MODULE 5
THE COMPOSITION, LOCATION AND FUNCTION OF THE FAT BODY

In the larva, pupa and adult hon



STORAGE • METABOLISM • IMMUNITY • LONGEVITY DETOXIFICATION

Coyriight Alan Baxter 2026

WHY IT MATTERS

The fat body is the bee’s metabolic command centre

Stores reserves. It holds fat, sugar and protein for later use.

Supplies the blood. It makes many proteins found in the haemolymph.

Protects the bee. It supports immunity and helps break down toxins.

Shapes lifespan. Its condition strongly influences how long a worker lives.

Thin layers of cells spread through the abdomen—especially along the dorsal and ventral body wall.

Varroa feeds on the fat body directly, and poor nutrition and pesticides also deplete it.

A STRIKING CONTRAST

Winter bees carry visibly larger fat-body reserves

SUMMER FORAGER



WINTER BEE

Image: Scientific Beekeeping

LOCATION

The fat body is distributed through the abdomen—not packed into one organ

Loose, creamy-white tissue forms thin sheets and lobes throughout the body cavity, directly bathed in haemolymph.

Parietal layer
Runs along the inner abdominal wall beneath the dorsal and ventral plates; it contains most of the tissue.

Perivisceral layer
Forms looser lobes around the gut and other internal organs.

Smaller amounts also occur in the thorax and head; products enter the open circulatory system directly.

In workers, tissue beneath the wax mirrors contributes to the wax gland complex.



Fig 10.41. Fat body cells from the roof of the abdomen

COMPOSITION

Fat bodies store three core resource types

LIPIDS
Neutral lipids—especially triglycerides—form droplets that supply energy and fatty acids.

CARBOHYDRATE
Glycogen can be mobilised into glucose and circulating trehalose.

PROTEIN
Substantial protein reserves support later physiological demands.

Vitellogenin is a key worker-bee reserve protein: the fat body synthesizes it and releases it into the haemolymph.

FUNCTION IN DETAIL

The fat body performs six overlapping jobs

NUTRIENT RESERVES
Pollen-derived lipids, glycogen and proteins buffer food scarcity and sustain brood provisioning.

VITELLOGENIN
Supports brood-food synthesis, antioxidant defence and delayed senescence.

ENERGY HOMEOSTASIS
Synthesises trehalose and mobilises lipid and glycogen reserves.

HUMORAL IMMUNITY
Secretes apidaecin, abaecin, hymenoptaecin and defensin as antimicrobial effectors.

XENOBIOTIC METABOLISM
Cytochrome P450 enzymes metabolise phytochemicals and pesticide xenobiotics.

ENDOCRINE SIGNALLING
Insulin/TOR pathways and juvenile hormone regulate the transition to foraging.

CELL TYPES

Two cell types divide storage, synthesis and detoxification

CELL TYPE	ORIGIN	CONTENTS	MAIN ROLES
Trophocytes (fat cells / adipocytes)	Mesoderm	Lipid droplets, glycogen and protein granules	Storage; vitellogenin and haemolymph-protein synthesis; immune peptides
Oenocytes	Ectoderm	Dense cytoplasm and extensive smooth endoplasmic reticulum	Lipid and hydrocarbon synthesis, including cuticular hydrocarbons; detoxification

Trophocytes dominate storage; oenocytes specialise in synthesis and detoxification.

LARVAL DEVELOPMENT

The larval fat body grows and accumulates reserves

GROWTH DURING FEEDING

Fat-body tissue expands as the larva grows. Trophocytes take up nutrients and accumulate energy reserves.

PREPARATION FOR METAMORPHOSIS

Lipid, glycogen and protein reserves support development after larval feeding ends.

The larval stage builds the reserves that sustain the non-feeding pupa.

Developmental overview for the honey bee, Apis mellifera

PUPAL DEVELOPMENT

The pupal fat body remodels as stored reserves fuel development

RESERVE MOBILISATION

The pupa does not feed. Stored nutrients provide energy and building materials for adult tissue development.

TISSUE REMODELLING

Fat-body cells change their organisation and metabolic activity during metamorphosis.

The emerging adult has a fat body adapted to adult metabolic demands.

AI-generated conceptual schematic. Amber indicates fat body. Not to scale or a histological image.

IMAGO: ADULT WORKER

The fat body in the adult honey bee

DISTRIBUTED TISSUE

Thin sheets and lobes lie beneath the abdominal wall and around internal organs, in direct contact with haemolymph.

METABOLIC AND IMMUNE FUNCTIONS

The fat body stores nutrients, synthesises vitellogenin and antimicrobial proteins, and helps metabolise toxins.

In workers, reserves are high in nurses and winter bees and lower in foragers.

Imago = adult insect. Fat-body condition varies with behavioural role, age and season.

COMPOSITION IN CONTEXT

Cell condition changes as the bee moves from nurse to forager

TROPHOCYTES

Most of the tissue. They swell with lipid and protein in nurse and winter bees and shrink in old foragers.

OENOCYTES

Larger, scattered cells that process lipids and detoxify.

Both cell types sit within a thin connective sheath threaded with oxygen-supplying tracheae.



ig 10.37. Fat body cells in the floor of the abdomen, with a high proportion of enocytes.

Urate cells, which store nitrogenous waste in some insects, are generally not described in the adult honey bee fat body.

BRAIN–FAT BODY SIGNALLING

Hormonal signals connect nutrition to worker behaviour

BRAIN
Neurosecretory cells make peptide hormones; their axons run to the corpora cardiaca.

→ CORPORA CARDIACA
This neurohaemal organ stores brain peptides and releases them into haemolymph.

→ CIRCULATING SIGNALS
Insulin-like peptides and other hormones carry the metabolic message.

↔ FAT BODY RESPONSE
Juvenile hormone and vitellogenin trade off against one another.

The signalling loop helps coordinate nutritional state with the transition from nursing to foraging.

SEASON AND AGE

Reserves peak in nurses and winter bees and fall in foragers

YOUNG NURSES
Fat cells swell with lipid and protein; vitellogenin is high and feeds the brood.

FORAGERS
Reserves shrink and vitellogenin falls as workers move from nursing to foraging.

WINTER BEES
Protein- and vitellogenin-rich reserves sustain the colony through winter.

SPRING
Reserves fuel brood-food production when nursing resumes.

Reserve content tracks role, age and season, not just the amount of tissue.

THE WINTER-BEE PATHWAY

Pollen reserves become overwinter survival—and then spring brood

01 POLLEN-DERIVED NUTRIENTS

→ 02 FAT BODY

→ 03 PROTEIN + LIPID RESERVES

→ 04 OVERWINTER SURVIVAL

→ 05 SPRING BROOD REARING

This chain is a major physiological difference between a short-lived summer worker and a long-lived winter worker.

LECTURE SUMMARY

Structure and function of the fat body

DISTRIBUTED TISSUE

Sheets and lobes beneath the abdominal wall and around organs exchange nutrients and proteins with haemolymph.

SPECIALISED CELLS

Trophocytes store nutrients and produce proteins. Oenocytes specialise in lipid and hydrocarbon synthesis and detoxification.

MORE THAN AN ENERGY STORE

Lipid, glycogen and protein reserves support metabolism. The tissue also produces immune proteins and metabolises foreign chemicals.

Vitellogenin supports brood-food production, antioxidant defence and longevity.

LECTURE SUMMARY

The fat body changes through the life cycle

LARVA
Feeding supports tissue growth and the accumulation of lipid, glycogen and protein reserves.

PUPA
Feeding stops. Stored nutrients fuel adult tissue development while the fat body remodels.

IMAGO (ADULT)
The fat body supports metabolism and immunity. Its condition varies with age, behaviour and season.

Larval reserves sustain metamorphosis. Adult reserves support changing worker demands.

LECTURE SUMMARY

Adult roles, hormonal control and colony health

RESERVES FOLLOW WORKER ROLE

Nurses and winter bees carry substantial reserves and high vitellogenin levels. Reserves decline as workers become foragers.

NUTRITION AND BEHAVIOUR ARE LINKED

Brain–fat body signalling, insulin-related pathways and juvenile hormone help coordinate the transition from nursing to foraging.

TISSUE HEALTH SUPPORTS COLONY SURVIVAL

Varroa, poor nutrition and pesticides threaten the fat body. Pollen-derived reserves support overwinter survival and spring brood rearing.

Fat-body condition connects individual physiology with colony resilience.

ANY QUESTIONS

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The role of the stomatogastric system and associated physiological pathways

From winter survival to spring activity: how changing food supply and gut function help reawaken the colony

The integrated pathway

Environmental cues (temperature, day length, pollen/nectar) → **SNS** (gut–brain–endocrine integration) → **Proventriculus** (regulated transport) → **Nutrient absorption** (haemolymph signalling) → **Hypopharyngeal glands** (royal jelly production) → **Brood rearing** (increased demand) → **Endocrine shift** (JH ↑, vitellogenin ↓) → **Behavioural transition** (winter → nurse → forager)

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1 Environmental and nutritional change

- Increasing day length and temperature
- Availability of fresh pollen and nectar
- Change in colony demand (brood rearing resumes)



Spring pollen and nectar provide the external trigger

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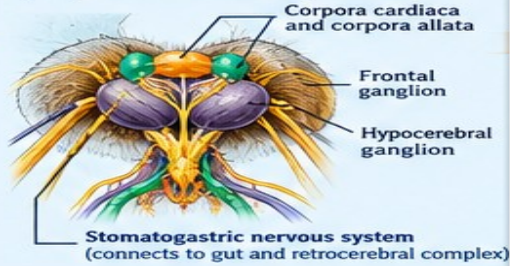
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Spring pollen and nectar provide the external trigger

2 Stomatogastric nervous system (SNS) activation

Sensory input from the gut and haemolymph (nutrient status) is integrated in the SNS, which connects with the retrocerebral complex (corpora cardiaca and corpora allata).



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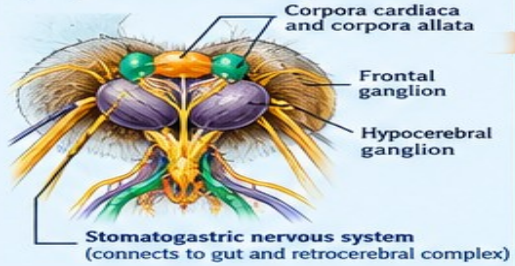
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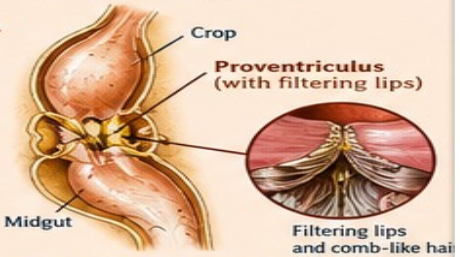
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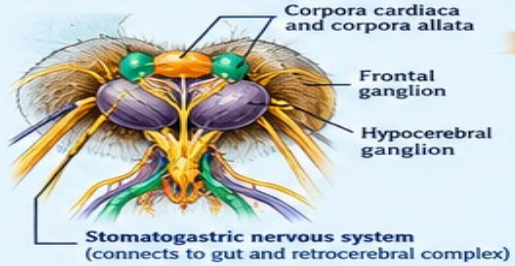
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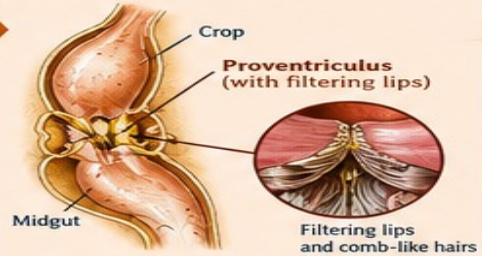
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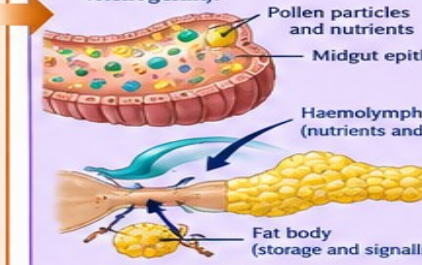
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4 Nutrient assimilation and haemolymph signallin

Increased pollen and nectar intake boosts nutrient delivery to the midgut. Nutrients are absorbed and transported in the haemolymph, triggering metabolic and endocrine changes (e.g. juvenile hormone, vitellogenin).



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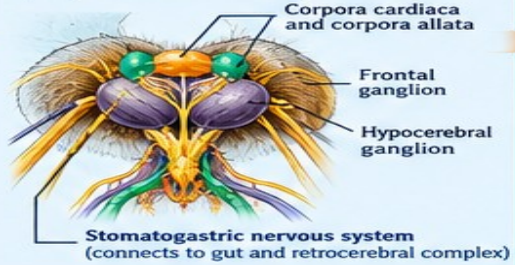
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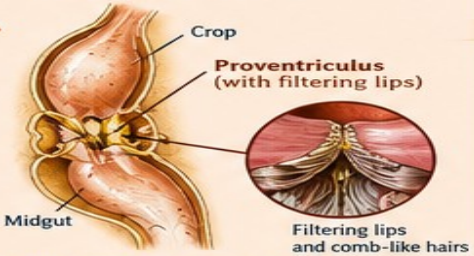
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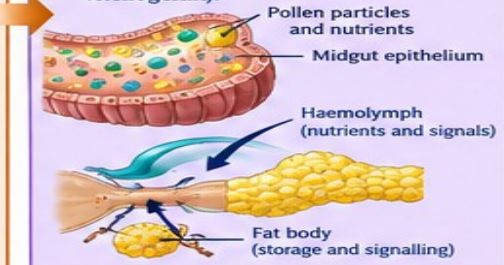
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The Winter to Spring Transition in Honey Bees

The role of the stomatogastric system and associated physiological pathways

From winter survival to spring activity: how changing food supply and gut function help reawaken the colony

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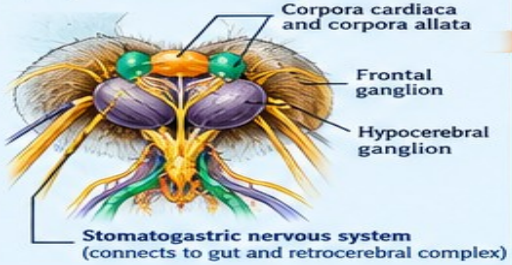
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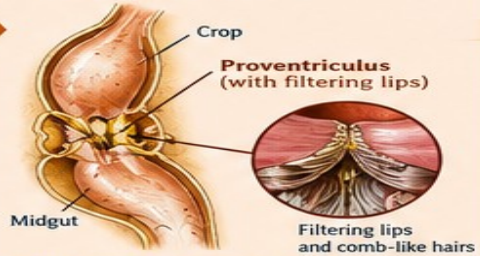
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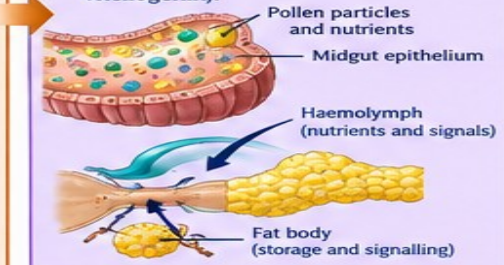
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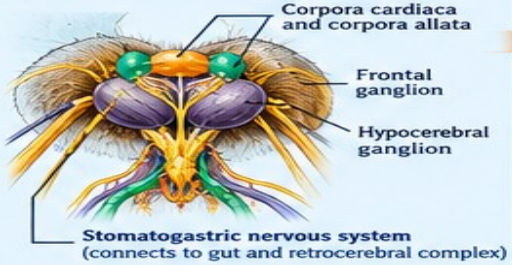
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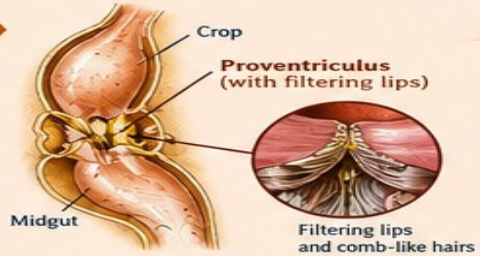
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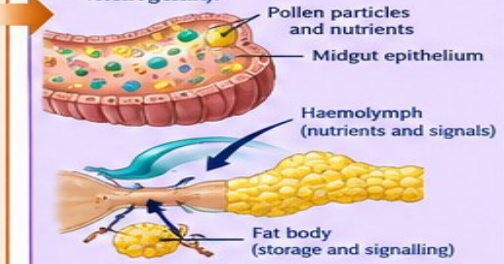
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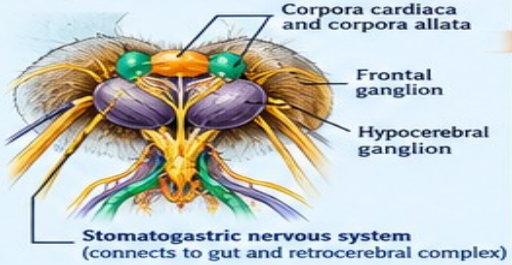
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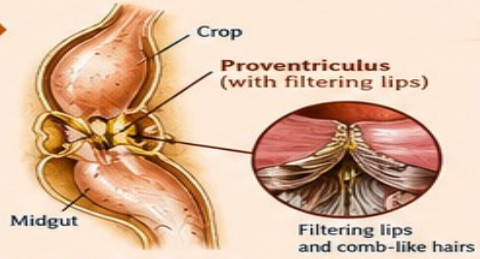
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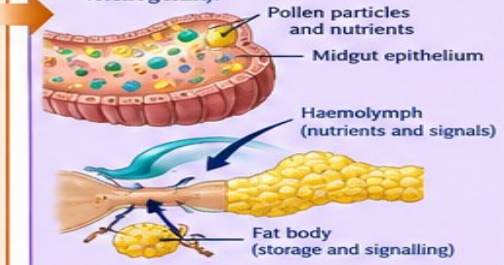
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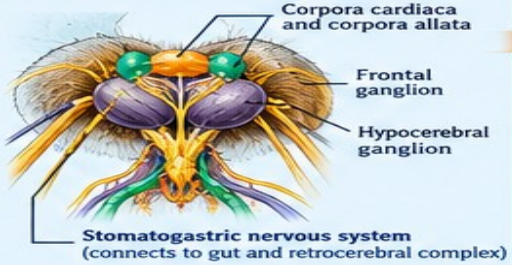
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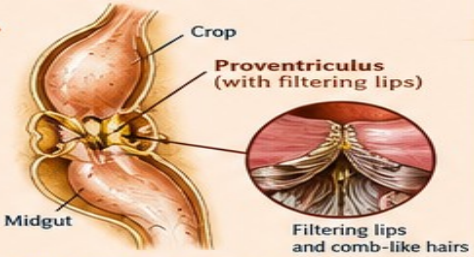
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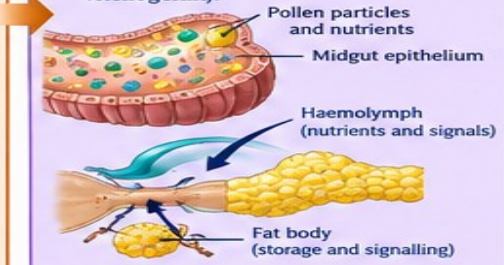
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Workers shift from winter behaviour (energy conservation, thermoregulation) to nursing and foraging roles, sustaining colony growth and population increase.



Winter bee (long-lived, low activity) → **Nurse bee** (brood care, high feeding) → **Forager** (outside colony, flights, nectar/pollen)

Kunz et al. (2019) *Apidologie* **50**, 819–833.

9 Outcome

- Reactivated hypopharyngeal glands
- Increased brood production
- Higher juvenile hormone (and lower vitellogenin)
- Shift to nurse and forager workforce
- Colony growth and increased foraging activity



A thriving colony in spring

The integrated pathway

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8. Behavioural transition: winter bee → nurse → forager
9. Reactivated colony growth and spring activity

Endocrine control of laying worker development

Apis mellifera — how removal of two pheromonal signals releases the worker ovary

Queenright colony

Ovaries suppressed

Colony signal	Queen mandibular pheromone (9-ODA, HVA) plus brood ester pheromone from open larvae
Brain	HVA holds dopamine signalling down; receptor expression reduced
Corpora allata	Juvenile hormone titre low in nurse-age workers
Fat body	Vitellogenin synthesised, then exported as brood food
Ovariole	Oocytes resorbed by programmed cell death
Outcome	Under 1% of workers with activated ovaries; stray eggs removed by policing

Endocrine control of laying worker development

Apis mellifera — how removal of two pheromonal signals releases the worker ovary

	Queenright colony Ovaries suppressed	Queenless and broodless Ovaries activated
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Juvenile hormone is consistently elevated in laying workers, but analogue treatment does not reliably induce ovary activation — read it as permissive rather than proven causal.