethanol (for fixation and dehydration)
- 10% KOH (or commercial clearing solution) for maceration/clearing
- Acetic acid (glacial, dilute) or acidified ethanol (optional, for neutralizing KOH)
- Chlorazol Black E or acid fuchsin (optional stains for chitin and sclerites)
- Distilled water

- Clove oil or xylene (clearing agent) — NOTE: xylene is toxic; use in fume hood
- Mounting medium: Canada balsam (traditional) or DPX/Mountant (synthetic)
- Glass microscope slides, cover slips (No. 1.5 preferred), labeling tape
- Fine forceps (#5), micro-scissors, minuten pins or insect needles, minuten pin-holder
- Small Petri dishes, watch glasses
- Dissecting microscope (stereo microscope) and compound microscope
- Fine camel-hair brushes or micropipettes
- Pippettes, microcentrifuge tubes if needed

Personal protective equipment (PPE)

- Lab coat, nitrile gloves, safety goggles
- Fume hood for KOH, xylene, and staining steps

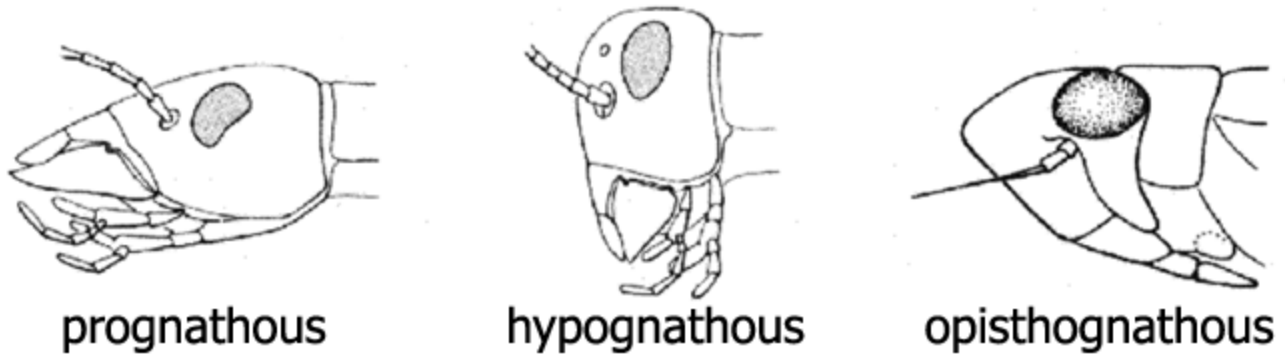

Fig : Different types of insect head

Protocols — three standard preparations

Tip: Work under a stereomicroscope for all dissection steps. Be patient and do gentle manipulations — damage to sclerites makes interpretation difficult.

A — Whole-head slide mount (small insects; e.g., aphids, tiny hemipterans)

1. **Fixation (if using fresh specimens):** Place specimen in 70% ethanol for 30 min to 1 hour. If specimens have been preserved in ethanol already, start from that vial.
2. **Clearing:** Transfer specimen to 10% KOH and leave at room temperature for 10–30 minutes (small specimens) or warm gently (not boiling) in a water bath for a few minutes until tissues appear translucent. Monitor under stereomicroscope.
3. **Neutralize:** Rinse in distilled water. If KOH smell or residue remains, briefly dip in 1% acetic acid or dilute ethanol with a drop of acetic acid to neutralize.
4. **Dehydrate:** Pass through graded ethanol series: 70% → 80% → 90% → 95% → 100%; 5–10 minutes each. Use gentle agitation.
5. **Clearing for mounting:** Move specimen into clove oil or xylene until fully cleared (becoming glassy and transparent). This may take 10–30 minutes depending on agent.
6. **Mounting:** Place a small droplet of Canada balsam or DPX on a clean slide. Using fine forceps or minuten, position the cleared head in the mounting medium in the desired orientation (dorsal, ventral, lateral). Carefully lower a coverslip to avoid air bubbles.
7. **Curing:** If using Canada balsam, allow to dry in dust-free area (several days). DPX sets faster (overnight). Label slide with specimen, date, student name, and orientation.

Notes: For larger small insects, consider removing thorax/abdomen to ensure the head sits flat under cover slip.

B — Dissected mouthparts & spread mount (prognathous head — grasshopper mandibles/maxillae)

1. **Preparation:** Place specimen in 70% ethanol. Remove the head from the thorax using micro-scissors.
2. **Dissection:** Under stereomicroscope, using two fine forceps or minuten, hold the head and tease off the labrum, labium, and other non-target tissues carefully. Isolate mandibles and maxillae as units, or leave intact if you want whole head view. Use minutens to manipulate.
3. **Maceration (optional):** If muscles/tissues obscure sclerites, place dissected parts in 10% KOH briefly until soft tissues clear.
4. **Staining (optional):** Rinse in water and stain in Chlorazol Black E (or other stain) for 30 seconds to 2 min to enhance sclerites; then rinse quickly in ethanol to remove excess stain.
5. **Dehydrate & clear:** As in Protocol A, pass through ethanol series and clear in xylene or clove oil.
6. **Mounting:** Place specimen parts flat and slightly separated in a droplet of mounting medium so that each sclerite is visible. If parts tend to curl, use small strips of paraffin or minute pins embedded in a thin layer of mounting medium to hold them in place until the medium sets.
7. **Curing & labeling.**

- **Lab work:** *Draw well labelled diagrams* of each type of insect head

Name & roll number of student: **Signature of course Instructor:**

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LAB EXERCISE NUMBER -05

TITTLE: Study of Biting and Chewing Mouthparts in Insects

MATERIALS: Adult grasshopper or cockroach, dissecting trey, dissecting microscope, Insect pins, Forceps, Camel hair brush, cotton.

Methodology:

1.Bring adult grasshopper or cockroach to the laboratory immediately after collection and killing.

2. Hold the head capsule between thumb and index finger and gently press it. All the components of mouthparts will be seen distinctly. Remove labrum, right & left mandibles, right & left maxillae, hypopharynx and labium.

3. Put these mouth parts on slide and mount.

4. Observe slide under the streo-zoom microscope to study structure of mouth parts.

5. Study the characteristics of mouth parts and sketch it on lab note book.

6. Take the help of information provided in lab manual for identification of different components of Biting and chewing mouth parts.

Description of biting and chewing mouth parts:

Labrum: It is a flap like bilobed structure attached to the clypeus by an articular membrane. It helps to guide the food into the mouth and also holds the food in position so that mandibles can act on it. Epipharynx is identified as a swollen area of the ventral surface of the labrum, which is an organ of taste.

ii. Mandibles: They are also called as primary or true jaws and concerned with chewing and grinding the food. They are hinged to the cranium by anterior and posterior articulations. They have transverse movement produced by abductor (outer) and adductor (inner) muscles. They are heavily sclerotized and are toothed on their inner border. Distal teeth are sharply pointed and area called incisors or cutting teeth. The proximal teeth are called molar or grinding teeth.

iii. Maxillae: They are called as secondary jaws or accessory jaws. The basal segment, known as the cardo, joins the maxilla to the head. This is joined to the central part of maxilla, the stipes. On the outer side of the stipes is a sclerite known as the palpifer to which the palpus is attached. Antennae like five segmented Palpi, bears tactile hairs and also probably organs of smell or taste. On the distal end of the stipes there are two lobes. The outer lobe is called galea and the inner lobe lacinia which is toothed. May be employed for grasping the food. Whenever these two distinct lobes are fused together to form a single lobe (e.g. Coleopterous larvae) it is termed as Mala.

Iv.Labium: It closes the mouth cavity from below or behind. It consists of three median sclerites viz. submentum (large basal sclerite), mentum (middle sclerite) and prementum (apical sclerite). On the lateral side of the prementum, there are two small lateral sclerites called palpiger bearing segmented labial Palpi. Distally prementum bears two pairs of lobes. The outer pair is called paraglossae and

inner pair glossae. Both pairs when fused together to form a median lobe (e.g. Grasshopper), it is termed as Ligula.

V. Hypopharynx : The hypopharynx, a tongue-like structure present in mouth cavity of insects.

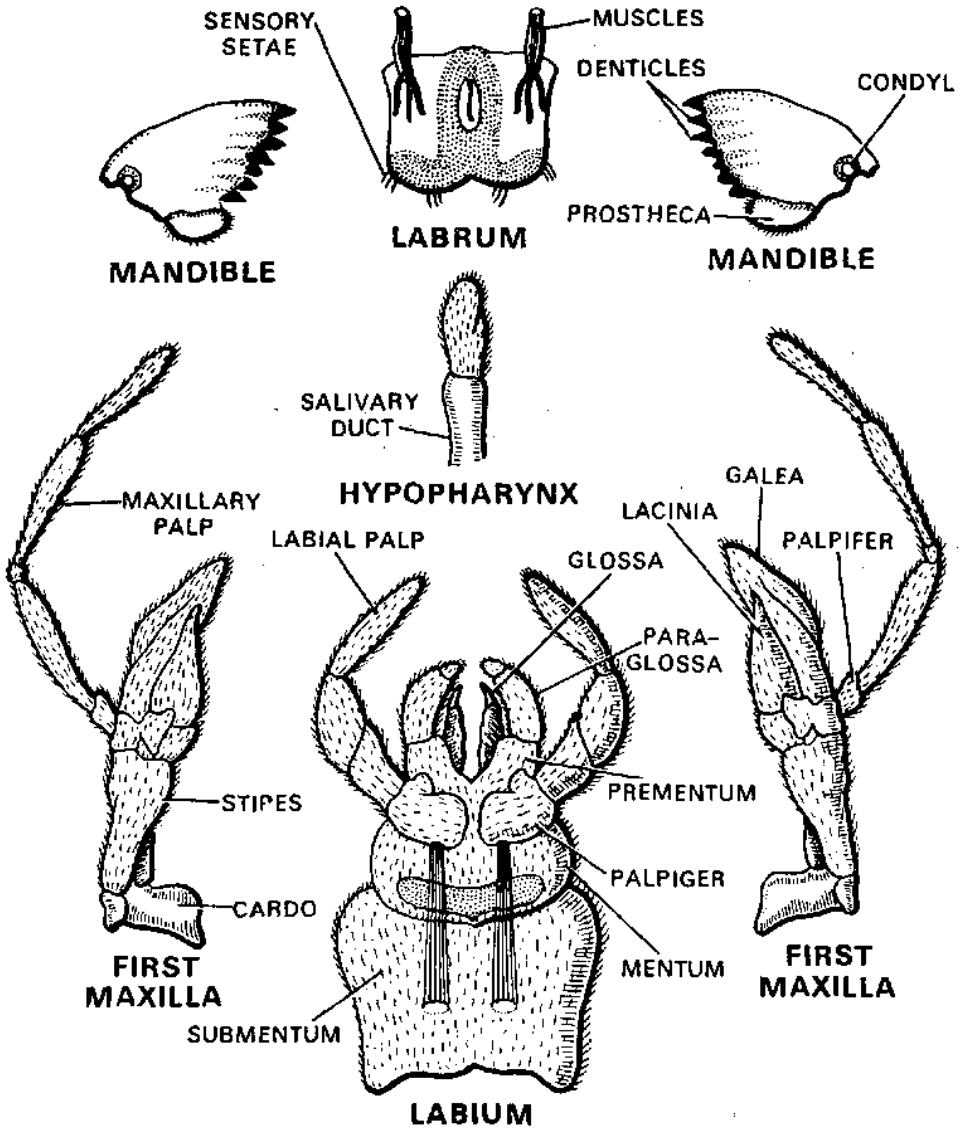
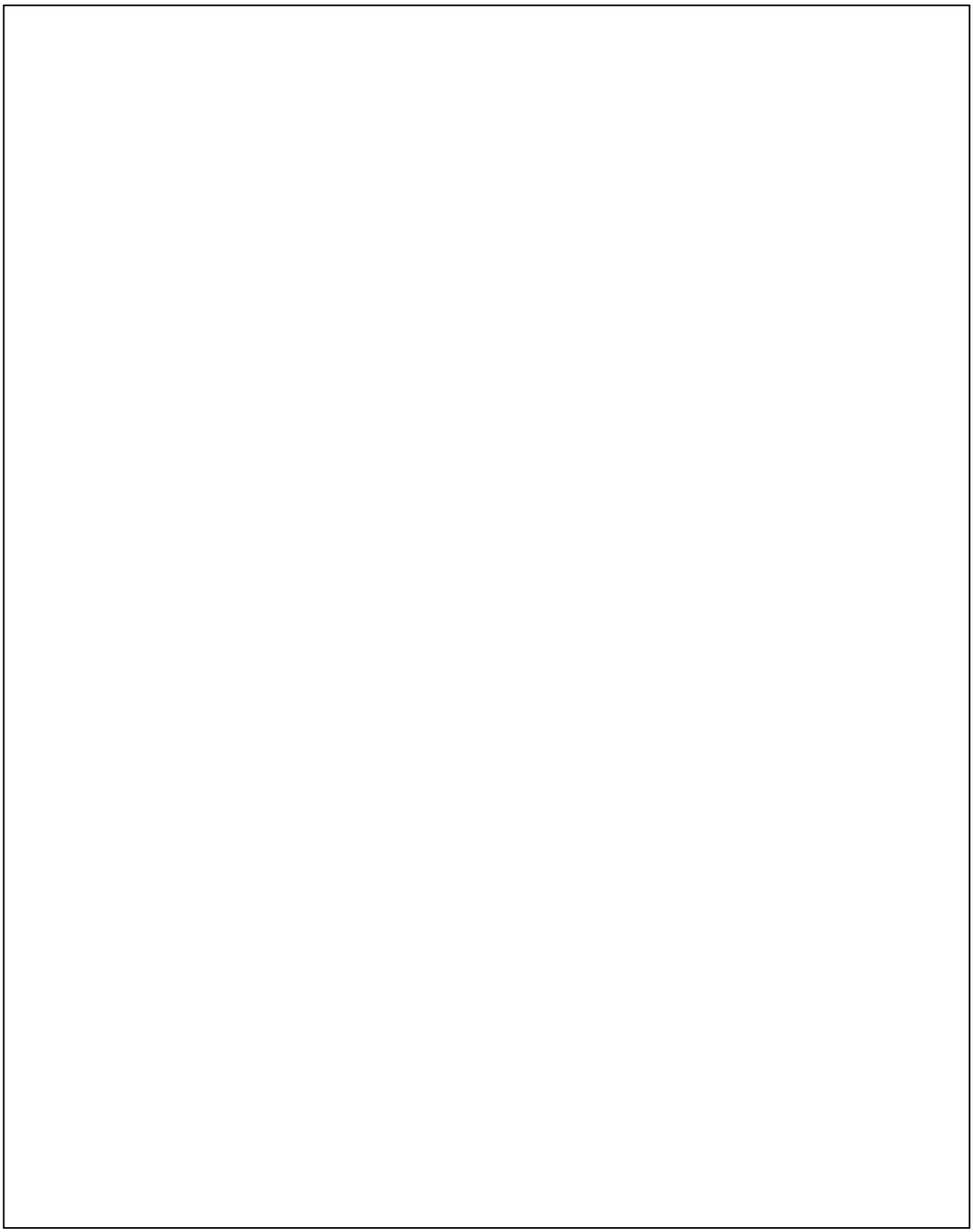


Fig: Biting and chewing Mouth Parts

Lab Work for Students : Draw well labelled diagram of biting and chewing mouth parts in the box given below



Name & roll number of student: **Signature of course Instructor:**

SHRI GURU RAM RAI UNIVERSITY

Department of Entomology

School of Agricultural Sciences

B.Sc.(Hons.)Agriculture Semester-II

Subject: Fundamentals of Entomology (BSAC-207)

LAB EXERCISE NUMBER -06

TITTLE : Structure and Modifications of Insect Legs

MATERIALS: Different insects collected from field, Scissor, dissecting trey, dissecting microscope, Forceps, Camel hair brush, cotton.

Methodology: o study a typical insect leg and its modifications, select representative insect specimens such as cockroach, grasshopper, praying mantis, or water beetle. Place the specimen on a dissecting tray and carefully detach one leg using fine forceps or scissors. Observe the leg under a dissecting microscope and identify its main segments — coxa, trochanter, femur, tibia, and tarsus with terminal claws or pads. Note the articulation between segments, presence of spines, hairs, or sensory structures, and make a labelled sketch showing all parts. Compare legs from different insects to study adaptive modifications such as cursorial (running), saltatorial (jumping), natatorial (swimming), raptorial (grasping), and fossorial (digging) types, noting their structural specializations like enlarged femur for jumping or flattened tibia for swimming. Record observations, measurements, and relate each modification to its functional significance in locomotion or adaptation to habitat.

Description of insect leg:

Insect legs have six parts viz.coxa, trochanter, femur, tibia, tarsus, pretarsus. The tarsus is subdivided and there is typically a 2- clawed pretarsus. A two segmented trochanter (only one is musculated) occurs in the Odonata and in some Hymenoptera, but the second trochanter actually appears to be a part of the femur.

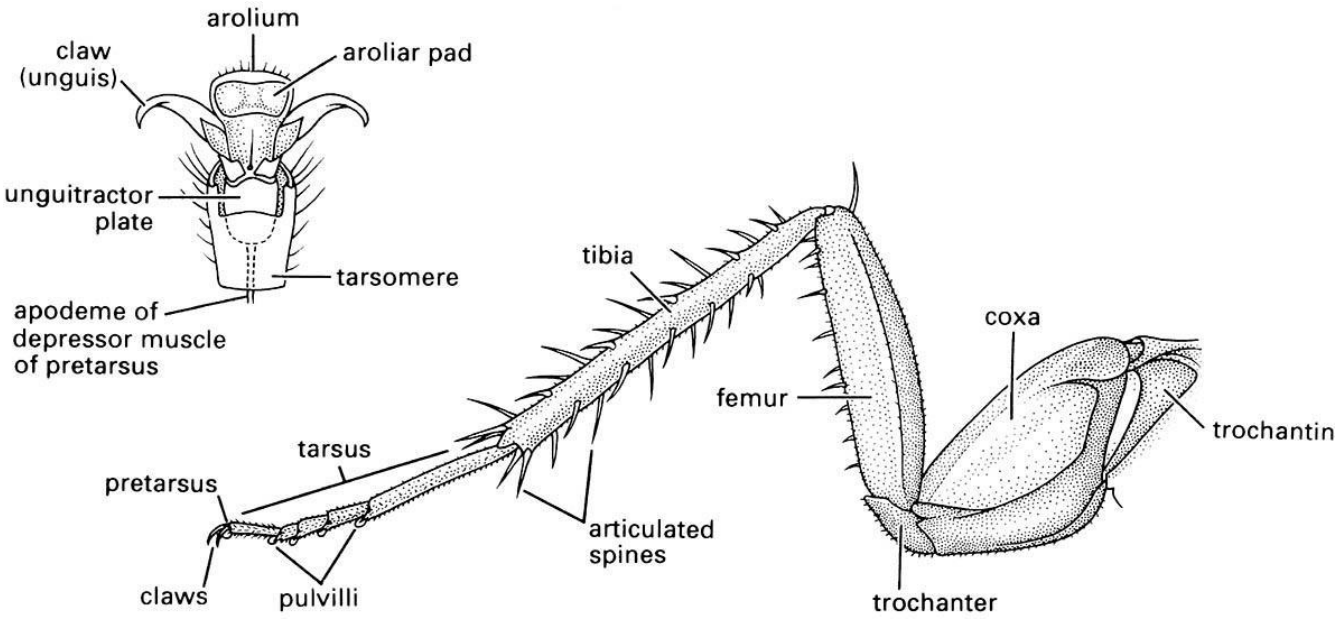


Fig 1 : Structure of typical insect leg

Coxa - The first segment of the insect leg is the coxa. It may be variously shaped, but is often in the form of a cone that articulates with the body wall proximally, and with the trochanter distally. The articulation with the body wall may be single or double. The coxa may have two articulations with the body wall, a pleural articulation and a sternal articulation .

Trochanter - This is usually a small segment, it has a dicondylic articulation with the coxa which limits movement to the vertical plane.

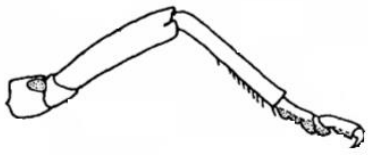
Femur - Often small in larval insects, but usually the largest and strongest leg part in adult insects. It is usually more or less fused with the trochanter, sometimes there is a little flexion between the two segments.

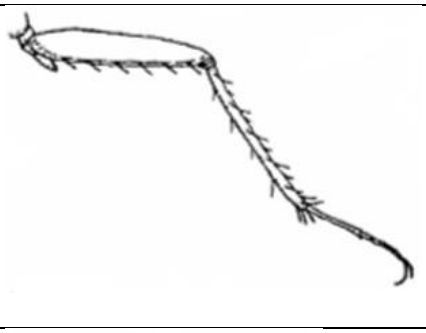
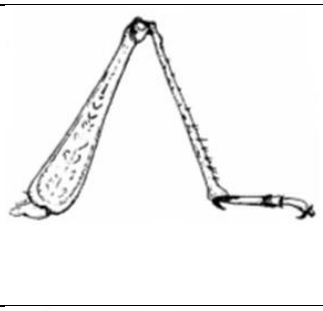
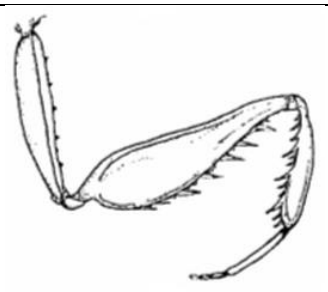
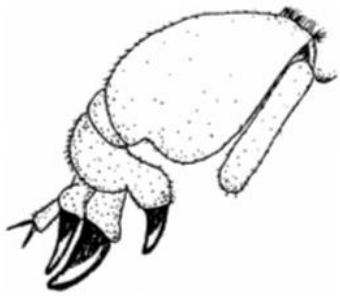
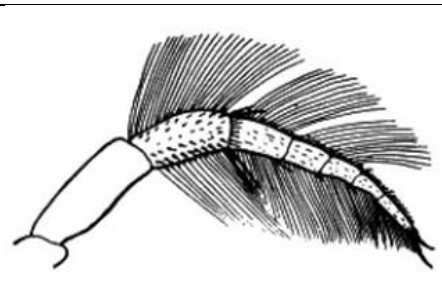
Tibia - Often a long narrow segment, with a dicondylic articulation with the femur - moves in a vertical plane. The proximal end of the tibia is often bent so that when the tibia is folded inward, it can lie up against the femur.

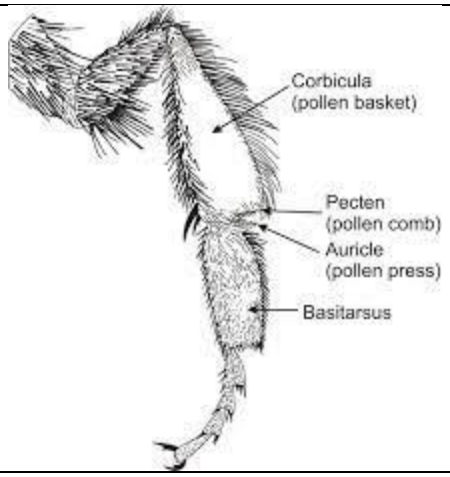
Tarsus - The tarsus, in most insects, is subdivided into from two to five tarsomeres, but never exceeds five. These tarsomeres are not true segments as they lack individual musculature as seen in the other segments. The basal segment, the basitarsus, has a monocondylic articulation with the tibia; the rest of the joints lack true articulatory structures, they are freely moveable in the membranous joints.

Pretarsus - The pretarsus of most insects consists of a membranous base supporting a median lobe, the *arolium*, and a pair of tarsal claws. There is a ventral plate, called the *unguitractor*, and between this plate and the claws are small plates called *auxilliae*. There is no arolium in most Diptera, but rather a membranous pulvillus arises from the base of each auxillia, while a median empodium arises from the unguitractor (may be spine-like or lobe-like). In most insects, the tarsal claws are rather uniform in size and shape, but in others one claw may be more highly developed than the other, and in some groups there is a single claw

Modification of insect legs

MODIFICATION	EXAMPLE	DIAGRAM	Description
Ambulatory legs	Bugs		

Cursorial legs	Tiger beetles		
Saltatorial legs	Grasshoppers		
Raptorial legs	Mantids		
Fossorial legs	mole crickets		
Natatorial legs	Aquatic beetes		

Pollen legs	Honey bee workers		

Lab Work for students : Draw well labeled diagram of insect leg you have studied during your lab work.

SHRI GURU RAM RAI UNIVERSITY

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LAB EXERCISE NUMBER -07

TITTLE : Structure and Modifications of Insect Wings

MATERIALS: Different insects collected from field, Scissor, dissecting trey, dissecting microscope, Forceps, Camel hair brush, cotton.

Methodology: Select different insect specimens representing various wing types (e.g., membranous, scaled, elytra, hemelytra, tegmina). Using forceps and scissors, carefully detach the wings at the base without damaging the thorax. Mount the wings on a glass slide using a drop of glycerin for better visualization under the microscope. Observe the overall shape, size, and texture of the wings.Examine venation patterns under a dissecting microscope. Identify primary veins such as costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), and anal veins (A). Classify the wings based on modifications.

Description of insect wing:

Apart from the vertebrates, insects are the only other group of animals to have successfully evolved flight. The wings are composed of two membranes of the cuticle pressed together and supported by a series of veins. The pattern of veins, the venation, is not haphazard but very regular, though it does show modifications. These are very useful in identification. The wings are more or less triangular in form and certain regions may be recognized.

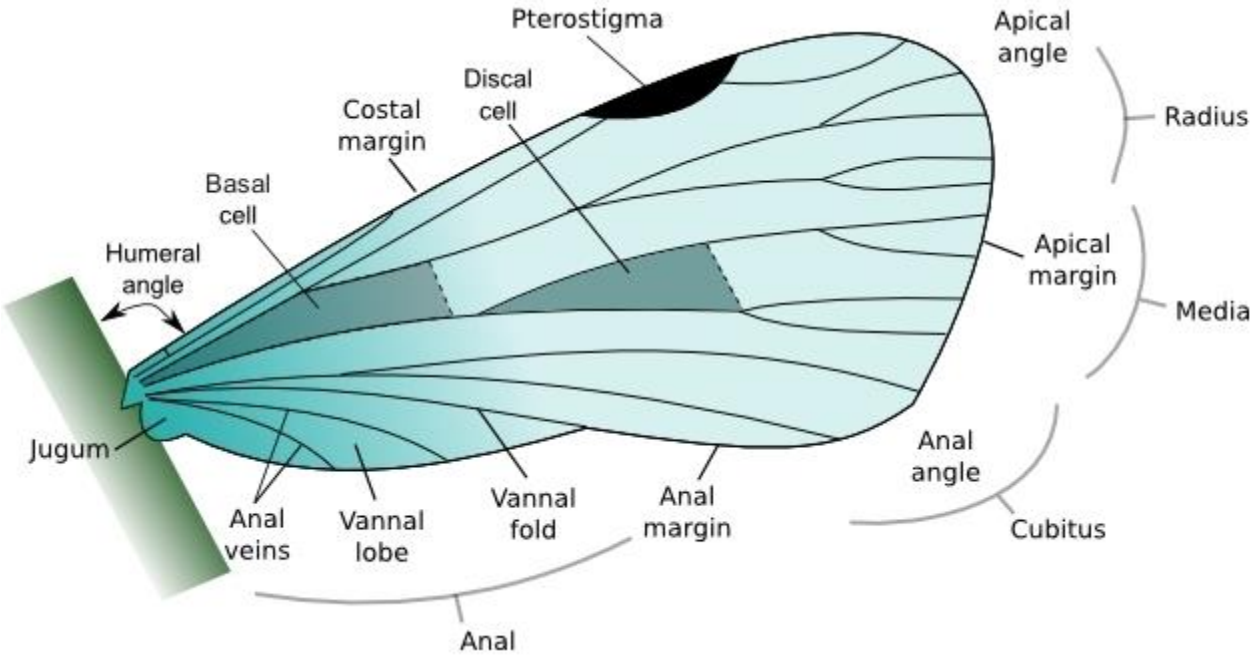
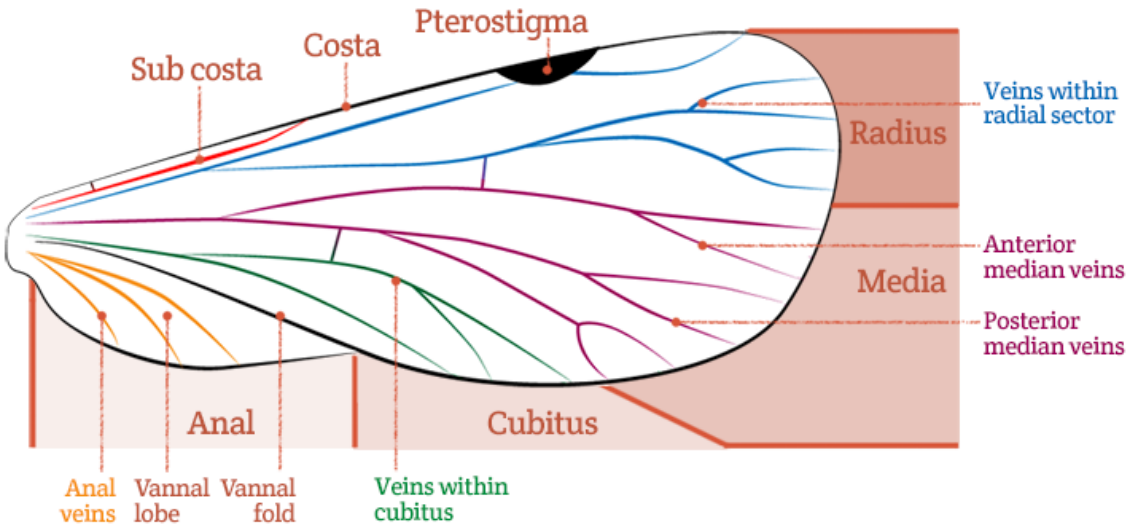


Figure: Main regions of the insect wing.

Wing Venation

These veins (and their branches) are named according to a system devised by John Comstock and George Needham — the Comstock-Needham System.



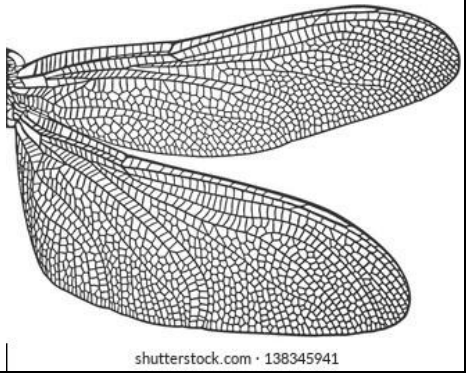
Longitudinal veins (anterior to posterior):

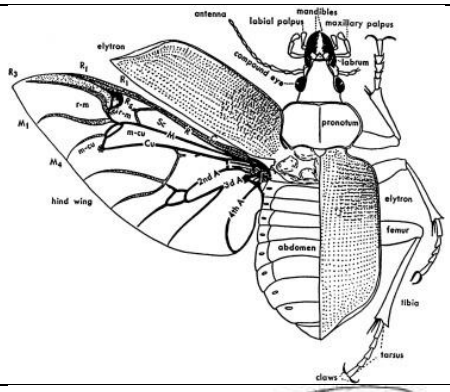
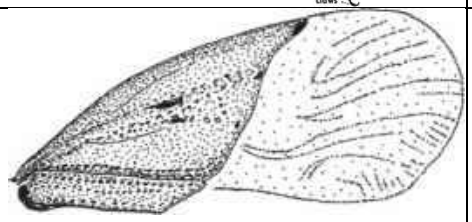
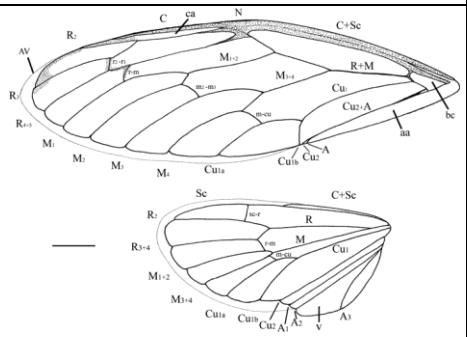
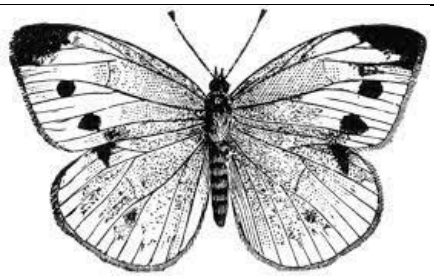
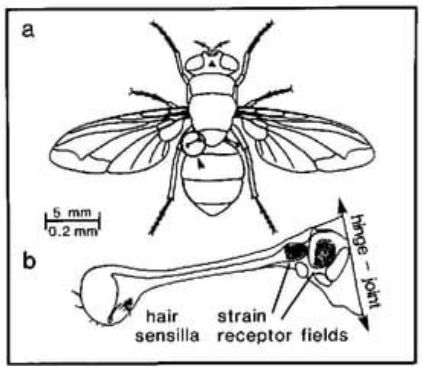
- Costa (C)
- Subcosta (Sc)
- Radius (R)
- Media (M)
- Cubitus (Cu)
- Anal veins (A)

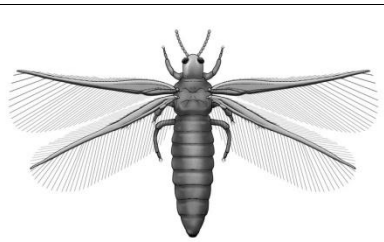
Cross veins: Names of cross veins are based on their position relative to longitudinal veins:

- Humeral (h)
- Radial (r)
- Sectorial (s)
- Radio-medial (r-m)
- Medial (m)
- Medio-cubital (m-c)
- Cubito-anal (cu-a)

Different Modifications of insect Wing

MODIFICATION	EXAMPLE	DIAGRAM	Description
Membranous	**Dragons Fly Honeybee and Termites:**		Wings are thin and transparent. They are supported by a system of tubular veins. They are useful in flight.

Elytra	**Forewings of Beetles and Weevils**		Wing is heavily sclerotized and thick. Wing venation is lost. Wing is tough and protective in function. It protects the hindwings and the abdomen. It is not used for flight. In flight they are kept at an angle to allow free movement of the hindwings.
Hemelytra	**Red Cotton Bug**		The basal half of the wing is thick and leathery. The distal half is membranous. They are protective in function and not involved in flight.
Tegmina	**Forewings of Grasshopper and Cockroach**		Wings are leathery or parchment-like. They are protective in function. They are not useful for flight.
Scaly	**Moths and Butterflies**		Wings are covered with scales which are unicellular, flattened outgrowths of the body wall. Scales are responsible for colour. They are important in smoothening the airflow over wings and body. They also insulate the insect against cold.
Haltere	**Hind Wings of Housefly**		Wings are modified into small knobbed vibrating organ called halters, which act as balancing organs and provided the needed stability during flight.

Fringed	**Thrips**		Wing lamina is usually reduced in size. Wing margins fringed with long setae. These insects literally swim through the air.

Lab work : Draw well labelled diagrams of insect Wings you have studied in the space provided below

Name & roll number of student: **Signature of course Instructor:**

SHRI GURU RAM RAI UNIVERSITY

Department of Entomology
School of Agricultural Sciences
B.Sc.(Hons.)Agriculture Semester-II
Subject: Fundamentals of Entomology (BSAC-207)

LAB EXERCISE NUMBER -08

Title: Anatomy of the Insect Digestive System

Materials Required:

- Cockroaches
- Scissors
- Dissecting tray
- Dissecting microscope
- Forceps
- Camel hair brush
- Cotton

Methodology:

1. Hold the specimen with your left hand and clip the wings.
2. Fix the specimen in a dorsal position on a dissecting tray using pins through the abdominal sterna and coxa of the legs.
3. Cut the lateral membrane (pleura) between the terga and sterna of the thorax and abdomen with fine scissors.
4. Posteriorly, make two incisions meeting at the hindmost end of the abdomen and proceed forward up to the anterior end of the thorax.
5. Give a transverse incision along the anterior border of the first thoracic segment and carefully remove the terga.
6. Expose the thoracic and abdominal cavity and add clear water in the tray.
7. Remove fat bodies and tracheae to expose the internal organs.
8. Carefully uncoil the intestine and stretch the alimentary canal to one side, securing it with a pin in the wax to prevent it from shifting.

Description of Insect Digestive System: The insect digestive system consists of a long, coiled tube called the alimentary canal, running lengthwise through the body. It is divided into three functional regions:

1. **Foregut (Stomodeum)**
    - Includes the mouth, pharynx, esophagus, crop, and proventriculus.
    - The mouth is a muscular valve that allows food to enter the buccal cavity, where cibarial muscles create suction for food intake.
    - The esophagus connects the pharynx to the crop, a storage organ where some digestion occurs.
    - The proventriculus, present in some insects, grinds food particles before they pass through the stomodeal valve into the midgut.

- The foregut is lined with an intima, a protective layer secreted to prevent abrasion by food particles.

2. **Midgut (Mesenteron)**
   - Begins past the stomodeal valve and includes gastric caecae and ventriculus.
   - Gastric caecae provide extra surface area for enzyme secretion and water absorption.
   - The ventriculus is the primary site for enzymatic digestion and nutrient absorption.
   - Lined with a semipermeable peritrophic membrane that protects digestive cells while allowing nutrient absorption.
   - Ends with the pyloric valve, regulating passage of materials into the hindgut.
3. **Hindgut (Proctodeum)**
   - Begins at the pyloric valve and includes Malpighian tubules, ileum, colon, and rectum.
   - Malpighian tubules function as excretory organs, removing nitrogenous waste and forming uric acid.
   - The hindgut regulates water and salt absorption, with rectal pads facilitating water recovery before waste is expelled through the anus.
   - Lined with an intima, which is shed and replaced during molting.

Lab Work for Students:

- Draw a well-labelled diagram of insect alimentary canal in your lab exercise book.

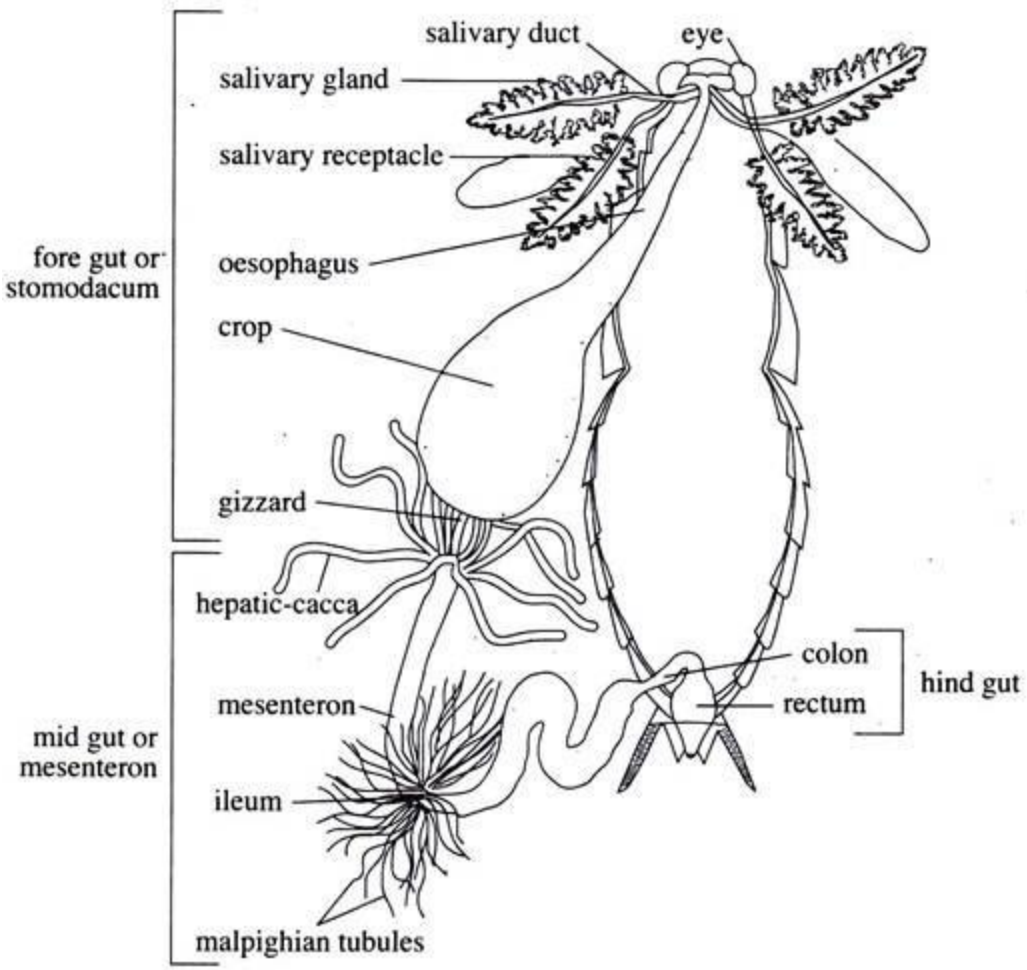
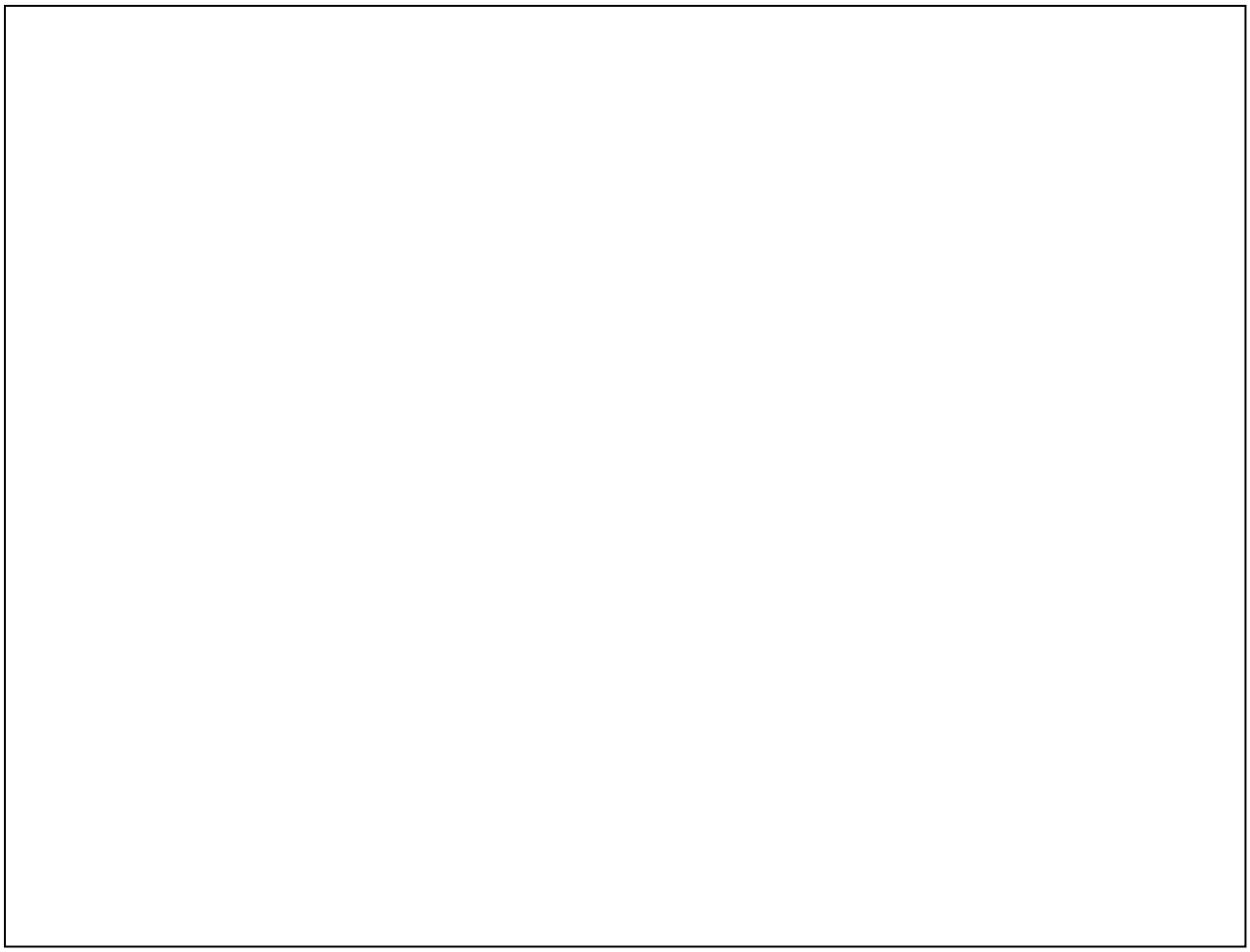


Fig. 2.41 : Alimentary system of *Periplaneta americana*.

Lab work : Draw well labelled diagrams of alimentary canal of insect you have studied in the space provided below



Name & roll number of student:

Signature of course Instructor:

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LAB EXERCISE NUMBER -09

Title: Anatomy of the Respiratory System of an Insect

Objective:

To observe and understand the structure and functioning of the insect respiratory system, including spiracles, tracheae, and air sacs, and to appreciate their role in gaseous exchange.

Materials & Equipment:

- Preserved insect specimens (e.g., grasshopper, cockroach, or housefly)
- Dissecting tray and wax
- Fine forceps, pins, scissors, and dissecting needles
- Stereo/dissecting microscope
- Glass slides and cover slips (optional, for finer observation)
- Glycerin or Hoyer's medium (for clearing tracheae, optional)
- Pencil, lab notebook, drawing sheets
- Labels and markers
- Safety gloves and goggles

Theory/Background:

Insects respire through a network of tubular structures called **t**racheae that directly deliver oxygen to tissues. Air enters through spiracles, openings located laterally on the thorax and abdomen. Tracheae may branch into fine tracheoles and sometimes form air sacs, aiding in ventilation and movement. Unlike vertebrates, insects lack lungs, and respiration occurs via passive diffusion or active pumping in larger, active species.

Procedure:

1. **Specimen Preparation:**
   Place the insect on a dissecting tray, dorsal side up. Pin the specimen gently to keep it stable.
2. **External Observation:**
   Observe and locate the **spiracles** along the thorax and abdomen. Count the number and note their positions.
3. **Dissection:**
   Using fine scissors or a scalpel, make a longitudinal dorsal incision along the thorax and abdomen. Pin the cut edges to expose the internal cavity.
4. **Internal Observation:**
   Identify and trace the **tracheal tubes** running along the body, noting their branching pattern. Observe any **air sacs** if present.

5. **Clearing for Fine Structures (Optional):**
   Remove a leg or thin abdominal segment, clear it in glycerin, and observe under a compound microscope to view fine tracheoles.
6. **Recording Observations:**
   - Make a labelled diagram showing spiracles, tracheae, and air sacs.
   - Record the number, position, and arrangement of spiracles.
   - Note structural adaptations (e.g., presence of valves, air sacs, tracheal thickening).
7. **Comparison:**
   If possible, compare respiratory structures in different insect species to study variations in tracheal system organization.

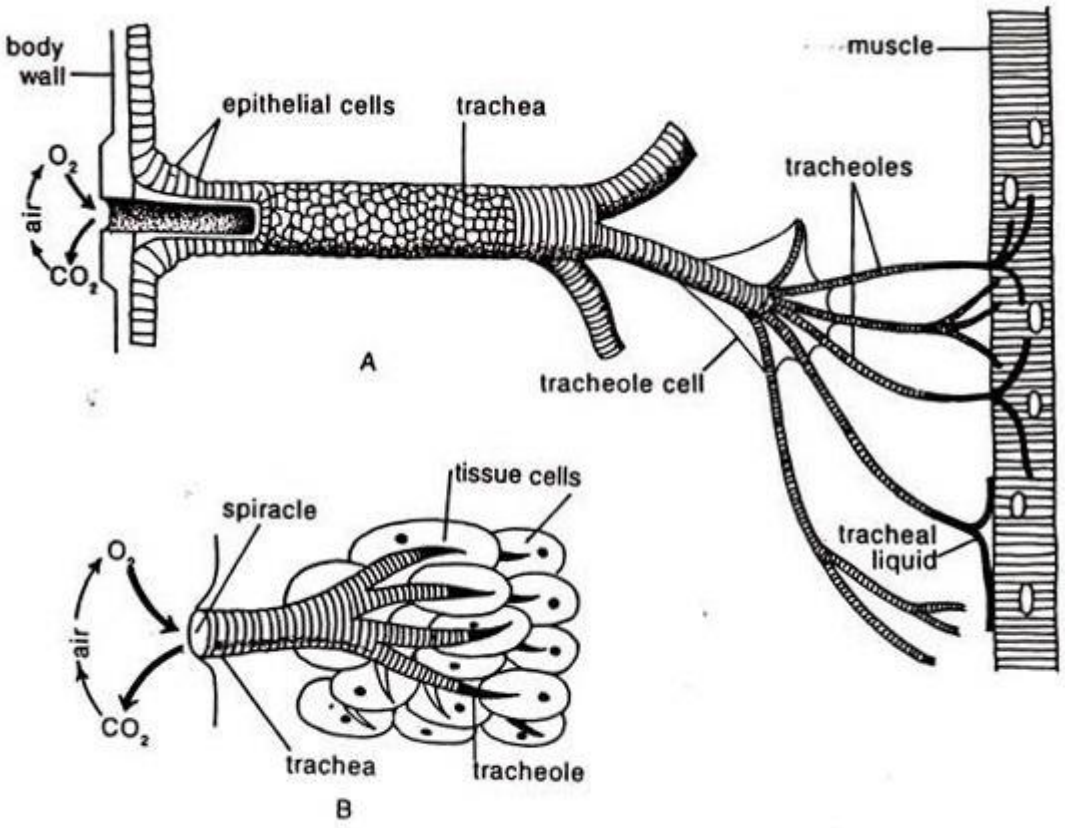

Fig. 9.7. Diffusion of gases in insects : A. The tracheal system, B. Trachea and tracheoles

Precautions:

- Handle sharp instruments carefully.
- Avoid crushing delicate tracheal tubes.
- Label specimens and drawings clearly.
- Preserve dissected specimens properly if needed for further study.

Lab work : Draw well labelled diagrams of Respiratory System of insect you have studied in the space provided below

Name & roll number of student:

Signature of course Instructor:

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School of Agricultural Sciences
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Subject: Fundamentals of Entomology (BSAC-207)

LAB EXERCISE NUMBER -10

Title: Anatomy of the Insect Excretory System

Objective:
To observe and understand the structure, components, and function of the excretory system in insects, including Malpighian tubules and associated structures.

Materials Required:

- Insect specimens (commonly cockroach or grasshopper)
- Dissecting tray and pins
- Forceps, fine scissors, and dissecting needles
- Stereo/dissecting microscope
- Compound microscope (optional for finer structures)
- Glass slides and cover slips
- 70% ethanol or preservative for specimens
- Glycerin or saline (for temporary mounts)
- Labels, chart papers, and pencil for drawings
- Gloves and safety goggles

Specimens Recommended:

- Cockroach (Periplaneta americana)
- Grasshopper (Locusta migratoria)

Procedure:

1. **Specimen preparation:** Place the insect on the dissecting tray dorsal side up and immobilize it with pins. If using preserved specimens, rinse briefly in water to remove preservative.
2. **Dissection:** Using fine scissors, make a longitudinal dorsal incision from the head to the last abdominal segment. Carefully pin the body open to expose internal organs.
3. **Locate the excretory system:** Identify the Malpighian tubules attached at the junction of the midgut and hindgut. These are slender, tubular structures floating in the hemolymph.
4. **Observation:** Note the number, arrangement, and attachment of the Malpighian tubules. Trace the connection of the hindgut (ileum, colon, rectum) and examine any associated fat bodies.
5. **Microscopic study (optional):** Remove a few tubules, place them on a glass slide in saline or glycerin, and observe under a compound microscope to see the tubular structure and cells.
6. **Sketching and labeling:** Draw a neat, labelled diagram showing the excretory system, including Malpighian tubules, ileum, colon, rectum, and their relative positions in the abdomen.
7. **Discussion:** Relate the structure to function, explaining how the Malpighian tubules aid in nitrogenous waste excretion, osmoregulation, and ionic balance in insects.

Precautions:

- Handle scalpels and scissors carefully to avoid injury.
- Do not damage the delicate Malpighian tubules while dissecting.
- Dispose of specimens ethically and as per institutional guidelines.
- Label all drawings and slides clearly.

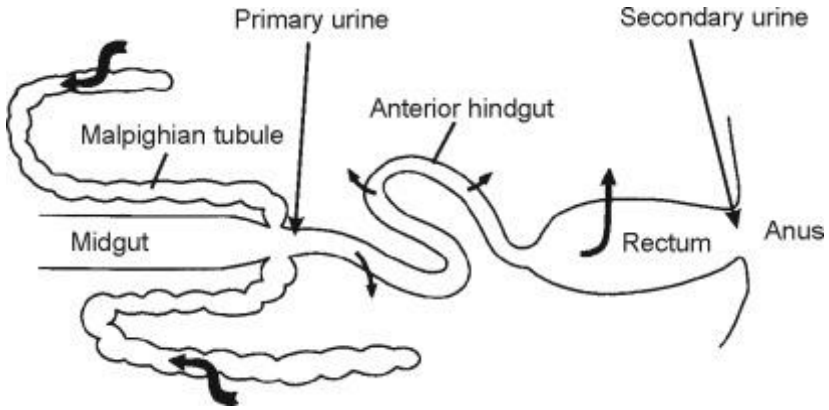

Fig 1 : **Malpighian tubules of an Insect**

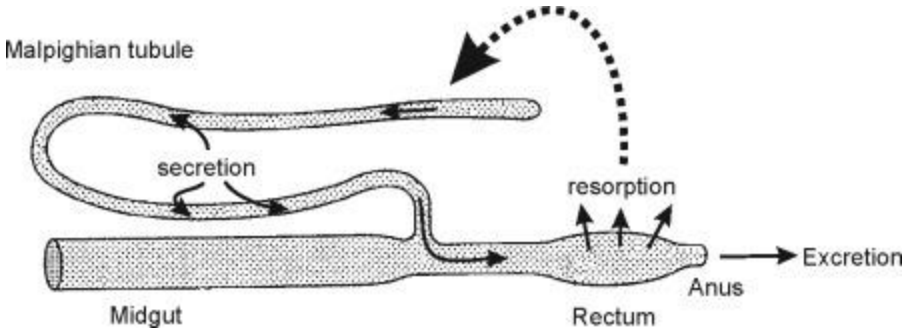

Fig 2 : Functional morphology of Malpighian tubules

Observations:

- Number and arrangement of Malpighian tubules
- Structure and connection to the gut
- Presence of associated fat bodies

Lab work : Draw well labelled diagrams of Excretory System of insect you have studied in the space provided below

Name & roll number of student:

Signature of course Instructor:

SHRI GURU RAM RAI UNIVERSITY

Department of Entomology
School of Agricultural Sciences
B.Sc.(Hons.)Agriculture Semester-II
Subject: Fundamentals of Entomology (BSAC-207)

LAB EXERCISE NUMBER -11

TITLE: Anatomy of the Insect Circulatory System

OBJECTIVE: To study the structure and components of the circulatory system in insects using cockroach as the specimen.

MATERIALS REQUIRED:

- Live or freshly euthanized Cockroach (Periplaneta americana)
- Dissecting tray
- Dissecting microscope
- Fine scissors
- Forceps
- Camel hair brush
- Cotton
- Pins
- Clear water

METHODOLOGY / PROCEDURE:

1. **Positioning the Specimen:**
    - Hold the cockroach gently with your left hand.
    - Clip off the wings using scissors for better visibility.
    - Place the specimen **dorsally** on the dissecting tray (i.e., with its back facing up).
2. **Pinning:**
    - Fix the cockroach in place by inserting **dissecting pins** through the **coxae of the legs** and **abdominal sterna** to prevent movement during dissection.
3. **Initial Incision:**
    - With fine scissors, make a **longitudinal cut** along the **pleural membrane** (between the tergum and sternum) on both sides of the thorax and abdomen.
    - Let the two cuts **meet posteriorly** at the end of the abdomen.
    - Extend the incision **anteriorly** to reach the front of the thorax.
4. **Exposure of Internal Cavity:**
    - Make a **transverse cut** along the anterior border of the first thoracic segment.
    - Carefully **remove the terga (dorsal plates)** to expose the internal organs.
5. **Cleaning:**
    - Pour **clear water** into the tray to keep tissues moist.
    - Use **forceps and camel hair brush** to remove **fat bodies** and **tracheae** to get a clear view of the circulatory organs.

OBSERVATIONS:

Circulatory System Type:

- **Open circulatory system** where **haemolymph** flows freely within the body cavity or **haemocoel**.

Haemocoel Sinuses:

1. **Dorsal (pericardial) sinus** – Surrounds the heart.
2. **Perivisceral sinus** – Contains the digestive organs.
3. **Ventral (perineural) sinus** – Houses the nerve cord.

Dorsal Vessel:

- Lies just below the terga along the dorsal midline.
- Divided into:
    - **Heart (posterior)** – With **ostia** for blood inflow.
    - **Aorta (anterior)** – Simple, unperforated tube for blood outflow.

Heart:

- Located in the **abdomen**, sometimes extends into the thorax.
- **Segmented** with chambers and **ostia**.
- **Ampullae** present near ostia for efficient circulation.
- **Suspended** by elastic filaments or attached to body wall.

Aorta:

- Continues from the heart anteriorly.
- Lacks ostia.
- Ends openly near the head, sometimes with modifications (e.g., diverticula in wings)

RESULT / INFERENCE:

The circulatory system of insects is open, and the dorsal vessel functions as the main pump (heart and aorta). The insect haemocoel is divided into sinuses, and blood is circulated with the help of accessory organs and the dorsal vessel. Unlike vertebrates, insect blood does not carry oxygen.

PRECAUTIONS:

- Use dissecting tools with care to avoid damaging internal organs.
- Keep tissues moist with water.
- Use a dissecting microscope for detailed observation.
- Dispose of specimens as per lab safety protocol.

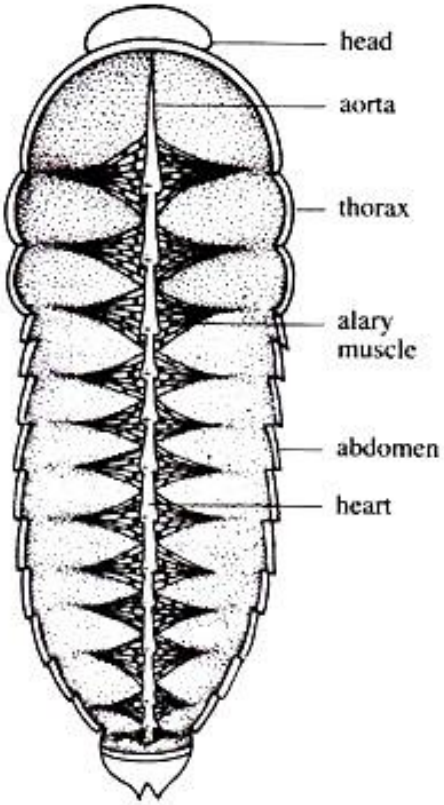

Fig. 2.65 : The structure of heart of *Periplaneta americana*.

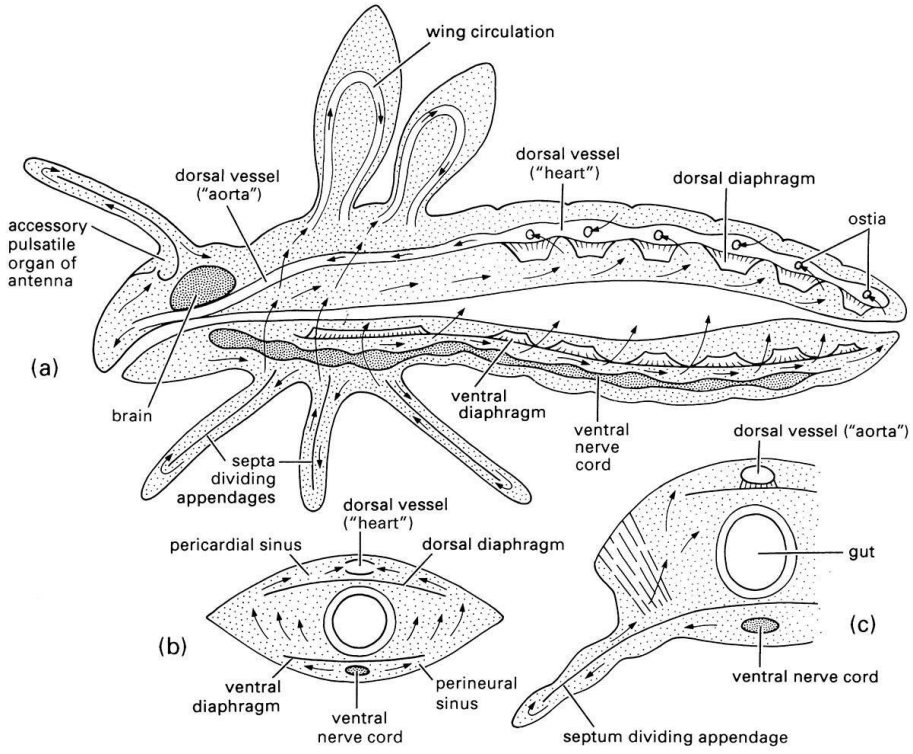

Fig : Circulatory system of an insect

Lab work : Draw well labelled diagrams of Circulatory System of insect you have studied in the space provided below

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LAB EXERCISE NUMBER -12

TITTLE : Anatomy of the Insect Reproductive System

MATERIALS: Cockroaches , Scissor, dissecting trey, dissecting microscope, Forceps, Camel hair brush, cotton.

Methodology: Fix the head of the specimen by pinning through the mandibles. The rest of the body should be fixed to the wax of the dissecting tray in the way already described.

Care should be taken while removing the terga. The paired testes are situated just beneath the 4th and 5th abdominal terga. The colour of the testes blends with the colour of the surrounding fat and it is difficult to distinguish them from the latter.

Male Reproductive System:

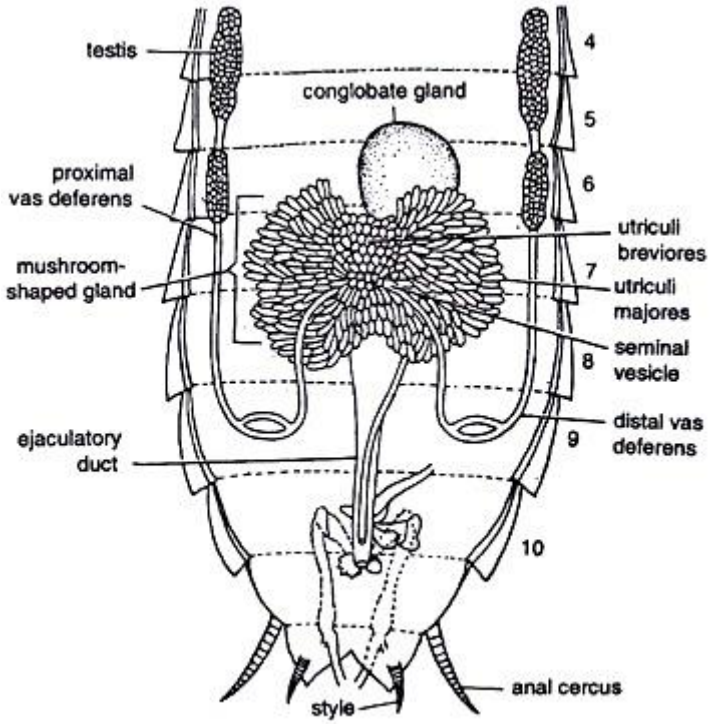

Fig. 6.7 : **Periplaneta sp.** Reproductive system. Male

Testes:

Paired, small in size, made up of a number of vesicles.

Vasa deferentia:

Two narrow tubes. Arising from the testes run posteriorly and join to form the muscular ejaculatory duct.

Ejaculatory duct:

It opens in a median genital armature, opening through male gonopore.

Mushroom-shaped gland:

A vesicle is formed by the swelling of each vas deferens before joining the other. Numerous, slender, blind diverticula are given out from the vesicles and the structure looks like a mushroom. The central region of the gland with smaller rounded diverticula is known as utriculi breviores and two lateral region with slender vesicle as utriculi majores.

Conglobate gland:

Median, ventral to the ejaculatory duct and associated with it.

Female Reproductive System:

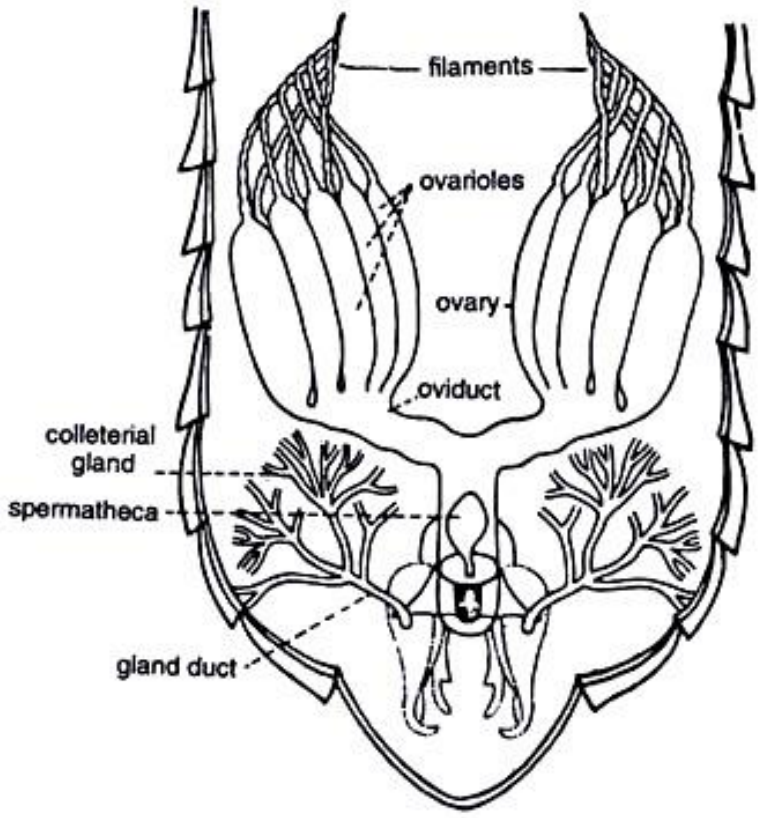

Fig. 6.8 : Periplaneta sp. Reproductive system, Female

Ovaries:

Paired, located under the 4th and 5th abdominal terga. Each ovary has 8 tubules, the ovarioles, which are held together.

Oviducts:

Two, short, wide tubes. The ovarioles unite to form the oviduct. The two oviducts join posteriorly and form a muscular tube, the vagina.

Vulva:

It is a slit-like external opening of the vagina.

Colleterial glands:

A pair of much branched glands opening on either side of the vulva.

Spermatheca:

A median sac opening into the genital pouch.

Lab work : Draw well labelled diagrams of Reproductive of insect you have studied in the space provided below

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LAB EXERCISE NUMBER -13

TITTLE : Anatomy of the Insect Nervous System

MATERIALS: Cockroaches , Scissor, dissecting trey, dissecting microscope, Forceps, Camel hair brush, cotton.

Methodology: Fix the head of the specimen by pinning through the mandibles. The rest of the body should be fixed to the wax of the dissecting tray in the way already described. Carefully remove the epicranial plate of the head capsule and expose the cerebral ganglia.

Cut the pharynx and pull it out with the oesophagus. Remove the viscera and the ventral nerve cord is exposed. Expose the roots of the circumoesophageal connectives on the lateral sides of the brain and trace them to the points where they meet the sub-oesophageal ganglia

Cerebral ganglia or brain:
ADVERTISEMENTS:

The two fused to form a mass. A number of nerves arise from the ganglionic mass, which innervate eyes, antennae and the adjacent structures.

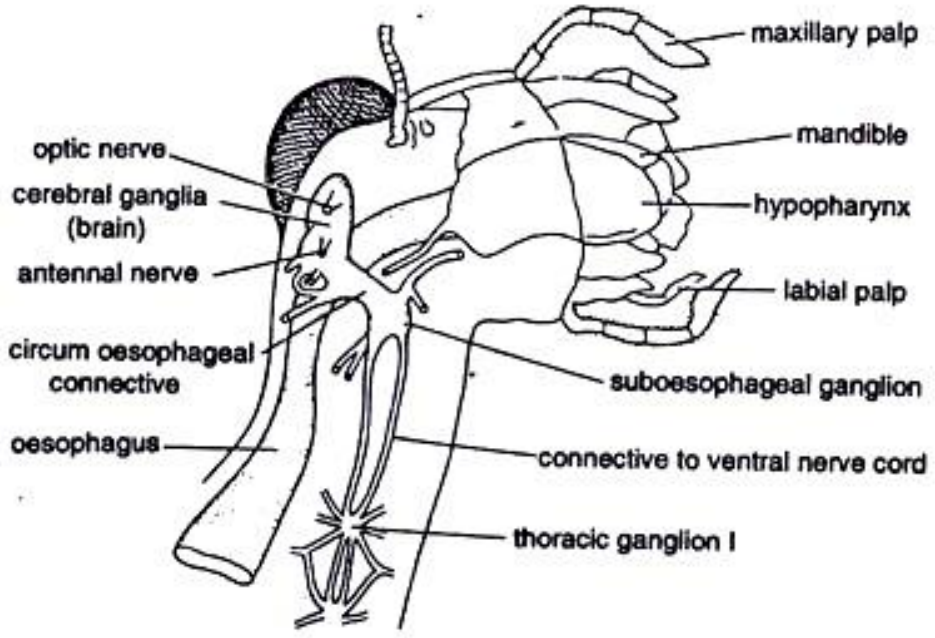

Fig. 6.5 : Periplaneta sp. Nervous system, anterior part, Lateral view

Circumoesophageal connectives:
Arising from the brain two short and broad nerves run around the oesophagus to meet the sub-oesophageal ganglia (Fig. 6.5).

Sub-oesophageal ganglia:
It is formed by the fusion of two ganglia and located in the mid-ventral region of the head just ventral to the oesophagus. Nerves arising from sub-oesophageal ganglia end in labrum, mandible and both pairs of maxillae. A pair of connectives run backward from the ganglia and join the first thoracic ganglion, (prothoracic ganglion).

Ventral nerve cords:
These are two solid nerves and run along the mid-ventral line of the thorax and abdomen. The nerve cords are connected by nine ganglia, three thoracic and six abdominal.

The three thoracic ganglia and the last abdominal ganglion are large in size. Nerves emanating from the thoracic ganglia innervate the musculature and structures of the thoracic region. Those from the abdominal ganglia send nerves to the structures in the abdominal region.

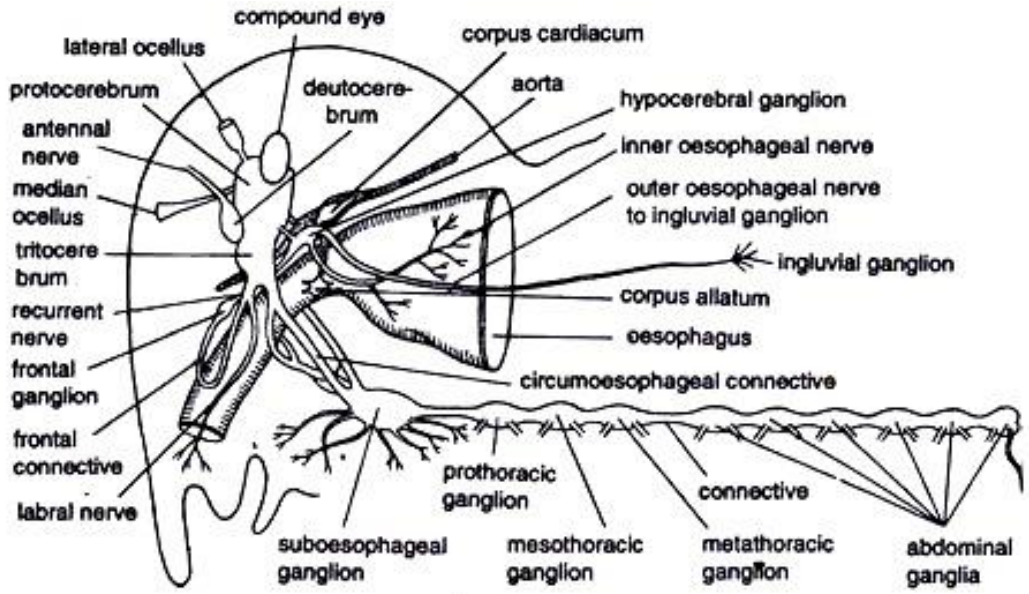

Fig. 6.6 : Periplaneta sp. Visceral nervous system (Lateral view)

Stomatogastric or Anterior Sympathetic Nervous System:
It consists of a median frontal ganglion, hypo-cerebral ganglion, oesophageal and ingluvial ganglion (Fig. 6.6).

i. Frontal ganglion:
Situated in front of brain, on the oesophagus, median in position. Connected to tritocerebral lobes of

brain by a pair of frontal connectives.

ii. Hypo-cerebral ganglion:

Situated on the oesophagus below the brain. Recurrent nerve connects frontal and hypo-cerebral ganglion.

iii. Oesophageal or pharyngeal or occipital ganglion or corpora cardiacum:

Situated on both sides of oesophagus slightly above the hypo-cerebral ganglion. From hypo-cerebral ganglia nerves go to corpora cardiaca or oesphageal ganglia. From corpora cardiaca of each side nerve connects ventrally to another ganglia corpora allatum.

iv. Ingluvial or Stomachic ganglion:

Situated on the posterior end of the foregut. Nerves from hypo-cerebral ganglion connect the ingluvial or stomachic ganglion. The nerves from ingluvial ganglion innervates the neighbouring regions of the stomodaeum.

Lab work : Draw well labelled diagrams of Nervous System of insect you have studied in the space provided below

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