MODULE 5
HONEY BEE BIOLOGY

STUDY GROUP SESSION 1

Led by Alan Baxter
Cornell University Master Beekeeper
Education Officer
FDBKA

Copyright Alan Baxter 2026

SESSION 1

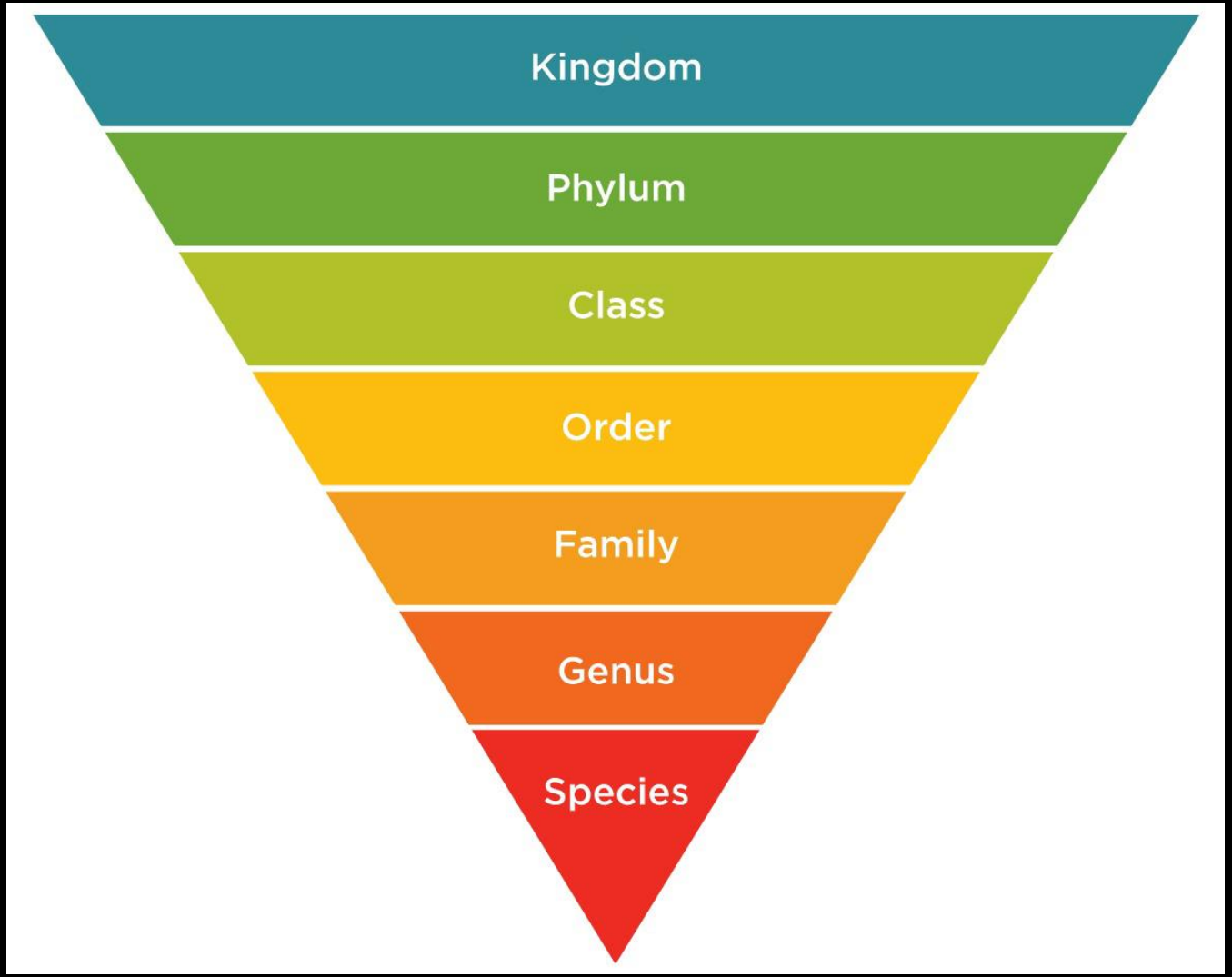
Introduction

Honey Bee Evolution

The Alimentary System

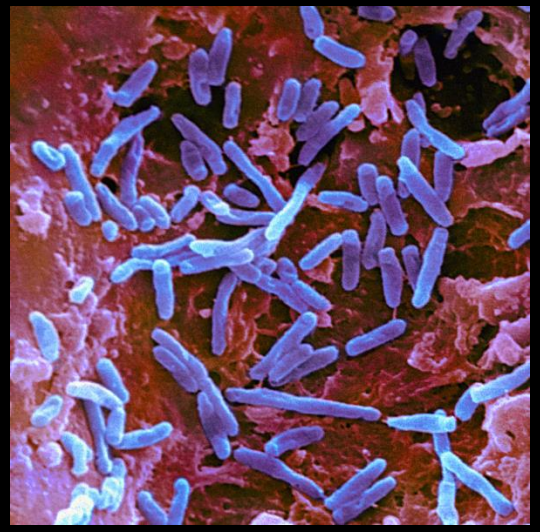
Copyright Alan Baxter 2026

CLASSIFICATION OF ORGANISMS



Copyright Alan Baxter 2026

5 Kingdoms

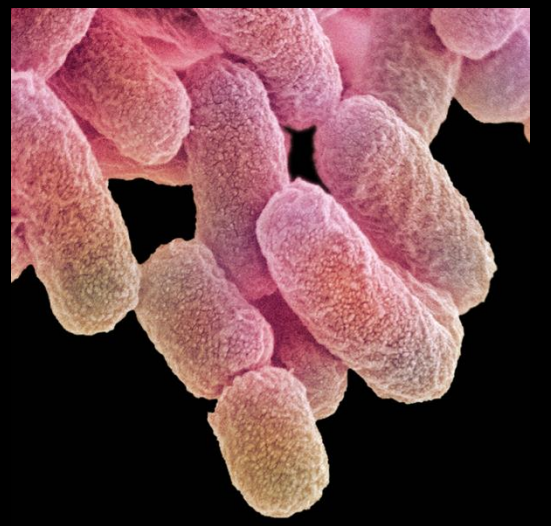


Bacteria

Archaea



Animals



Archaea



Fungi



Plants

Copyright Alan Baxter 2026

Phylum Arthropoda:







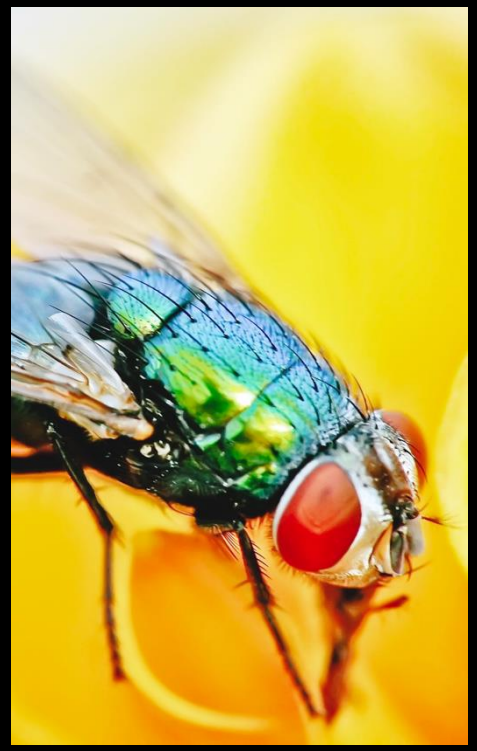
All arthropods are invertebrates.
they do not develop a backbone and
instead have a tough outer body shell called an exoskeleton.
Arthropods have segmented bodies and pairs of jointed appendages

Copyright Alan Baxter 2026

Class Insecta





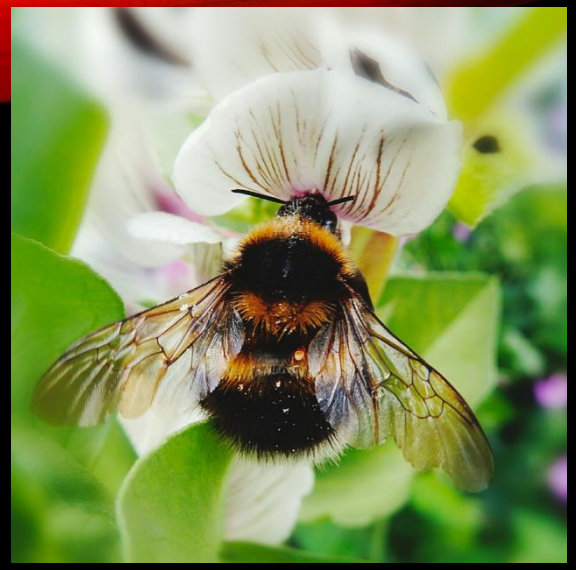


Insects are defined by having

- six legs
- across three body parts (head, thorax, and abdomen),
- compound eyes
- a pair of antennae.

Copyright Alan Baxter 2026

Order Hymenoptera







Hymenoptera usually have two pairs of wings joined together by small hooks.

Females have a hardened ovipositor (egg-laying organ) that may be used for stinging or reproduction.

They are the biggest-brained insects

Considered the "intelligentsia" of the insect world.

Copyright Alan Baxter 2026

Family Apidae.







All bees within this family carry pollen on their legs.

It is the largest family of bees and includes

bumble bees, carpenter bees, and many others in addition to honey bees.

Copyright Alan Baxter 2026

Genus Apis

Every organism has a two-part species name.

The first part is the *genus* name and the second part is the *species* name.

Bumble bees, for instance, are all part of the genus ‘Bombus’, while honey bees are all part of the ‘Apis’ genus.

Organisms within the same genus often look similar to each other.

Copyright Alan Baxter 2026

There are eight species of honey bee (members of the genus Apis) found throughout the world, and some that you may be familiar with



Apis cerana
Eastern honey bee



Apis florea
Dwarf honey bee



Apis dorsata
Giant honey bee

Copyright Alan Baxter 2026

Species Apis mellifera



The Western honey bee has Apis mellifera for its species name.

What does "mellifera" mean? Melli means "honey" and fera means "maker",

So it was named as the "maker" of honey.

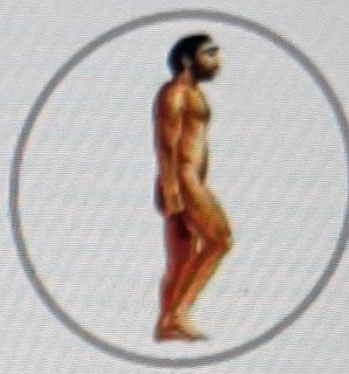
Copyright Alan Baxter 2026











230 MYA Dinosaurs appeared

140 MYA First flowers evolved

130 MYA First bees evolved

60 MYA Honey bees evolved

2.8 MYA Humans evolved

Copyright Alan Baxter 2026

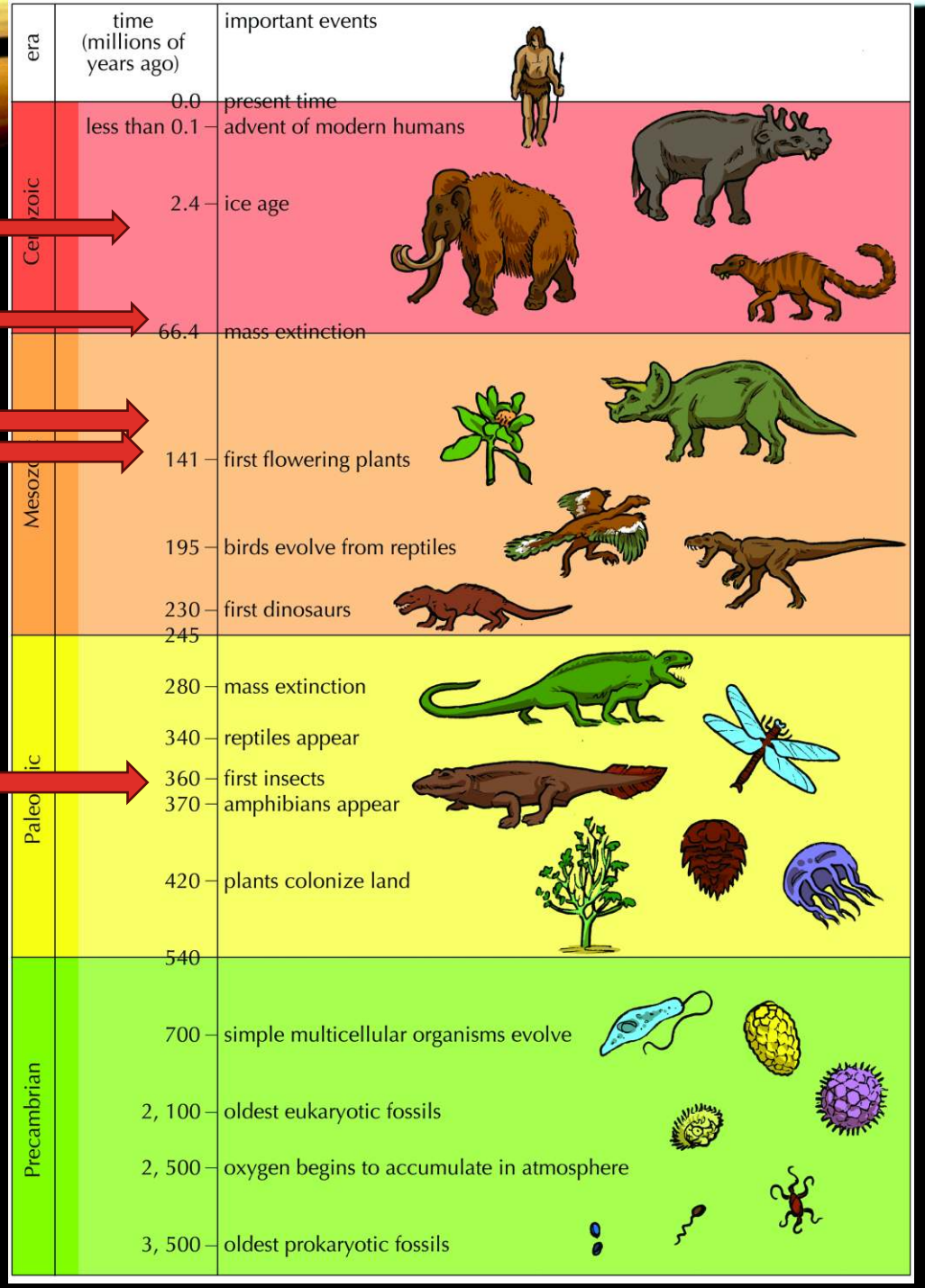
Humans

Honey bees

First bees

First flowers

First insects



Copyright Alan Baxter 2026

Fossil of primitive bee

Mesozoic period

100 MYA

Wasp-like

Carnivore



Copyright Alan Baxter 2026

Fossil of honey bee

37 MYA Eocene epoch

Palynivore



Copyright Alan Baxter 2026

A honey bee colony is a Superorganism

With a Eusocial structure:

- **Overlapping of generations**
- **Cooperative brood rearing**
- **Reproductive division of labour**

Natural selection

Polyandry

Genetic diversity



Photo: Giant nest built by termites (an example of a superorganism). Photo credit: Graham Thompson

Copyright Alan Baxter 2026



Copyright Alan Baxter 2026



Copyright Alan Baxter 2026

THE ALIMENTARY SYSTEM

The alimentary/digestive system of any animal has 4 parts:

- **Ingestion – eating food or drink by swallowing or absorption**
- **Digestion – breaking food down to its simplest parts by enzymes**
- **Absorption – passing those components from the digestive system into the blood**
- **Elimination – removing any indigestible material in the form of faeces from the body via the anus**

Copyright Alan Baxter 2026

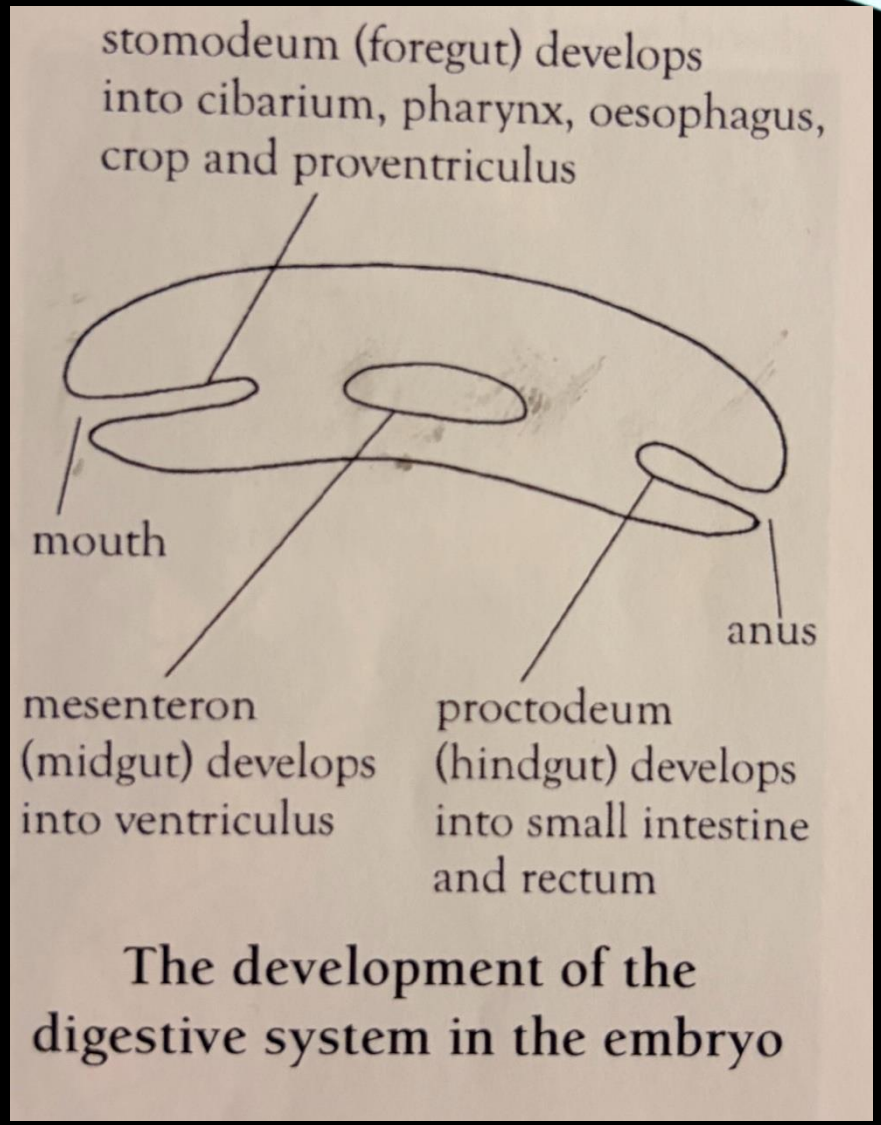
THE ALIMENTARY SYSTEM OF THE HONEY BEE

Consists of a long flexible tube in 3 sections

Begins with an opening at the front, the mouth, and ends at the rear,the anus.

Even before the egg hatches it already has developed those 3 parts

- **Stomodeum (foregut) grrows inwards from the front of the embryo**
- **Mesenteron (midgut) forms a structure round the yolk of the egg between the stomodeum and the proctodeum.**
- **Proctodeum (hind gut) grows inwards from the rear**

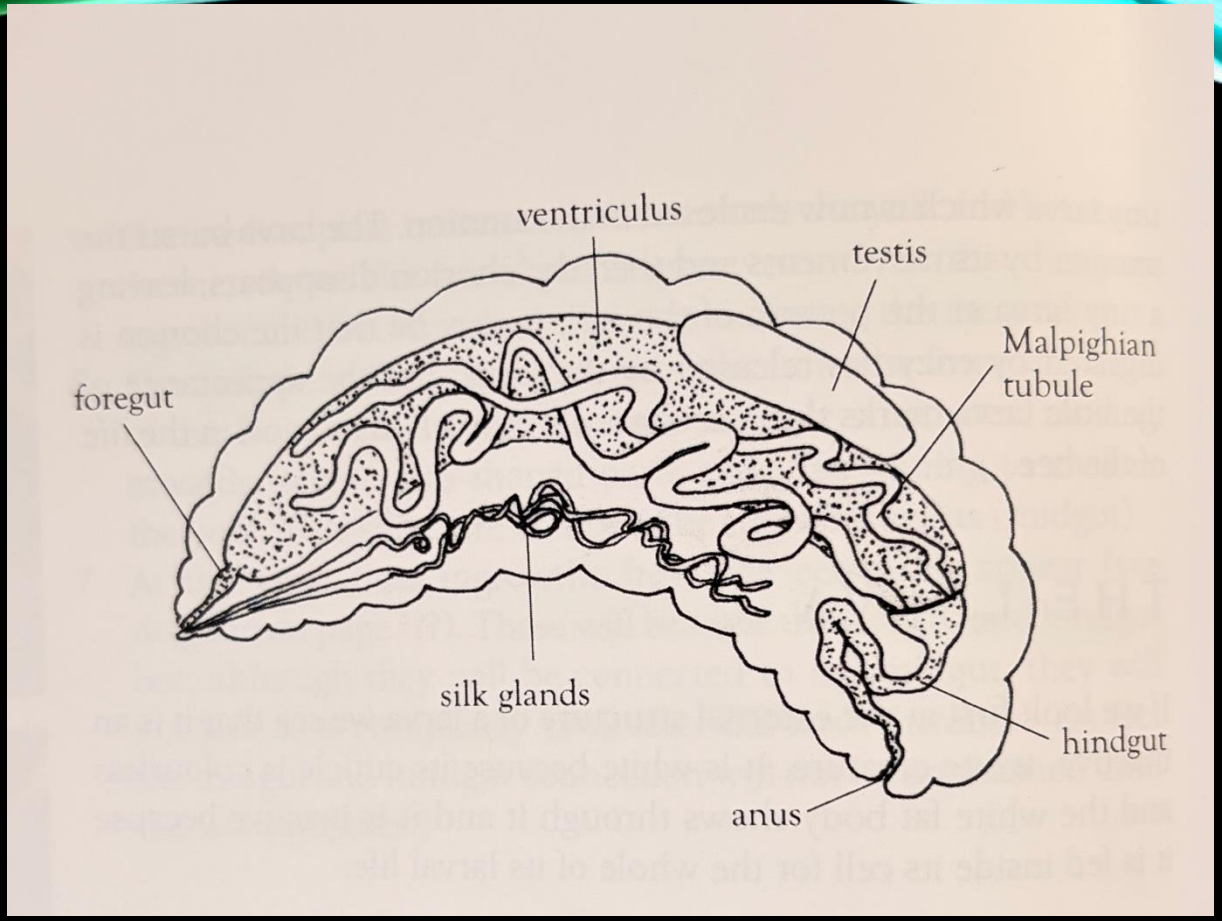


The development of the digestive system in the embryo

Credit Celia Davis

Copyright Alan Baxter 2026

- When the larva hatches from the egg the stomodeum and the mesenteron will have fused to form a continuous tube.
- The proctodeum joins up when the larva is fully grown in the pupa stage before the final moult and defecation takes place for the first time.

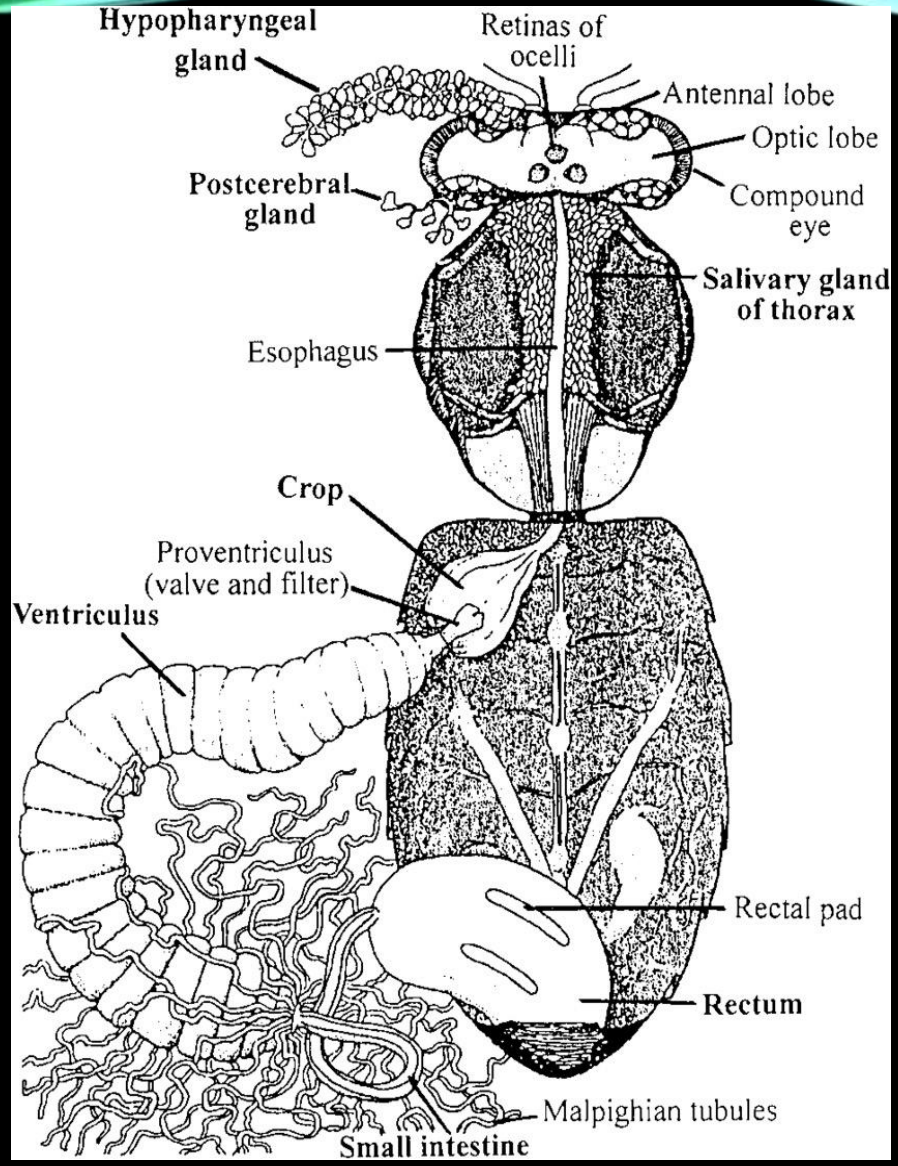


Credit Celia Davis

Copyright Alan Baxter 2026

Fully formed adult

Development of the egg, larva, pupa and imago in future session



Credit HA Dade

Copyright Alan Baxter 2026

Ingestion

Entry to the canal is through a cavity area, the cibarium and the pharynx which correspond to a mouth*.

These are surrounded by muscles that allow the cavity to expand and contract to draw in liquids by suction.

The tongue, or proboscis has the ability to lap and to suck liquids.

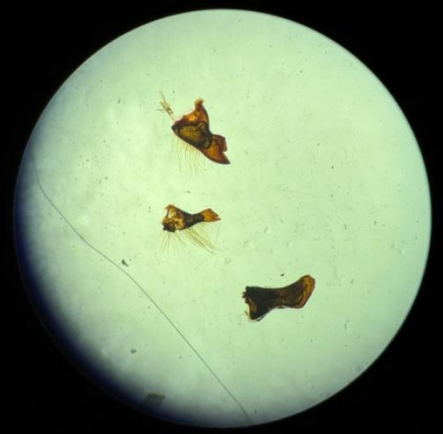
**The complex anatomy and function of the mouthparts and mandibles will be covered in a later session*

Copyright Alan Baxter 2026

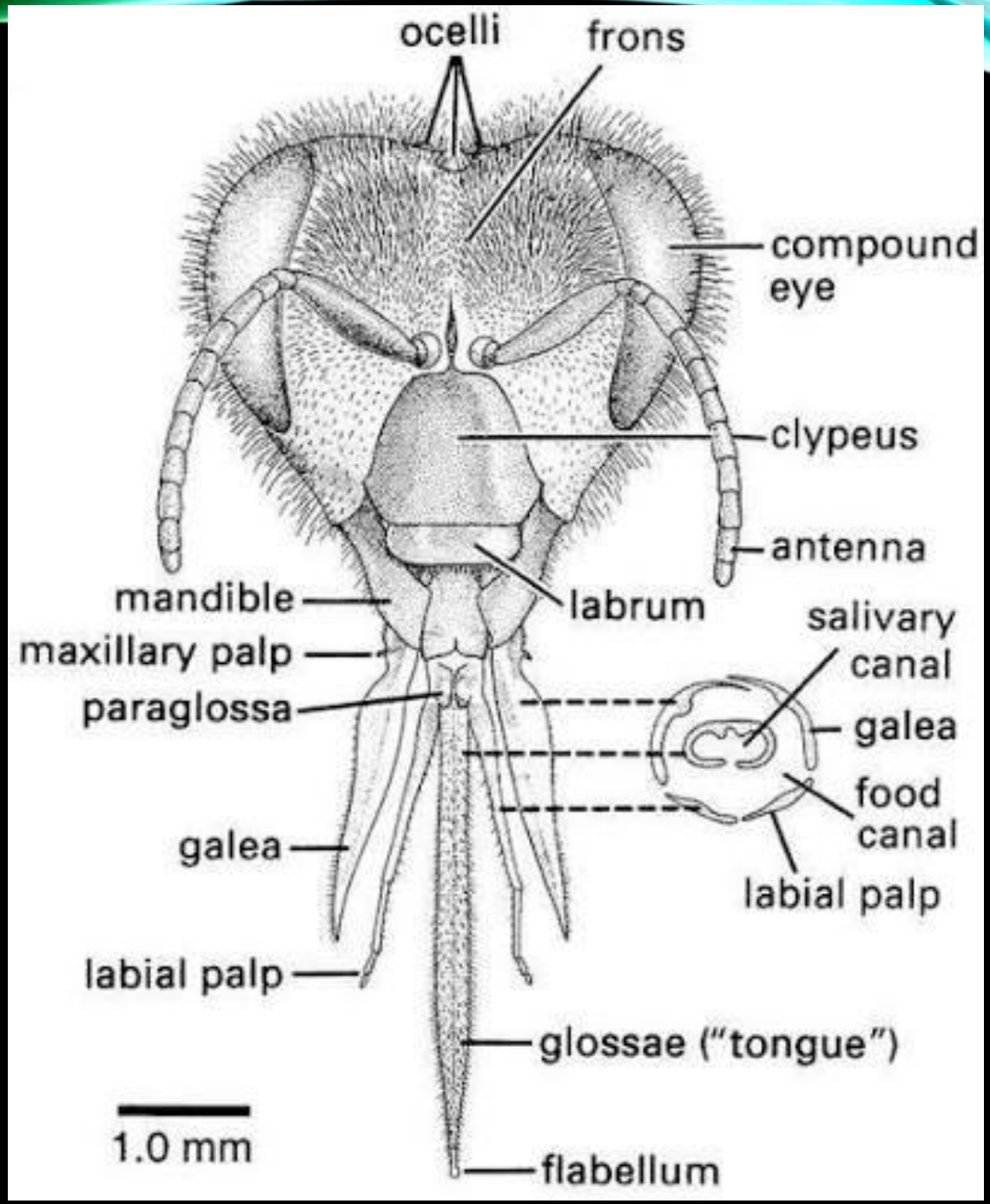
THE MOUTH

MANDIBLES









The esophagus

Long, thin tube that connects the mouth to the honey stomach or crop via the waist or petiole.

It transmits nectar and water collected during foraging

Surrounded by muscles – inner layer longitudinally – outer layer laterally

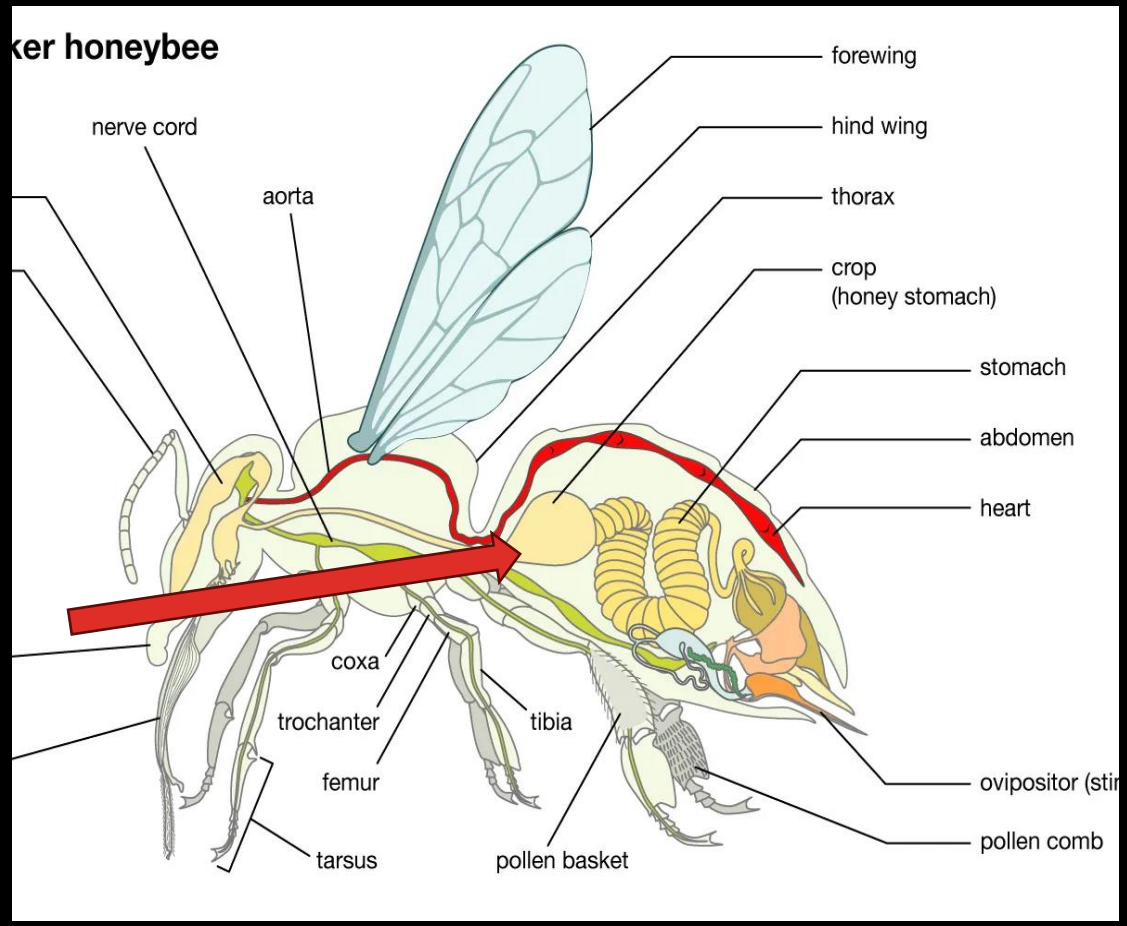
Pushes food along in waves of muscular contractions –

called peristalsis

Copyright Alan Baxter 2026

Honey stomach or Crop

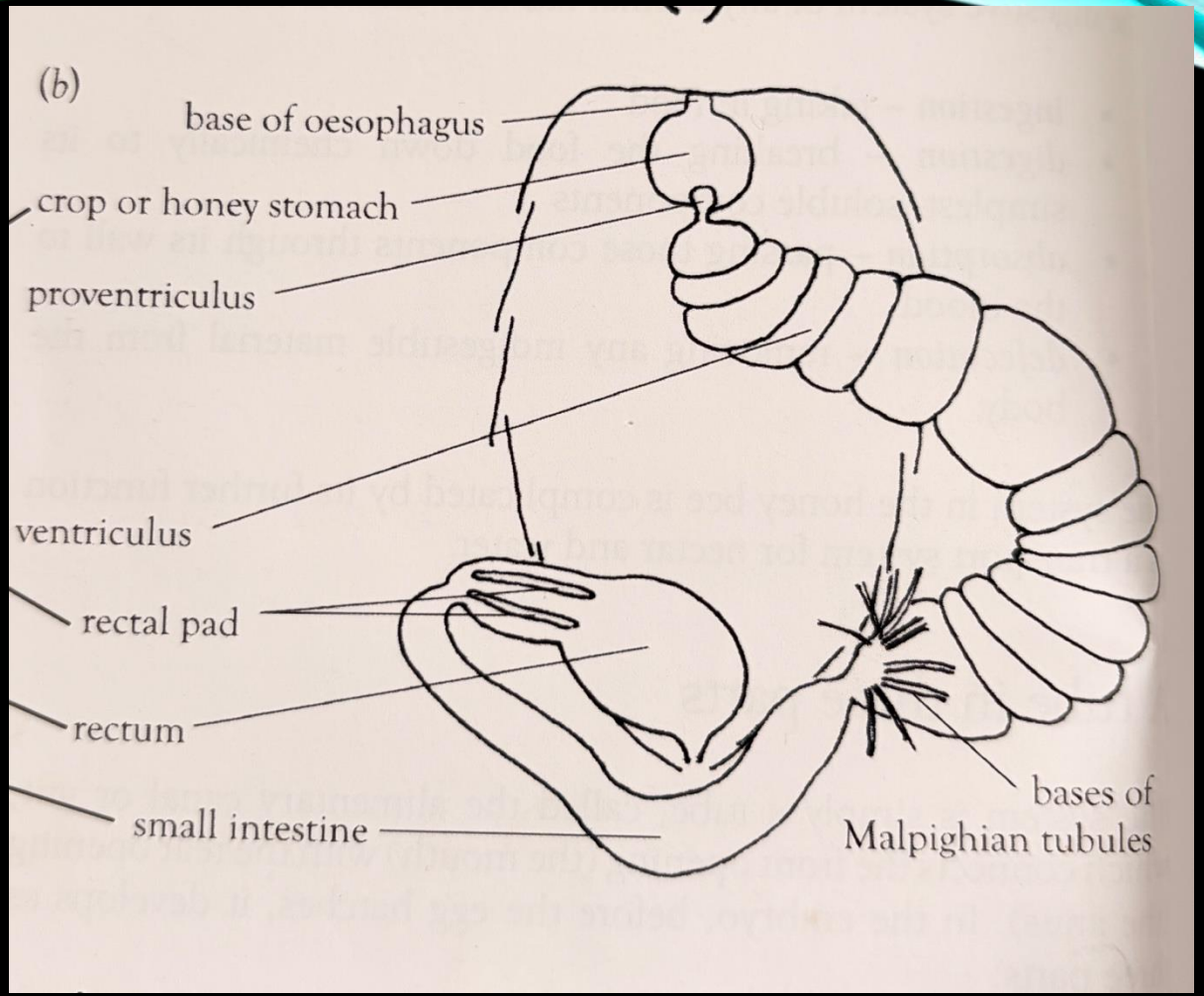
- Elastic sac that can expand to fill most of the abdominal cavity
- Can carry up to about 40mg of nectar
- Acts as a reservoir for nectar and water
- Not part of the digestive system so uncontaminated by digestive material
- Exit guarded by the proventriculus or proventricular valve



Copyright Alan Baxter 2026

PROVENTRICULAR VALVE

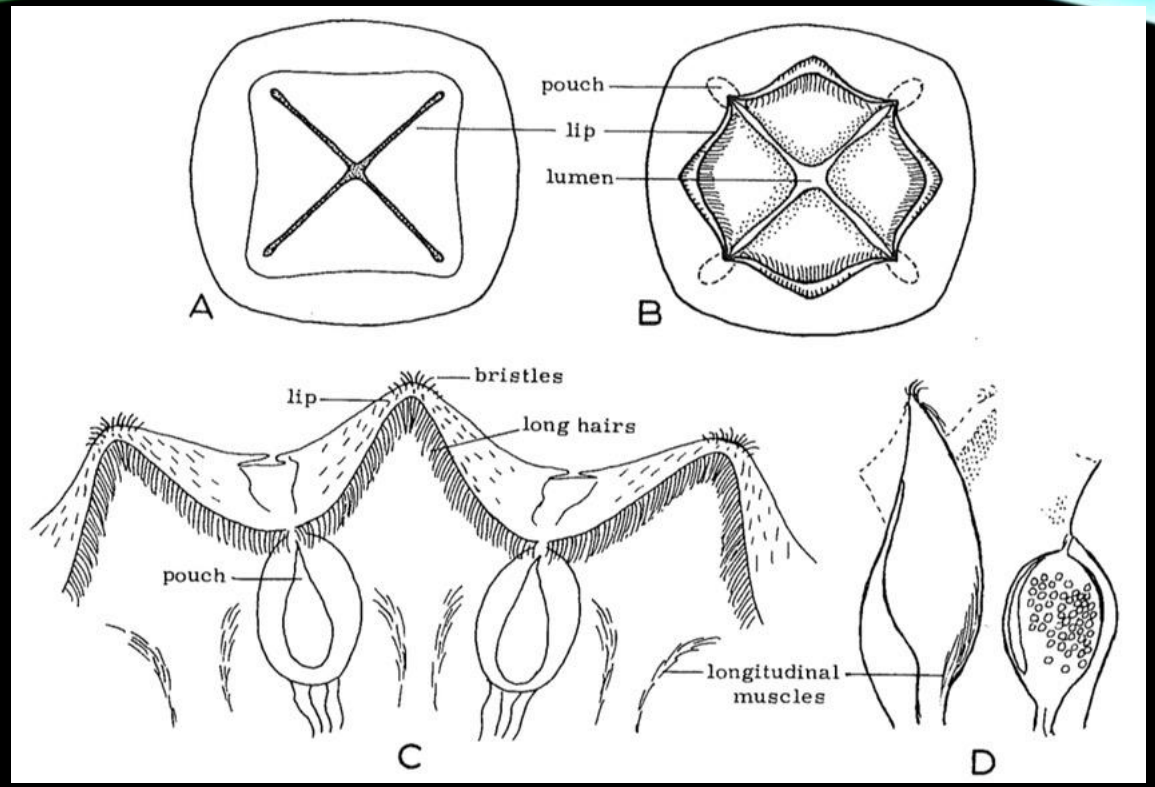
- When closed prevents nectar and water from entering the ventriculus
- Pollen is ingested by the mandibles and passes through the eosophagus to the proventriculus where it is filtered and mixed with nectar
- and passed into ventriculus for digestion



Copyright Alan Baxter 2026

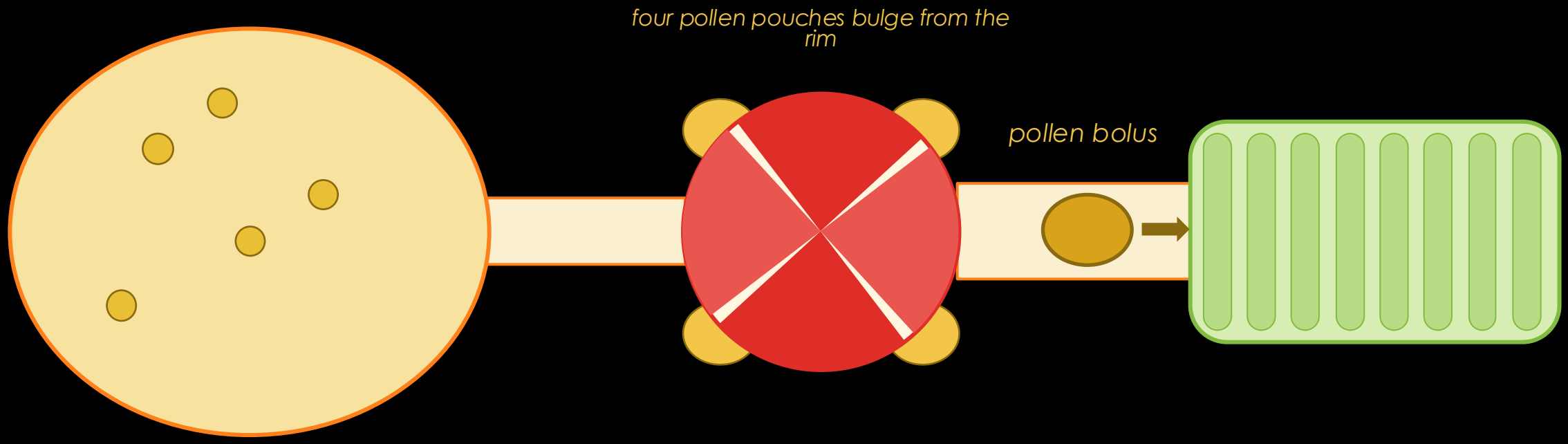
Proventricular valve

- Made up of 4 triangular flaps of tissue
- Edges lined with spines projecting towards the opening
- Filters out pollen grains in the nectar
- Makes gulping movements as it extracts the grains
- Forms grains into a bolus
- Passes them into the ventriculus for digestion



Copyright Alan Baxter 2026

Proventricular valve: gulping to filter pollen from nectar



Nectar stays in the crop while the lips retract and snap shut in rhythmic gulps — their spines rake out the pollen grains and pack them into a bolus that passes into the ventriculus.

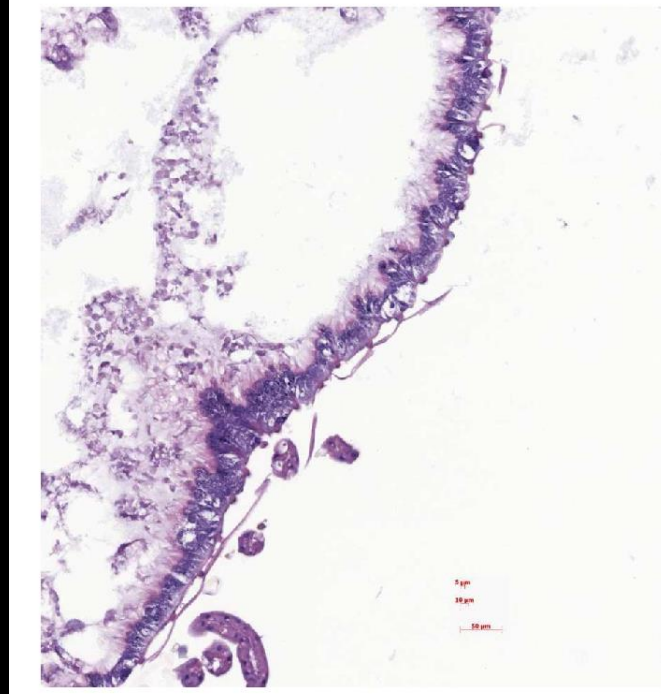
Copyright Alan Baxter 2026

VENTRICULUS OR MID-GUT

- Where most of digestion and absorption takes place
- Convoluted walls lined with epithelial cells in constant state of proliferation
- Produces cells which mix with the food mass
- Produces digestive chemicals and enzymes including:
-
    - Sucrase (invertase) chemical breaks down carbohydrates into simple sugars glucose and fructose
    - Amylase (diastase) chemical breaks down proteins from pollen
    - Lipase group of enzymes breaks down lipids into fatty acids and glycerol
    - Proteases group of enzymes facilitating certain processes in different amino acids
    - Some of these substances are also injected into the nectar by the hypopharyngeal glands of foraging bees, starting the process of transforming the nectar into honey before reaching the hive

- Food in the ventriculus is surrounded by a jelly-like peritrophic membrane produced continuously by the epithelium which

- Protects the wall of the ventriculus
- Allows enzymes and products of digestion to pass through and be absorbed by the haemolymph
- Prevents the passage of some pathogens into the haemolymph

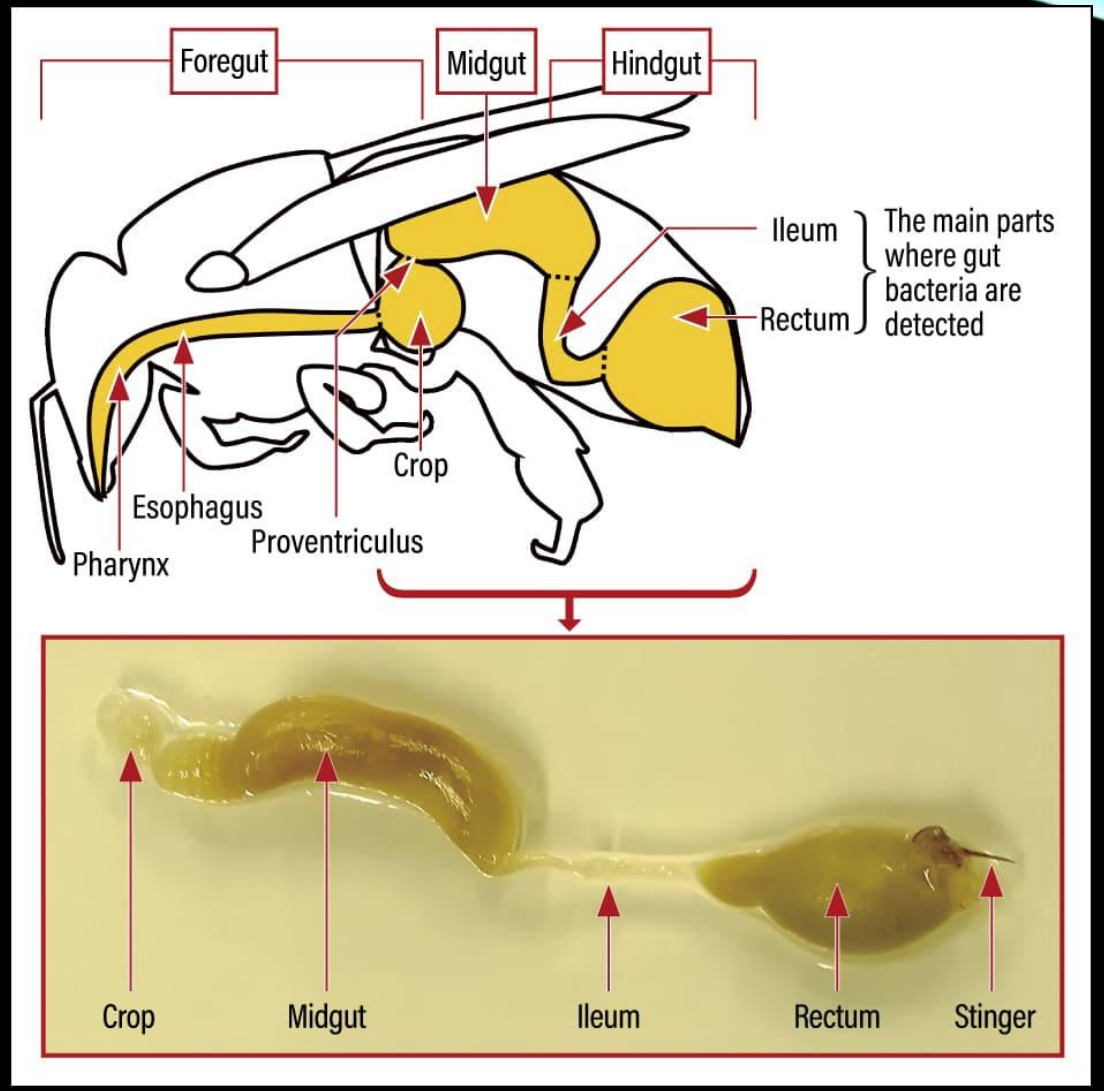


s section of ventriculus of a bee fed on pollen substitute. Strong merocrine

Copyright Alan Baxter 2026

ILEUM OR SMALL INTESTINE

- Continuation of the peritrophic membrane that lines the ventriculus
- Further absorption of digested food and some water and salts
- Walls folded to give greater surface area
- At the beginning is the pylorus with the openings of the Malpighian tubules



Copyright Alan Baxter 2026

THE EXCRETORY SYSTEM

Malpighian tubules

- Long, thin, blind-ended tubes
- single layer of epithelial cells
- float freely within the abdominal cavity
- empty directly into the digestive tract
- attach at the boundary between the midgut and hindgut (pylorus)
- contain tiny muscle fibres that cause them to wave around, maximizing exposure to the haemolymph.

Copyright Alan Baxter 2026

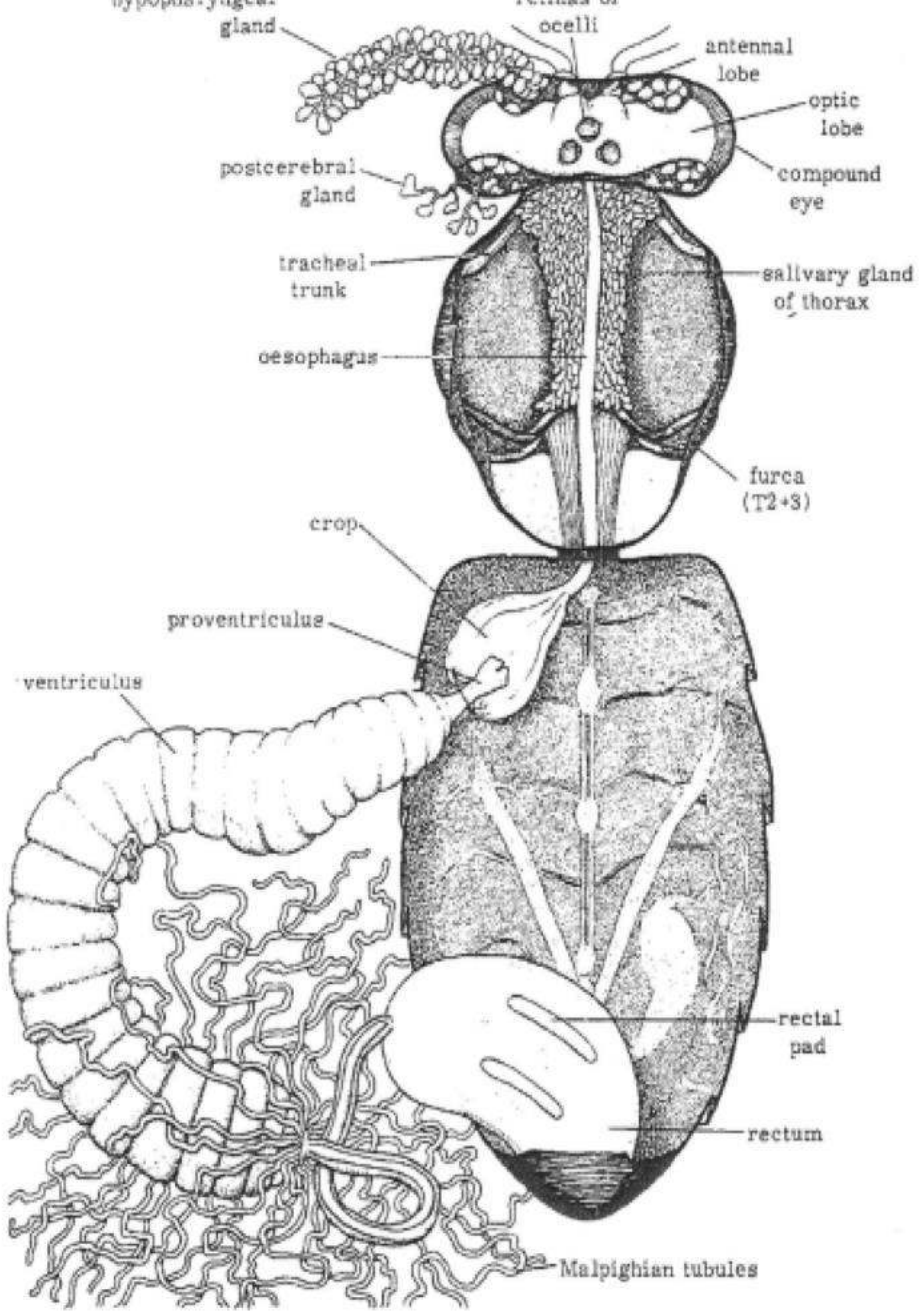


PLATE 9. Dissection of worker, Stage 2.
Glands of head lifted out, indirect flight muscles removed from thorax to expose underlying organs, and alimentary canal displayed.

HOW THE EXCRETORY SYSTEM WORKS

Consists of 4 processes:

Waste matter filtered from the haemolymph

Return to haemolymph of reusable elements

Transmission of waste products into the alimentary system

Removal of waste via the anus

Copyright Alan Baxter 2026

THE MALPIGHIAN TUBULES

- Wave around like thin threads in the abdominal cavity surrounded by heamolymph
- Waste substances are absorbed at the distal end of the tubules from the haemolymph
- Waste is filtered as it passes along the tubes
- Some water and dissolved salts are reabsorbed to maintain fluid balance
- Remaining waste passed into small intestine at the pylorus
- Main substance excreted is nitrogenous waste in the form of uric acid
- Solid waste products accumulate in the rectum as faeces.

Copyright Alan Baxter 2026

STRUCTURE OF MALPIGHIAN TUBULE

B Lumen

C. Microvilli

D Tracheole

E Muscle fibre

F Basement membrane

G Single layer of cells

H Showing the wall as a single layer of cells

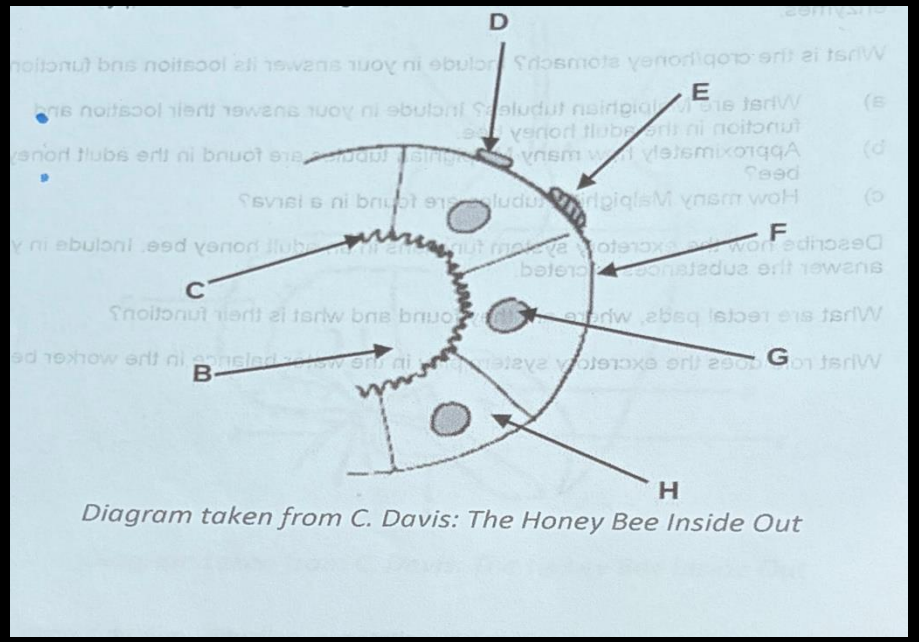


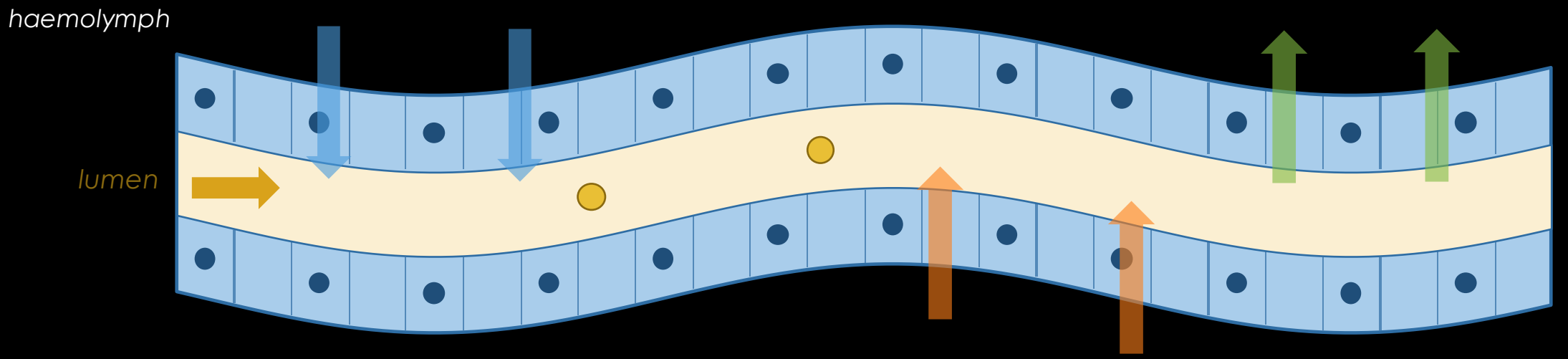
Diagram taken from C. Davis: The Honey Bee Inside Out

Copyright Alan Baxter 2026

Malpighian tubule: filtration, secretion and reabsorption

passive filtration
from haemolymph

reabsorption of useful substances
+ water into haemolymph



single layer of epithelial cells

active secretion
from haemolymph

t

Copyright Alan Baxter 2026

THE RECTUM AND RECTAL PADS

Extension of the tube after the ilium where the waste products of digestion in the form of faeces accumulate

Can expand enormously to hold the faeces until the bee can leave the hive to defaecate

Water and some remaining salts can be reabsorbed from the rectum

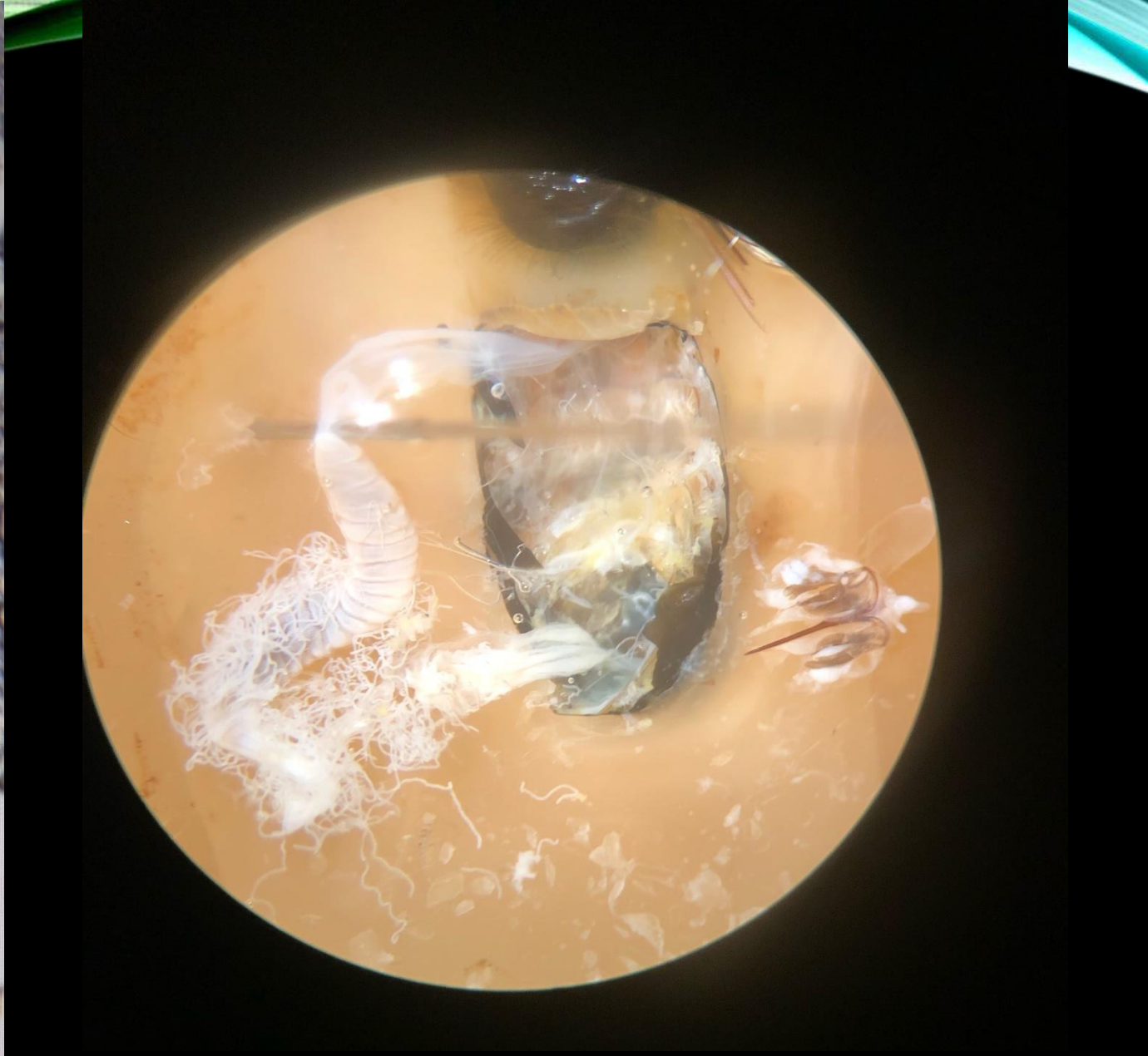
Carries 6 rectal pads which are thickened areas of the rectal wall

Metabolically active in the movement and reabsorption of > 90%of the water and dissolved substances back into the haemolymph

Important in maintaining a constant environment around the body's cells

Copyright Alan Baxter 2026





Copyright Alan Baxter 2026

THE ANUS

The opening to the outside

Situated on the proctiger, the hidden 10th abdominal segment as part of the sting chamber

Copyright Alan Baxter 2026

ANY QUESTIONS ?

Copyright Alan Baxter 2026

- **GLANDS ASSOCIATED WITH NUTRITION**
- **Salivary or Labial glands**
- **Hypopharyngeal glands**



Copyright Alan Baxter 2026

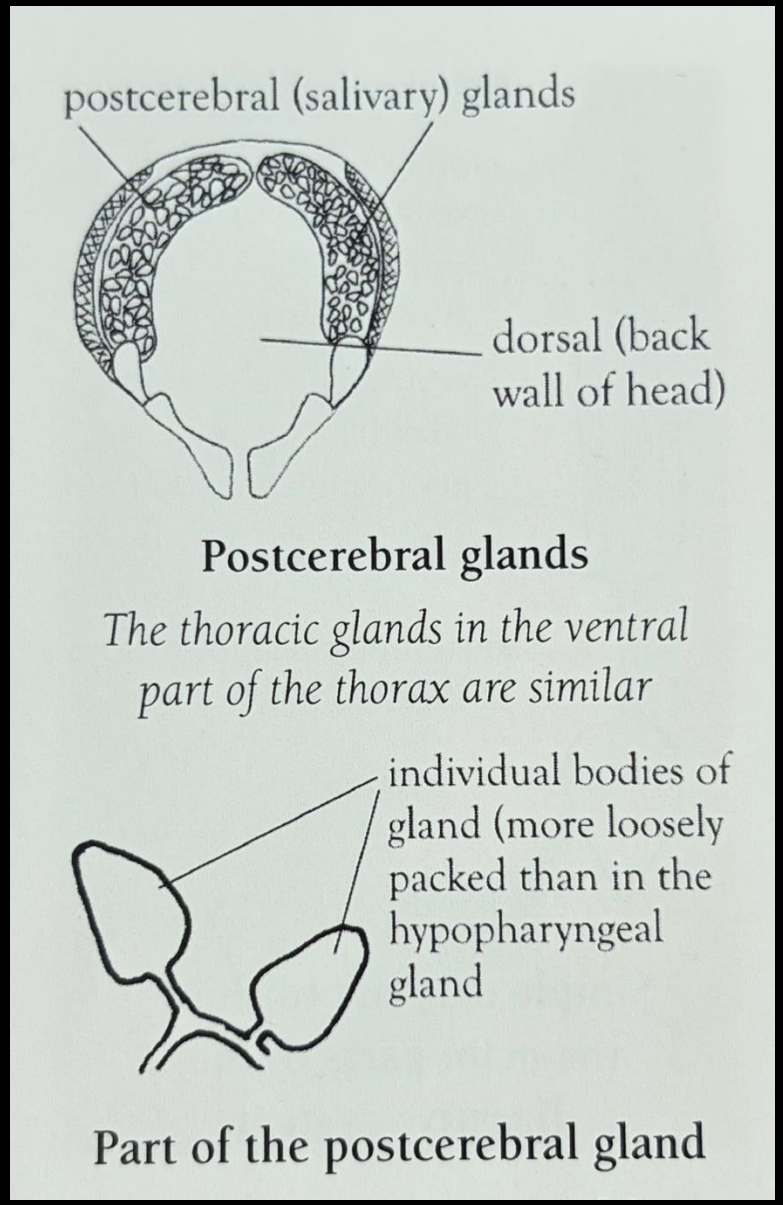
SALIVARY or LABIAL GLANDS

2 main salivary glands

- **Postcerebral in the head lead into the mouthparts**
- **Thoracic in the ventral part of the thorax**

Function:

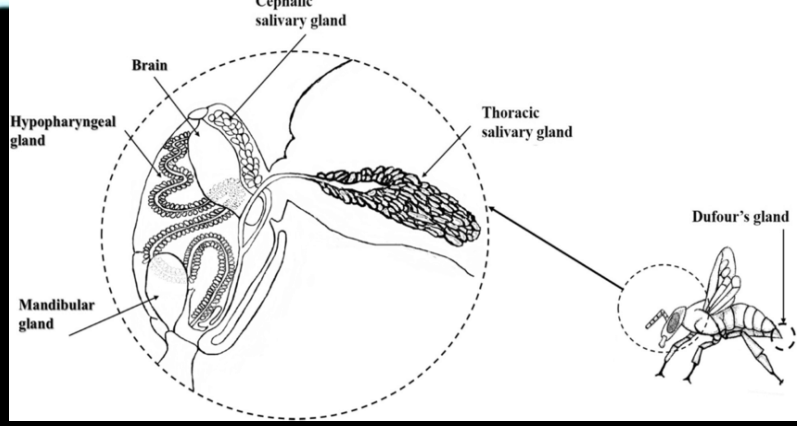
- **dissolve and lubricate dry foods such as pollen, crystallised stores and honeydew**
- **grooming the queen and other bees**
- **May contain elements of the enzymes involved in digestion as well as hydrocarbons and wax esters**

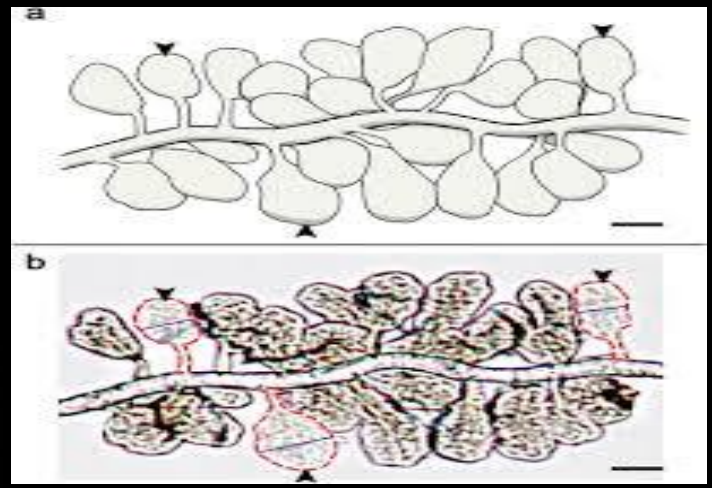


Copyright Alan Baxter 2026

HYPOPHARYNGEAL GLAND

- Located on each side of the head like bunches of grapes
- Have branches called acini
- Young bees produce brood food & royal jelly
- Older bees produce enzymes sucrase and glucose oxidase for the processing of honey
- Atrophied in winter bees but can reactivate in spring to feed larvae







Copyright Alan Baxter 2026

ANY QUESTIONS ?

Copyright Alan Baxter 2026

HOMEWORK

(a) Name five component parts of the alimentary system of the honey bee. (5 marks)

(b) State the main function of each component named in (a). (5marks)

(c) Describe the process by which food is broken down. (12 marks)

(d) Explain how the products of digestion are absorbed into the body of the honey bee. (8 marks)

(e) Describe the functions of the hypopharyngeal glands (5 marks)

NEXT WEEK

The Respiratory system of the honey bee

Copyright Alan Baxter 2026