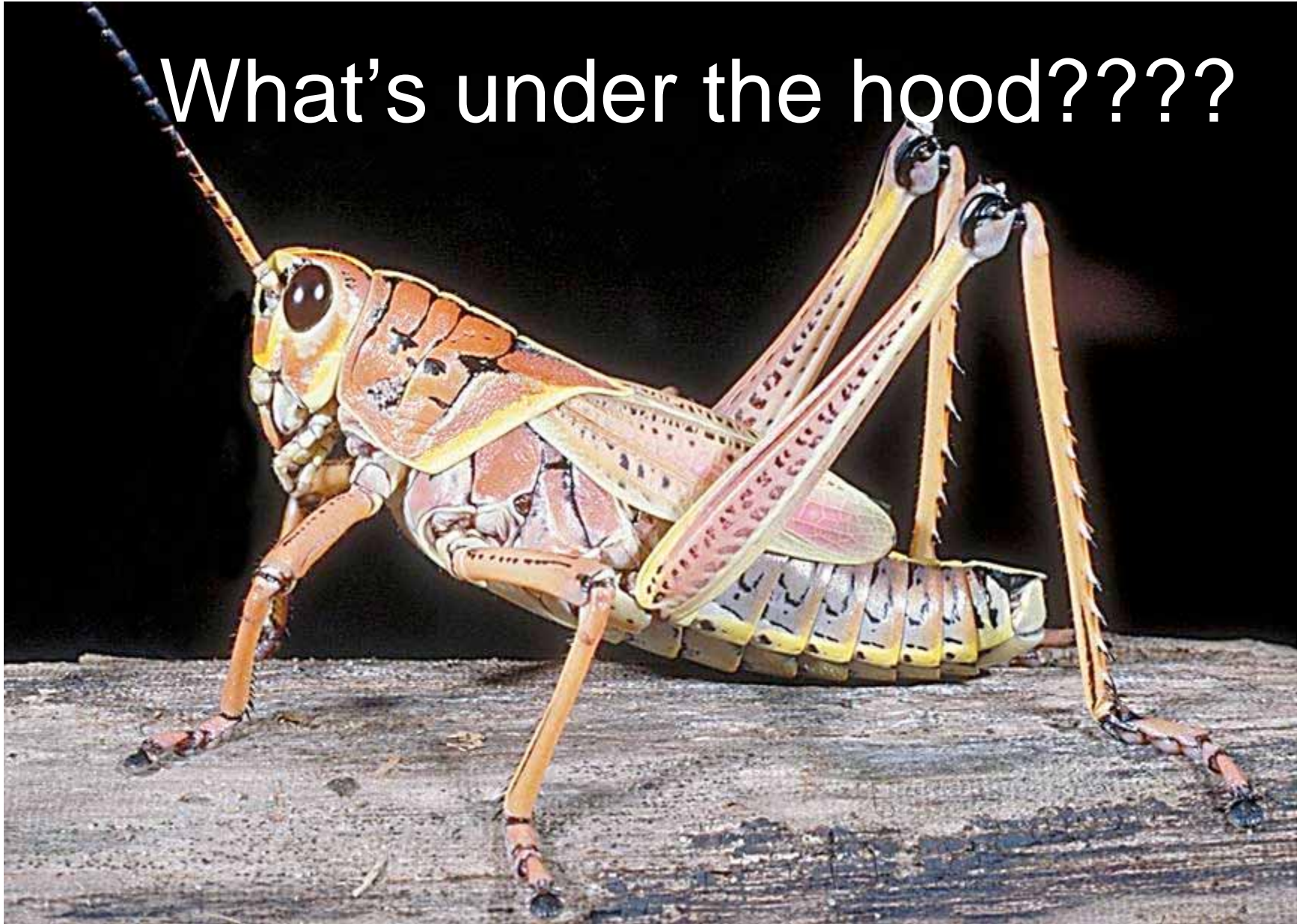


What's under the hood????



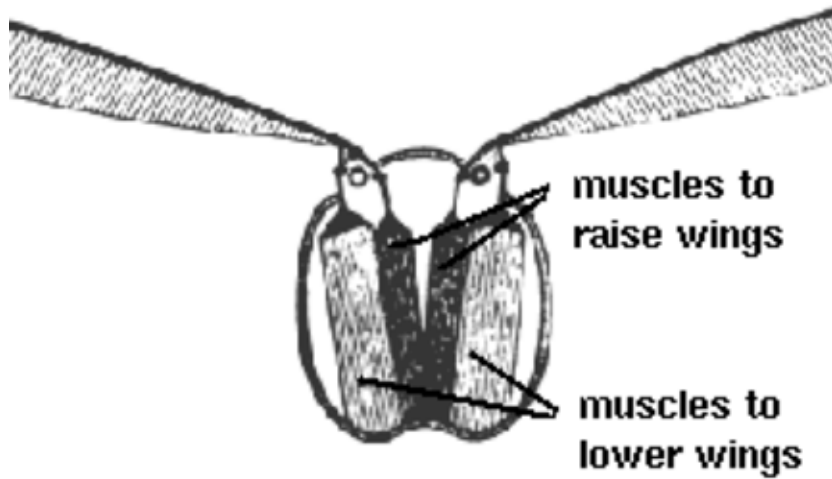
Internal Insect Systems

1. Flight- Musculature of wing movement
2. Digestive- Consumption and processing of food
3. Circulatory - movement of body fluids.
4. Respiratory - breathing
5. Nervous – enervation of muscles, and production of neurohormones
6. Reproductive

Flight System

- Direct/Indirect Flight Muscles
 - Refers to muscle attachments relative to wing
 - Indirect flight in more advanced groups
- Synchronous and Asynchronous muscles
 - Refers muscle contraction relative to innervation
 - Asynchronous contraction allows more rapid contraction and higher wing beats present in more advanced groups of insects

Direct flight muscles



- Muscles are directly articulated to the wings
- Found in more primitive orders
 - Paleoptera
 - Odonata
 - Ephemeroptera
 - and Blattodea

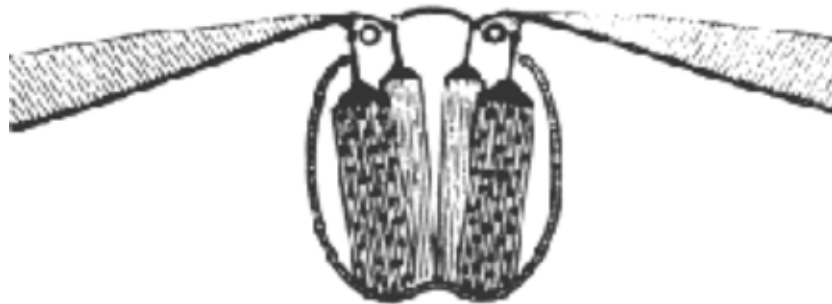
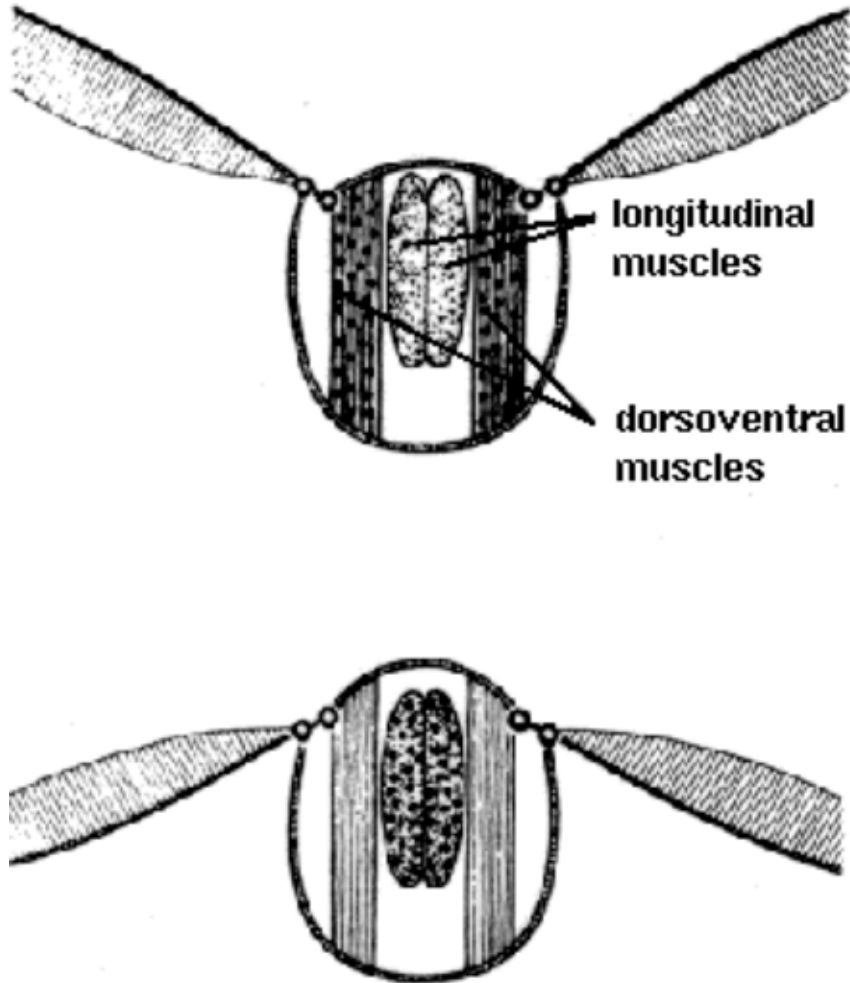


Illustration Source: Hooper Virtual Paleontological Museum

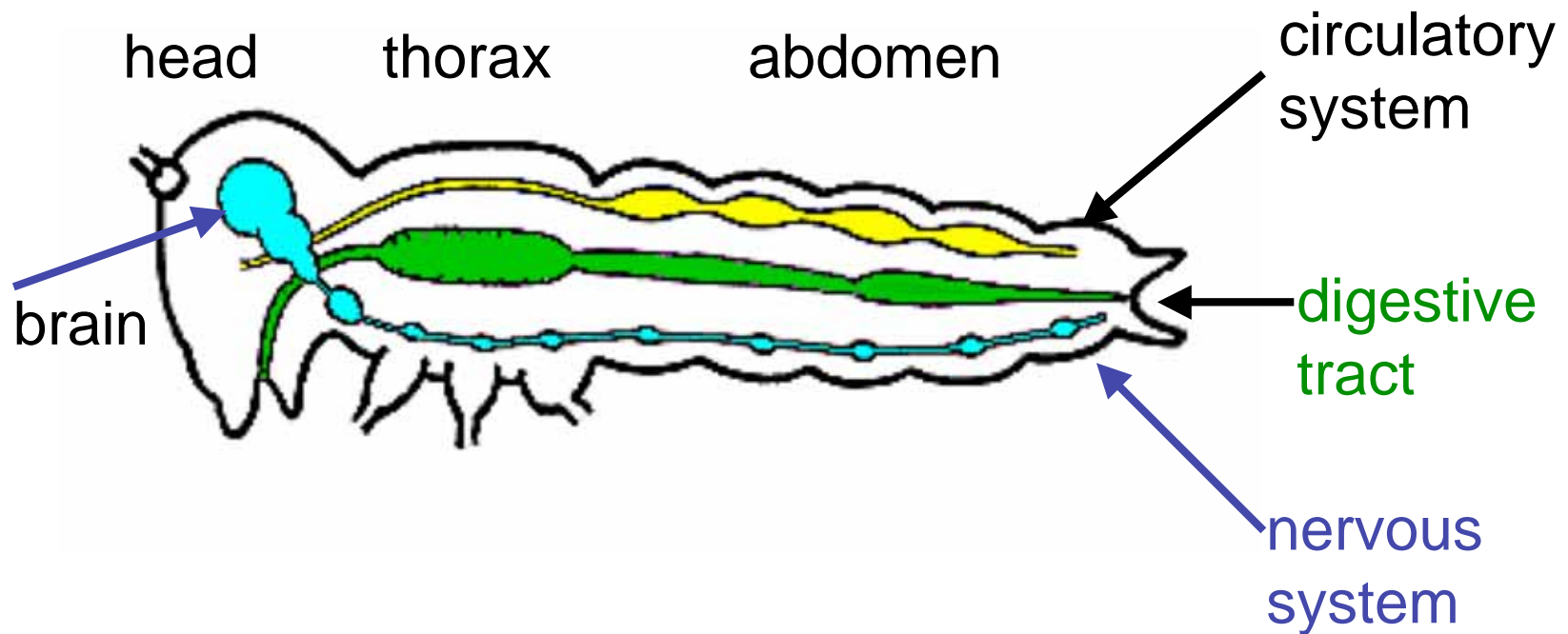
Indirect flight muscles



- Muscles are NOT directly articulated to the wing
- Contraction of longitudinal and dorsoventral muscles alternately contract to depress and relax the thoracic tergum.
- Flight is powered by force of muscle contraction and tergum distortion.
- Direct muscles attached to wing serve as minor adjustors
- Neopterous Orders Only

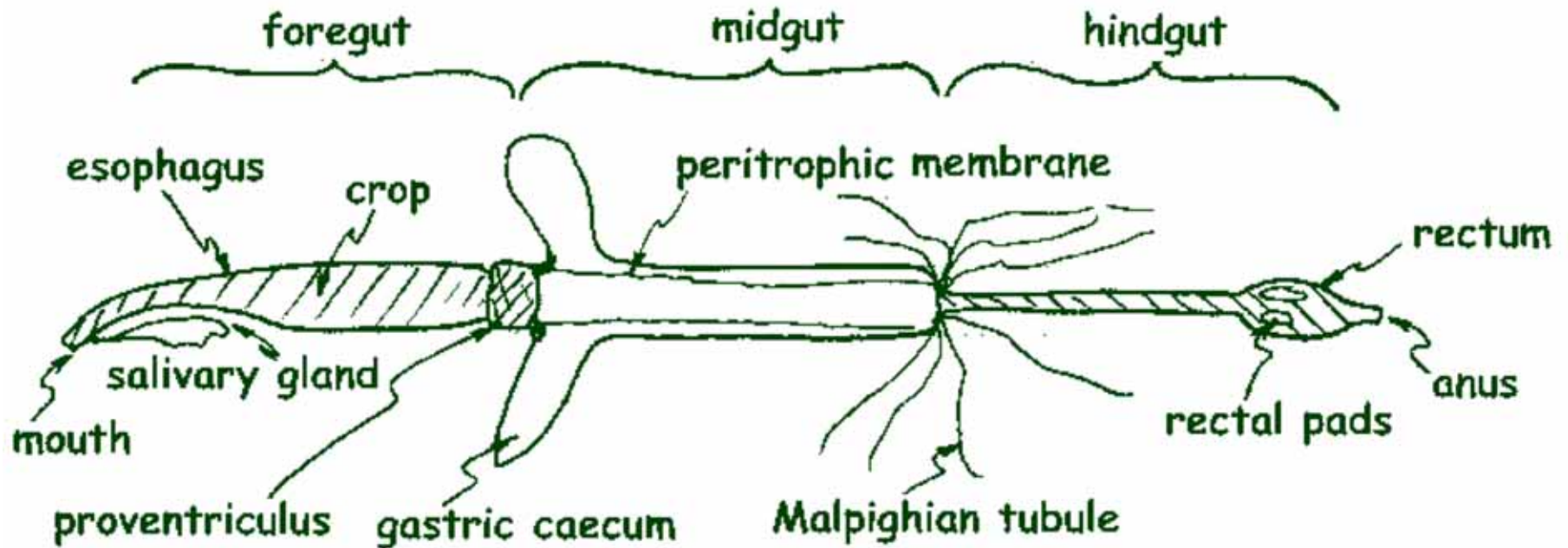
Illustration Source: Hooper
Virtual Paleontological Museum

Internal Insect Systems



(after John Meyer NC-State)

Insect Digestive System

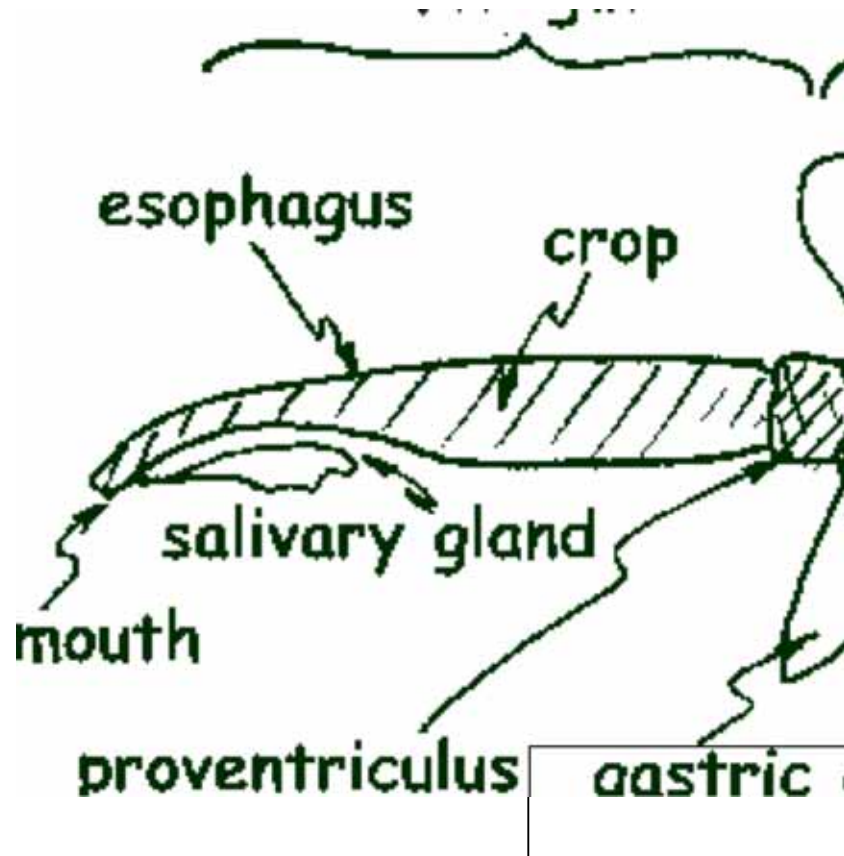


Generalized Diagram (typical of grasshopper)

Functional Regions of Insect Digestive System

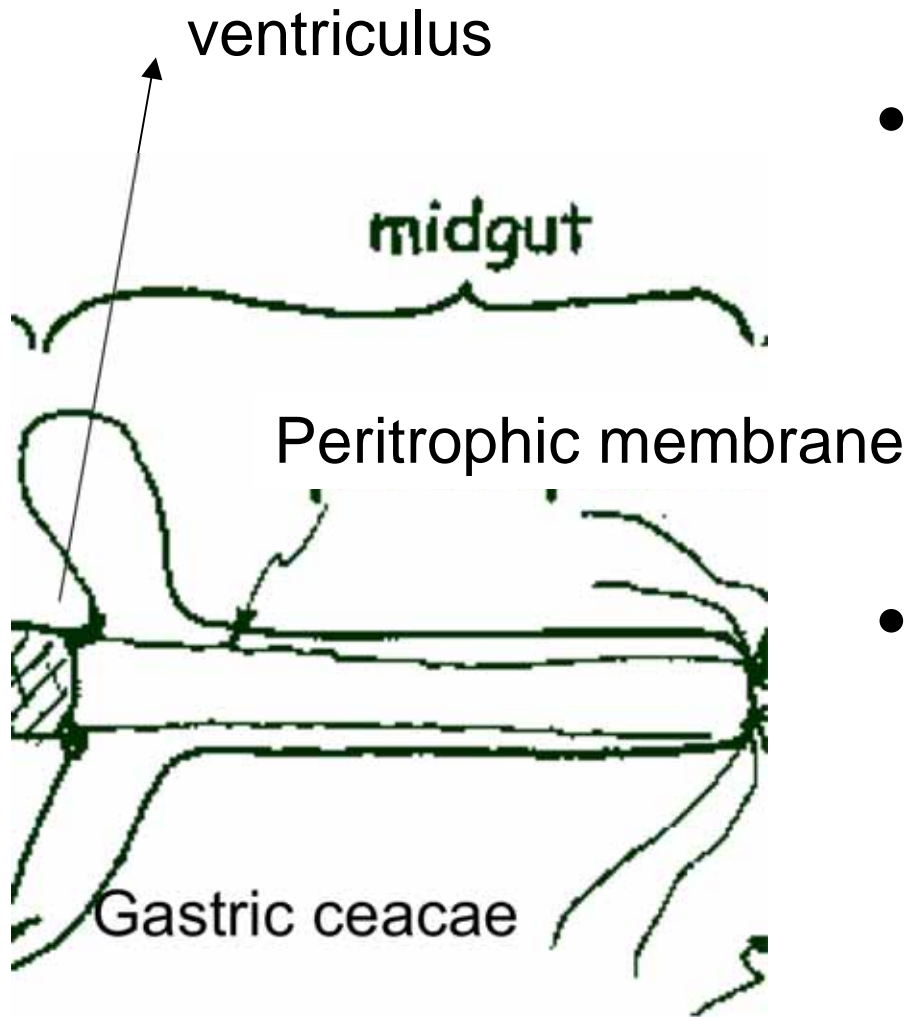
- Foregut- Ingestion, Storage, grinding and transport of food to midgut
- Midgut- Biochemical breakdown (digestion via secretion of enzymes) and nutrient absorption
- Hindgut- Absorption of water, salts and other important minerals, elimination of feces through anus

Key Parts of Foregut



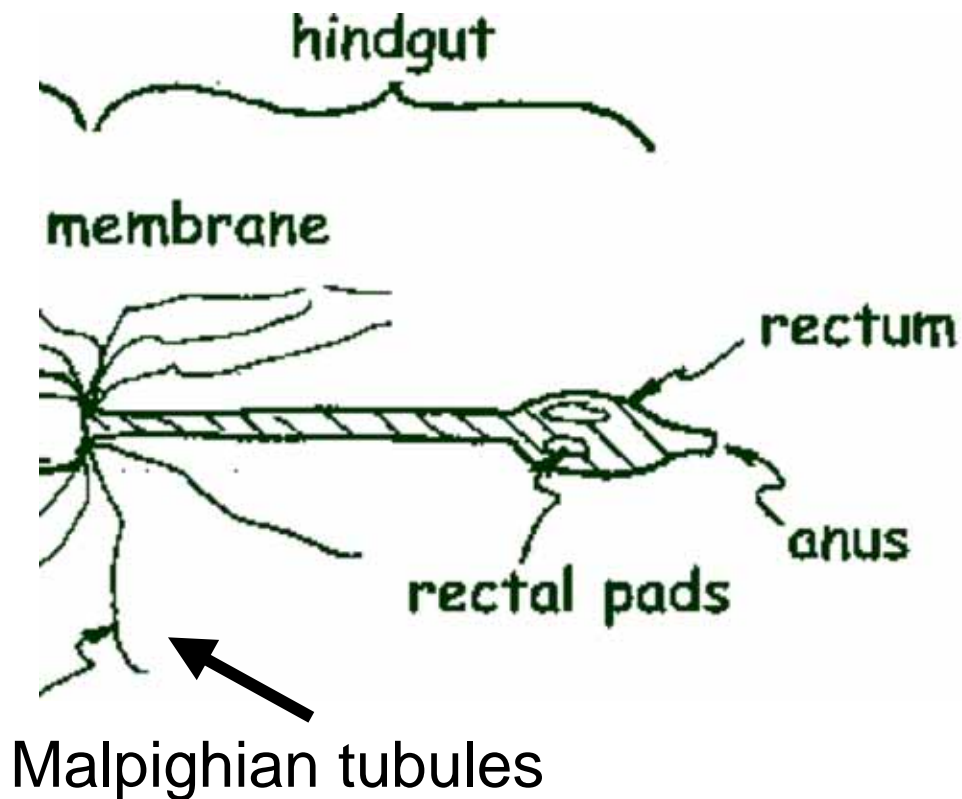
- Mouth -ingestion
- Oesophagous –tube
- Salivary glands
–digestive enzymes
- Crop- holding
- Proventriculus -
grinding

Key Parts of Midgut



- **Ventriculus** - lines the food bolus with a fine mesh made of chitin/carbohydrate/protein mesh called the **peritrophic membrane**
- **Gastric caecae** are where nutrients are absorbed. Cecal structure varies across orders

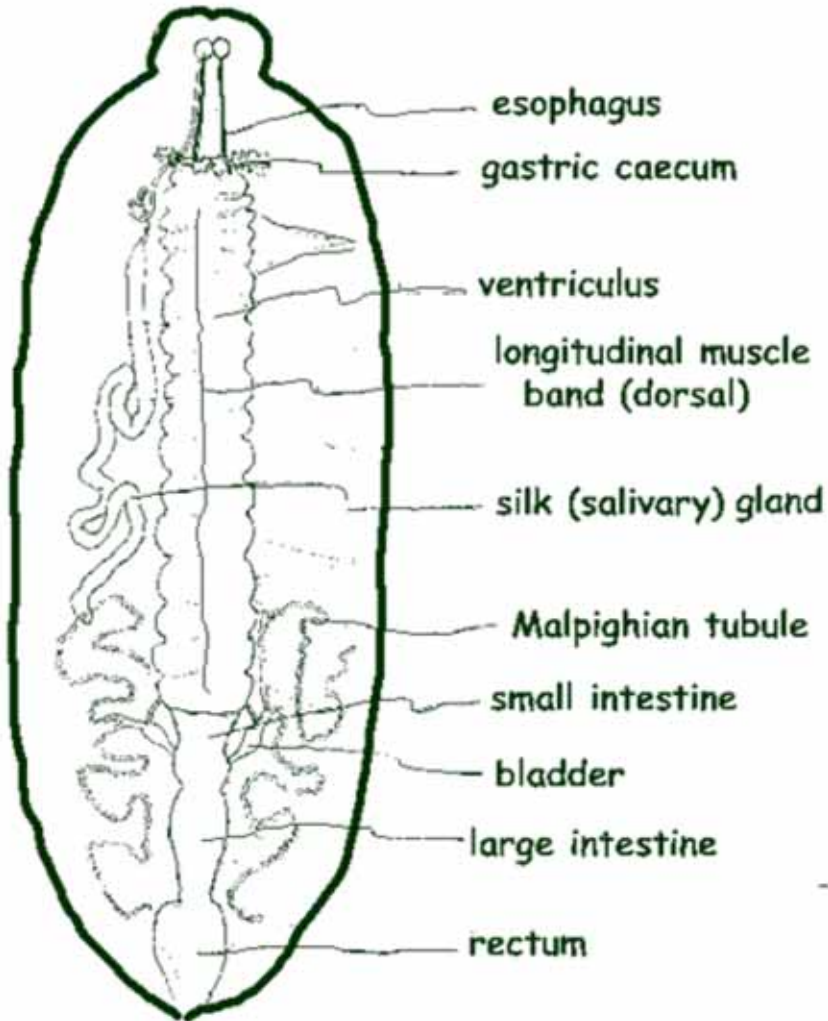
Key Parts of Hindgut



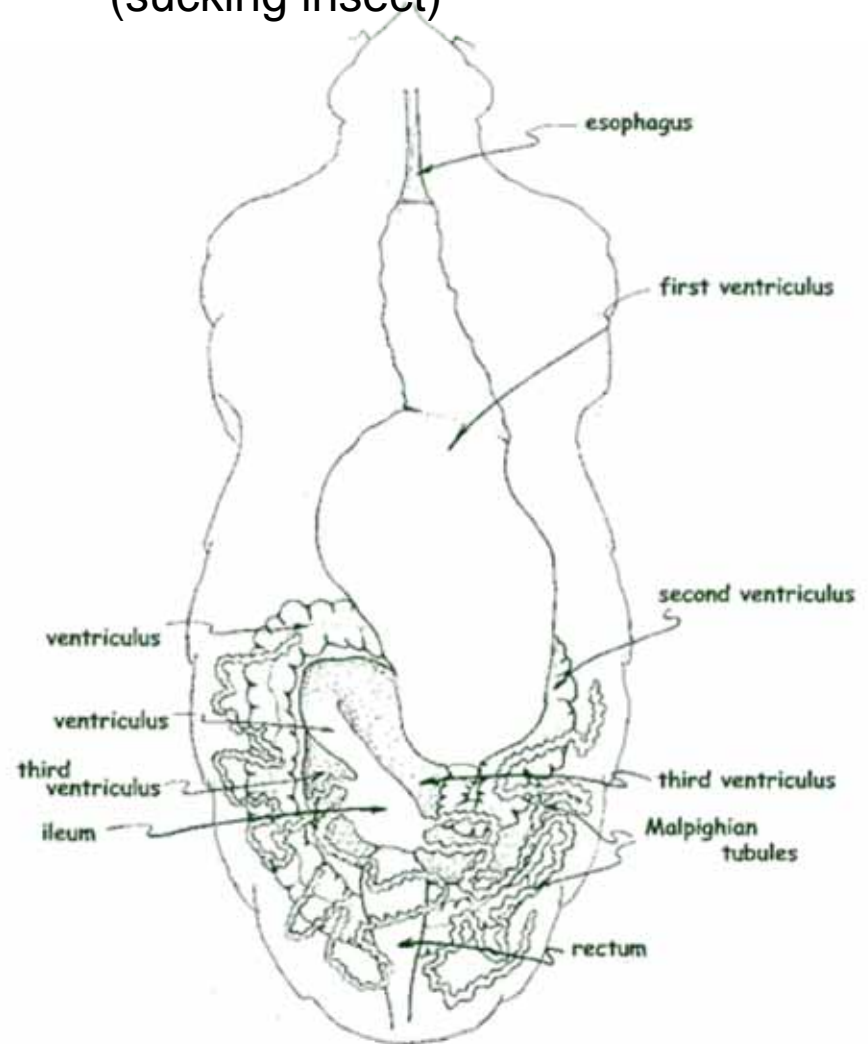
- **Malpighian tubules**, like kidneys, filter waste out of insect blood (haemolymph), releasing urine into hindgut
- **Rectal pads** resorb water and minerals into haemolymph

Insect Digestive System

Caterpillar Digestive System
(chewing insect)



Milkweed Bug Digestive System
(sucking insect)



Insect Circulatory System

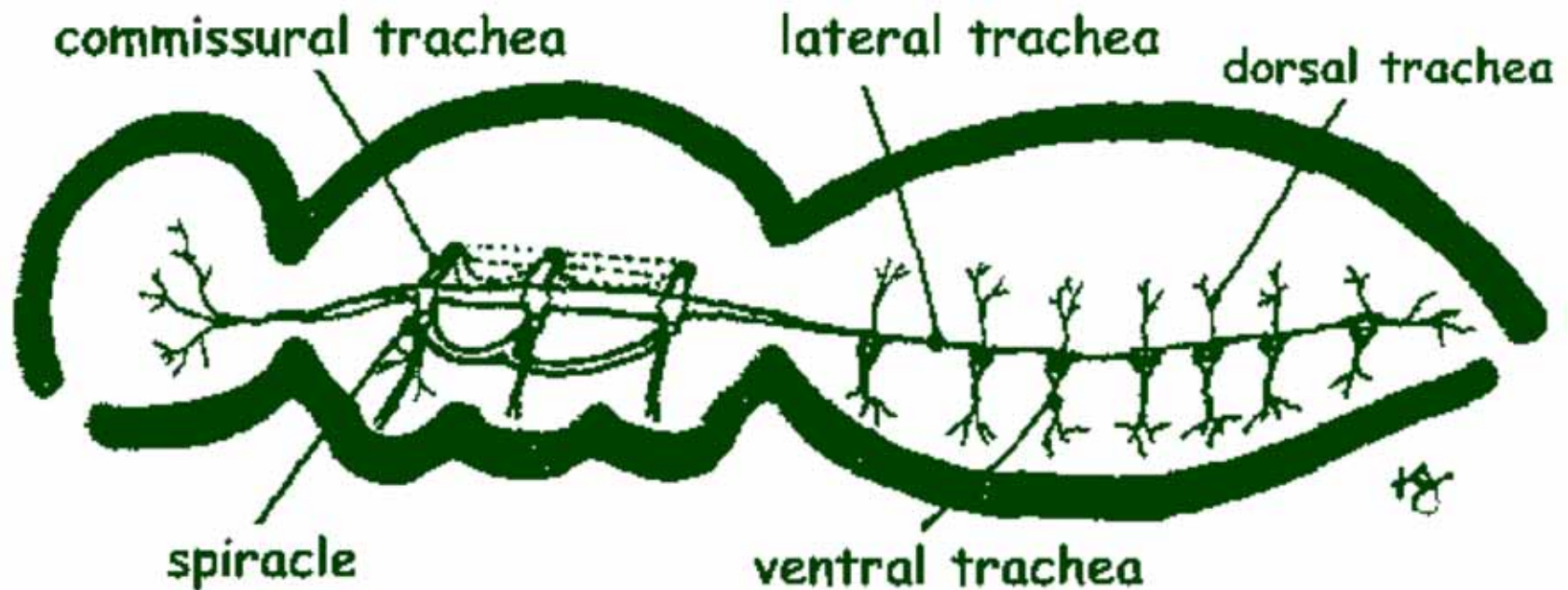
- Open circulatory system
- Dorsal vessel supported by alary muscles that pump blood to head
- Paired Ostioles in each segment are one way valves that suck blood into dorsal vessel
- No hemoglobin in blood. Oxygen is delivered by respiratory system.

Insect Circulatory System Animation

<http://www.cals.ncsu.edu/course/ent425/tutorial/circulatory.html>

Click on the peristaltic contractions link to see pattern of insect blood movement

Insect Respiratory System



Spiracles, Tracheae, Tracheal Trunks & Air Sacs, Tracheoles

Insect Respiration



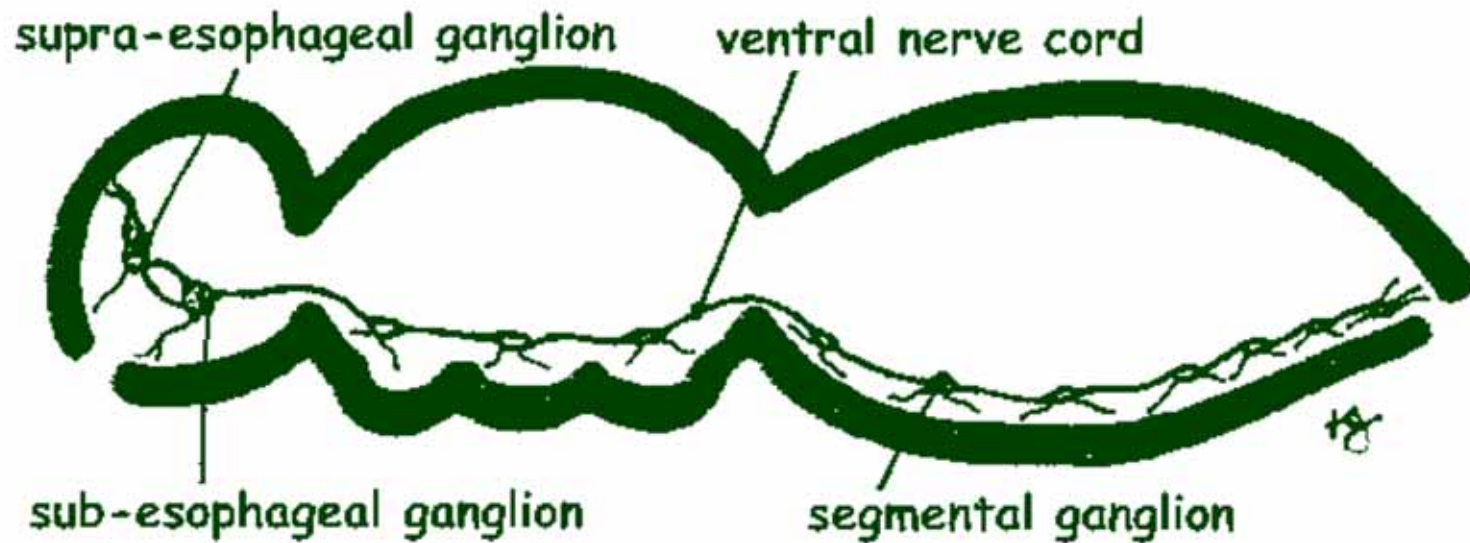
Key Parts of Respiratory System

- Spiracles –breathing holes
- Tracheal tubes- coiled vacuum like hoses re-enforced with chitin strands called taenidia
- Tracheoles – fine tubes with thin membranes that foster gas exchange
- Oxygen in , Carbon Dioxide out

Tutorial

<http://www.cals.ncsu.edu/course/ent425/tutorial/respire.html>

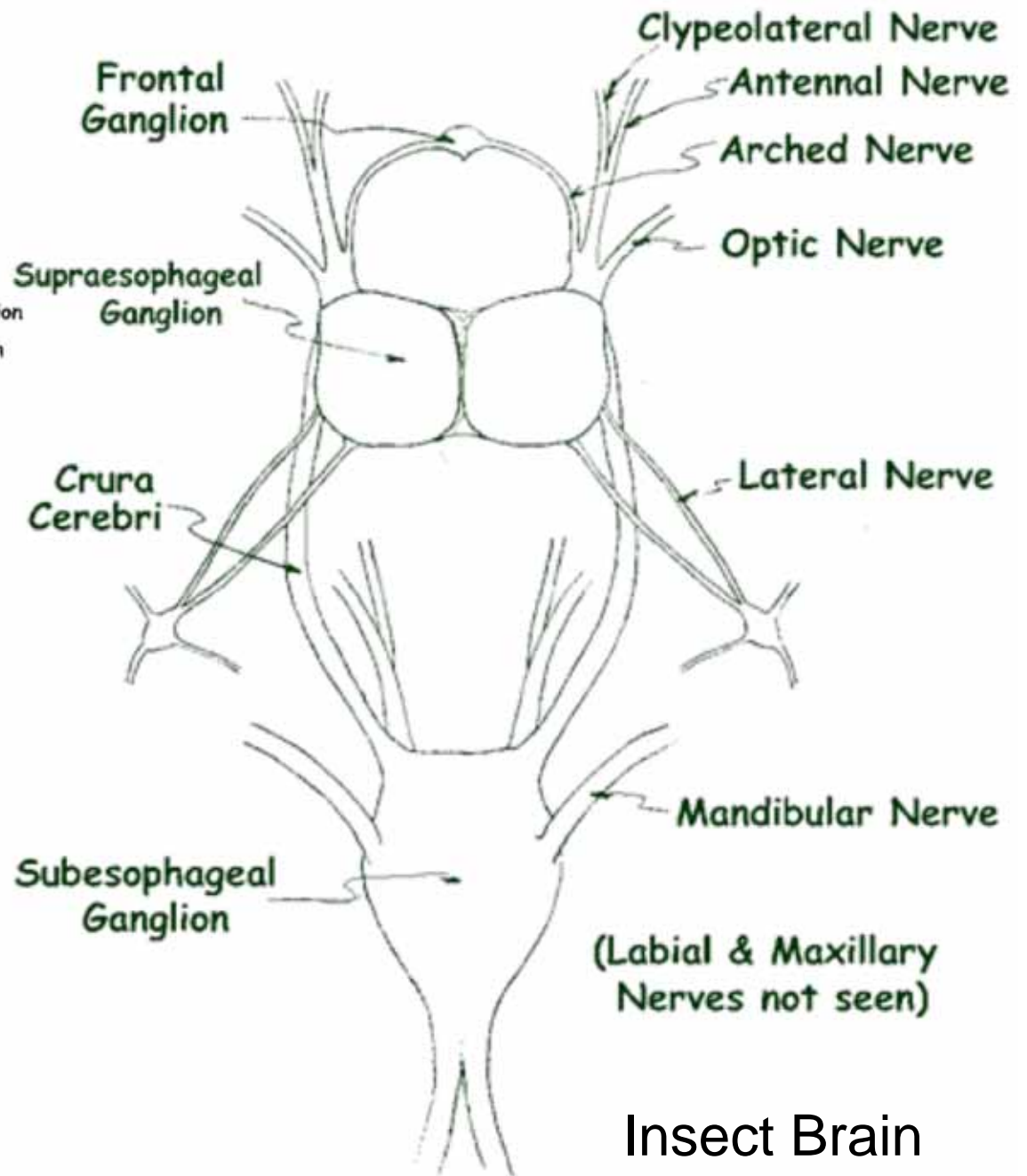
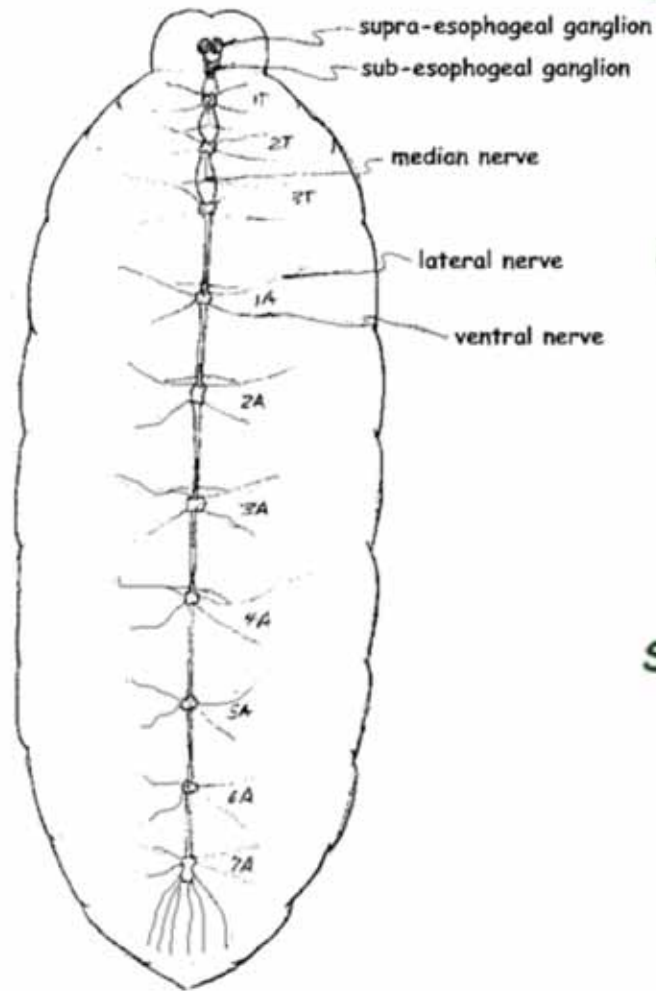
Insect Nervous System



Key Points for Nervous System

- 1 central signal processing unit (ganglion) per segment.
- Brain is a super ganglion with many ganglia
- Brain and ganglia secrete and moderate production of neurohormones involved in critical processes such as moulting and reproduction
- Ventral nerve chord
- Nerves and neurohormone activities are targets of many insecticides

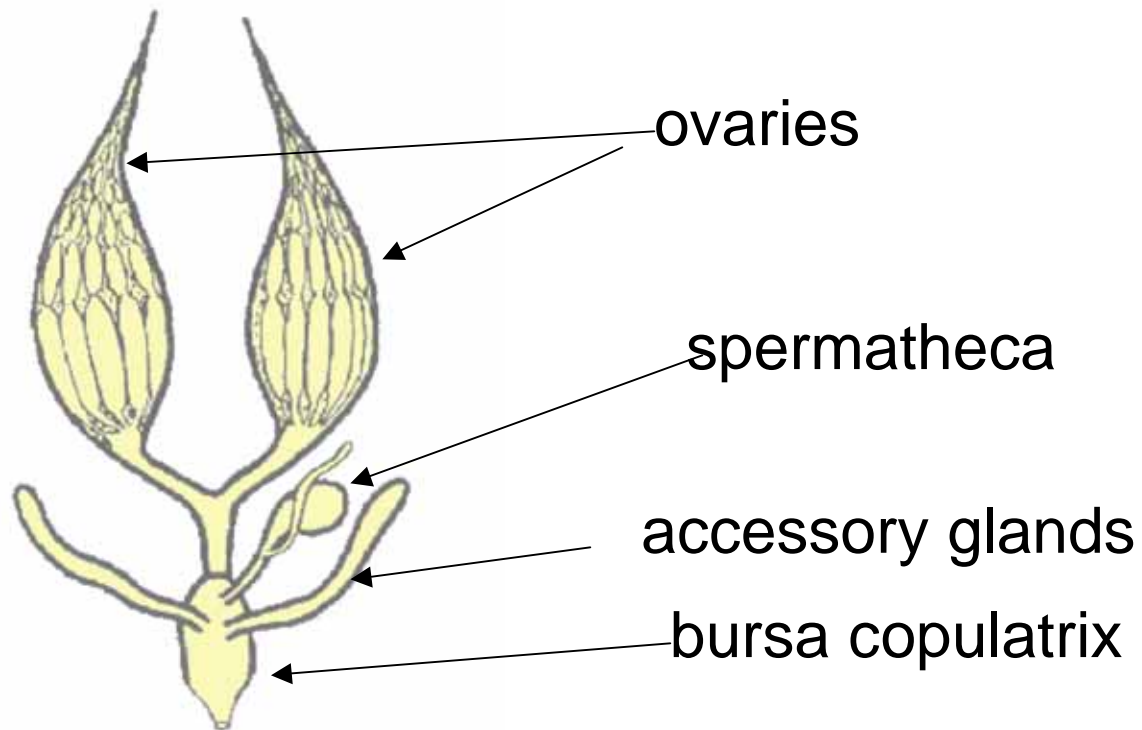
Insect Nervous System



Insect Nervous System Tutorial

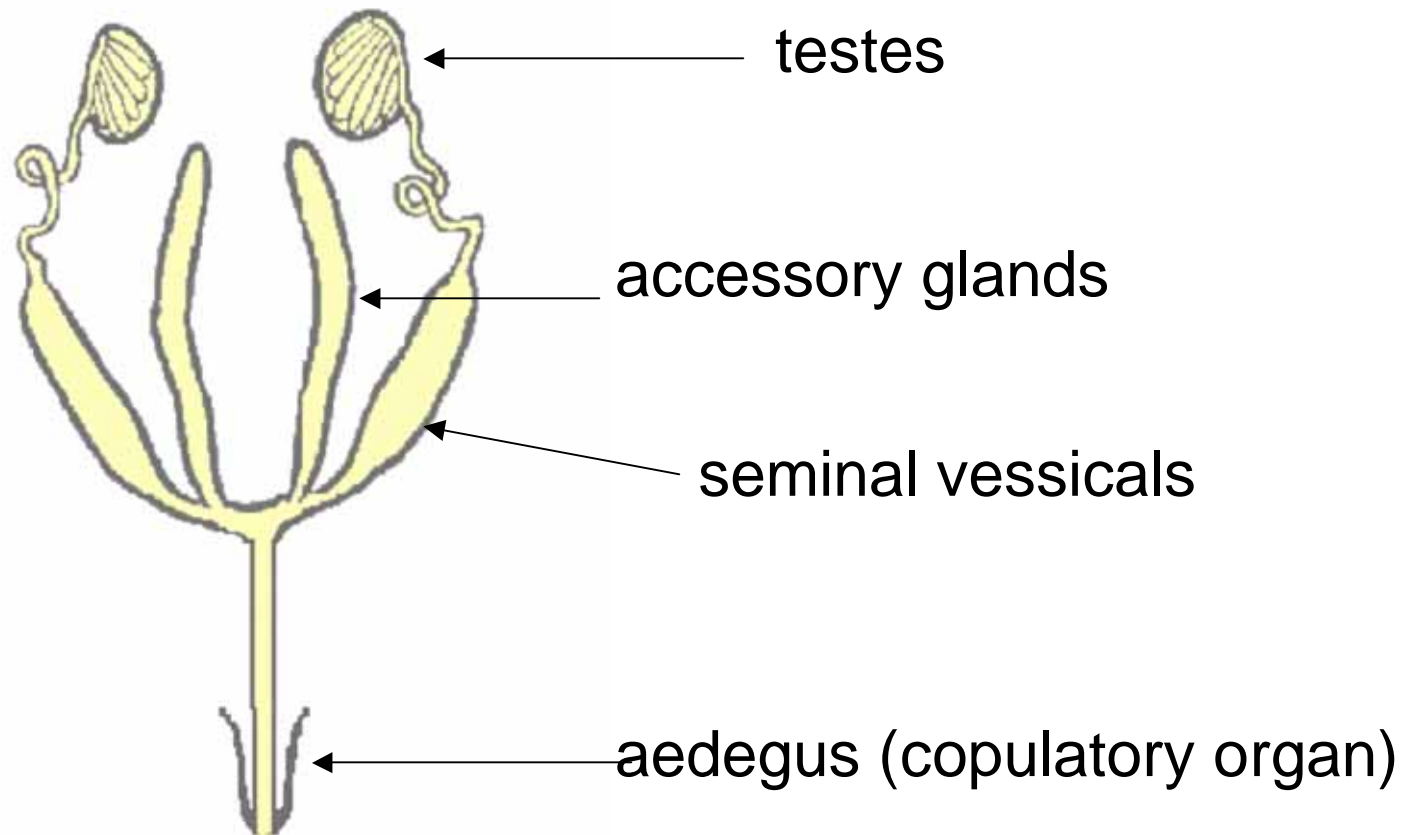
<http://www.cals.ncsu.edu/course/ent425/tutorial/nerves.html>

Female Reproductive Organs



http://www.cals.ncsu.edu/course/ent425/library/tutorials/internal_anatomy/female.html

Male Reproductive Organs



http://www.cals.ncsu.edu/course/ent425/library/tutorials/internal_anatomy/male.html

Novel Aspects of Insect Reproduction

- Sperm is encased in protein like sacks (spermatophores) that protect sperm cells during delivery to the female
- Females possess a specialized organ to hold sperm, and allow for selective fertilization of eggs.
- Insects with haplodiploid chromosome systems can determine sex of offspring (only fertilized eggs become females)
- Parthenogenesis- reproduction without mating is common in many groups

Insect Reproductive System

