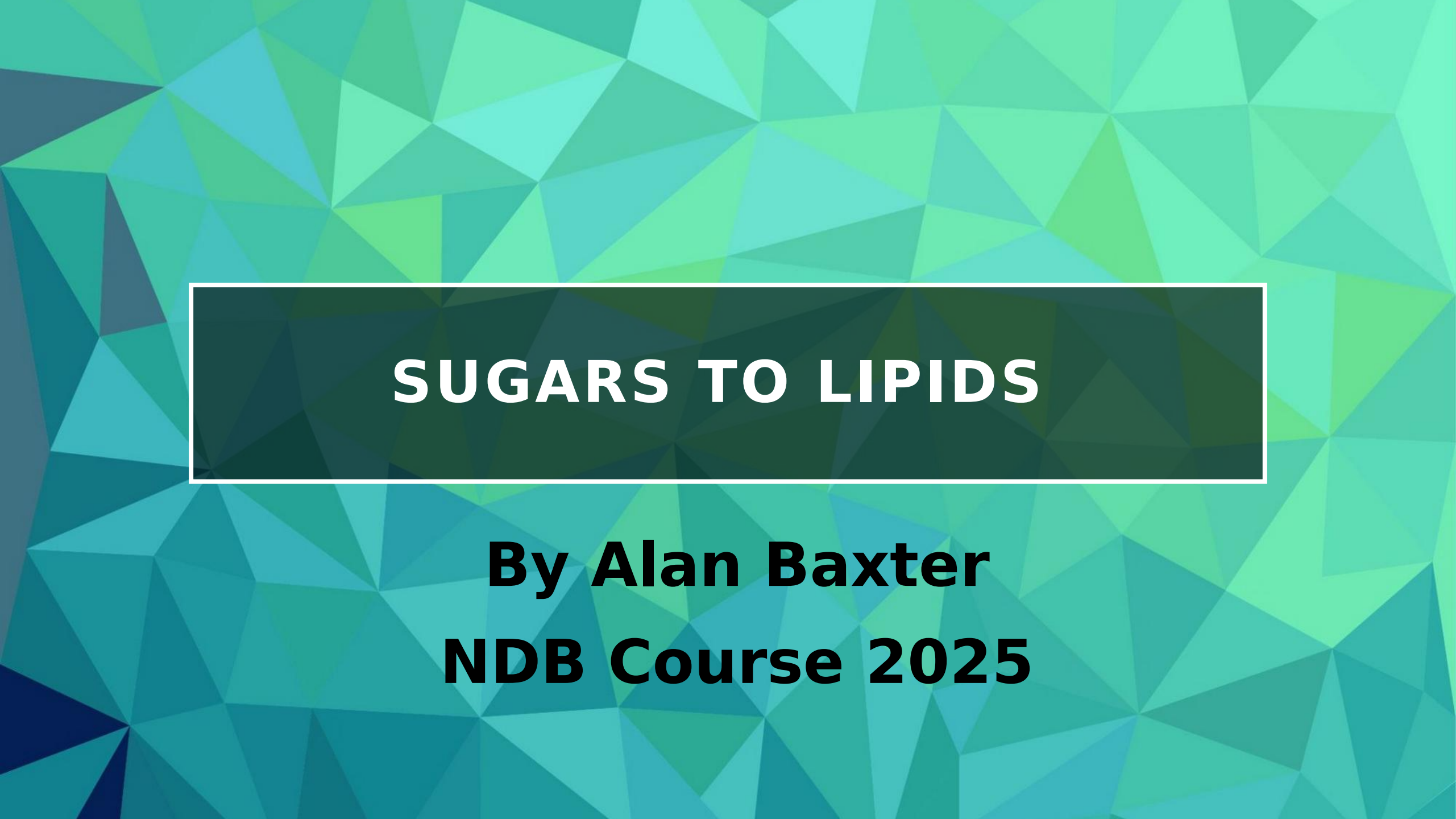




# **SUGARS TO LIPIDS**

**By Alan Baxter**  
**NDB Course 2025**

# Introduction

- All organisms need to balance processes that *consume* energy against those that *produce* energy.
- As evolution produced an increase in biological complexity, regulation of this balance became much more complex, resulting in specialisation of metabolic tasks between organelles, cells and organs.
- In the case of honey bees which are eusocial organisms, characterised by cooperative brood care, overlap of generations and reproductive division of labour, specialisation is between the individuals that comprise the 'superorganism'.
- Those individuals specialise in different tasks, a process we

- **The rise in metabolic disorders in the past decades has heightened focus on achieving a healthy dietary balance in humans.**
- **This is also an increasingly important issue in the management of honey bees (*Apis mellifera*)**
- **Poor nutrition having negative effects on honey bee health is suggested as a contributing factor in the recent global declines in honey bee populations and in particular in the United States.**

# **Nutritional needs of honey bees**

**For survival and reproduction honey bees require :**

- **Carbohydrates in the form of sugars in nectar or honey**
- **Protein, obtained from diverse sources of pollen,**
- **Vitamins, minerals (salts), and water.**
- **Lipids (fatty acids, sterols),**
- **All must be present in the right ratio at the right time for honey bees  
to maintain a healthy gut microbiome and to survive and thrive.**
- **excess glucose can also be converted to body fats and stored.**

# **Pollen**

- **Pollen provides bees with protein, minerals, lipids, and vitamins.**
- **All animals need essential amino acids, which must be obtained externally and cannot be synthesized by animals.**
- **Honey bees also need the same 10 amino acids as other animals.**
- **In the case of honey bees, amino acids are obtained from pollen only, because honey bees do not have any other sources of protein.**
- **When honey bees are provided with insufficient pollen, or pollen with low nutritional value, brood rearing decreases, ultimately affecting colony productivity**

- **Studies have shown that spring pollen supplement can lead to faster spring buildup and higher honey yield**
- **reduce the effects of varroa parasitism and nosema.**
- **lipids provide long-term energy reserves and are the major components of the fat body.**
- **Pollen supplements or substitutes are recommended to contain 5-8% of lipids.**
- **Not all pollens are equal, and a variety of different pollens are needed to fill the gaps in areas of monoculture e.g. almonds in America.**

# Sugars

- **Honey bees forage for nectar**
- **The bees inject into the nectar the enzymes sucrase (invertase) and diastase**  
**for converting sucrose to the two simple sugars , glucose and fructose.**
- **Glucose oxidase converts glucose to gluconic acid the antibacterial agent hydrogen peroxide.**
- **Sugars are used for immediate energy requirements by being broken down to create energy plus carbon dioxide and water as by-products.**
- ***When there is excess sugar, the bees convert it into lipids in a***

# **Lipids**

- **Reproduction requires a high metabolic rate that provides viable eggs in a relatively short time.**
- **an accurate interplay between the endocrine system and nutrients is essential to produce healthy offspring.**
- **Lipids provide the metabolic energy needed for egg formation and represent the main energy source consumed during embryogenesis.**
- **Sterol is the precursor for important hormones such as moulting hormone, which regulates pupal growth.**

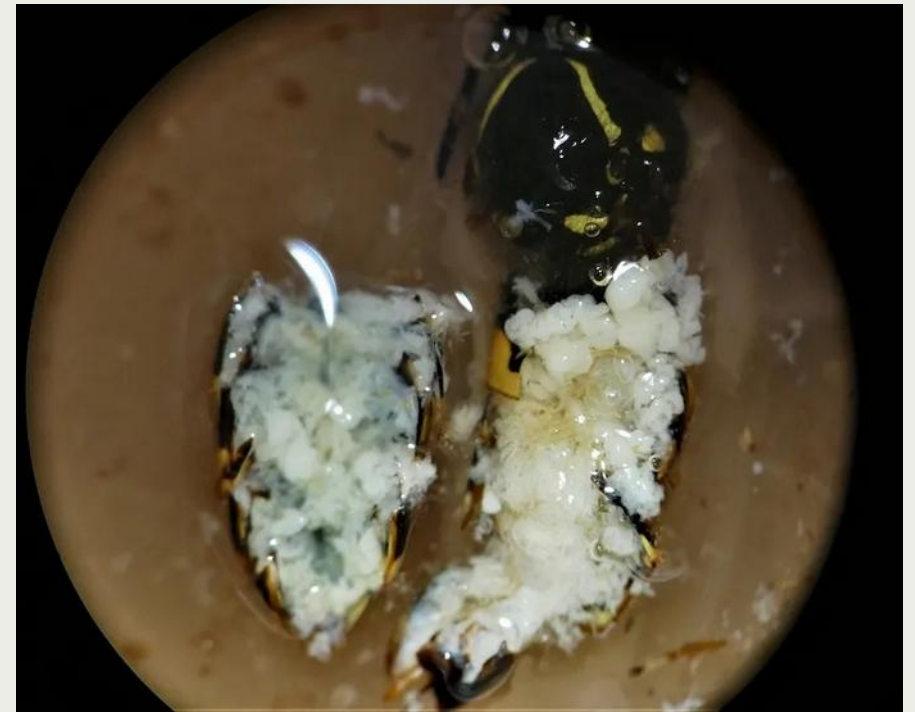
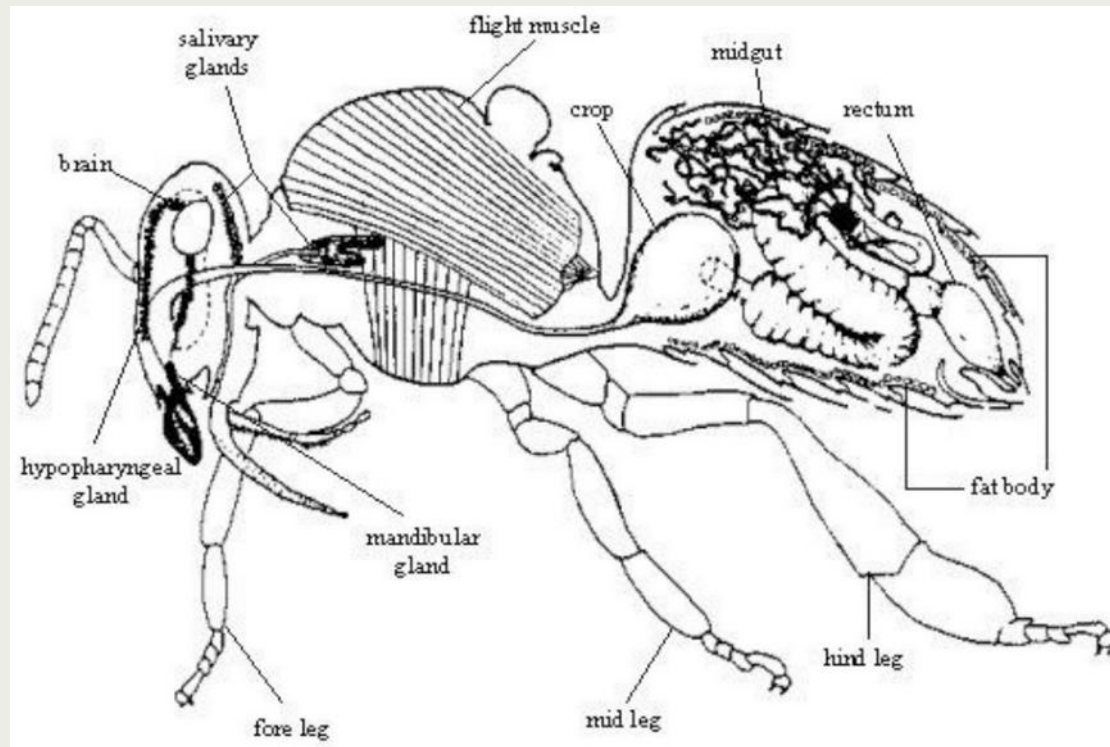
- **Mandibular gland secretes the lipid-rich component in Royal Jelly (about 4%).**
- **Lipids stored in the fat body of the winter bees are an essential factor in the survival of the colony over winter and its ability to feed larvae in spring.**
- **Lipids are involved in bee behavioural development, when the transition from nurses to forager bees is accompanied by a decrease in lipid storage in the fat body.**

# Lipogenesis

- Occurs mainly in the fat body which is an organ similar to the liver in mammals.
- Fat body contains various different cell types
- Adipocytes and oenocytes are the primary cells related to lipid metabolism.
- Lipid metabolism starts with the hydrolysis of dietary lipids and absorption of glycerine and fatty acids
- Followed by transport of the lipids from midgut to the fat body



*Honey bee fat body  
Photo Scientific  
Beekeeping*



***Fat body of queen bee  
Photo by Ann Chilcott***

- **Lipids availability is tightly regulated by a complex network of endocrine signals**
- **by the central nervous system and the endocrine glands, the *corpora allata* and *corpora cardiaca*.**
- **provide hormones and neuropeptides that affect tissues involved in reproduction:**
- **the fat body supplies the lipid resources and energy for egg formation and the ovaries, where the developing oocytes recruit lipids that will be used for embryogenesis.**
- **Phospholipids are present in honey bee semen.**
- **The corpora allata produces the chemical precursor for Juvenile Hormone.**

- **Increases in the haemolymph level of Juvenile Hormone underlie behavioural development, from nest duties to foraging.**
- **Acting antagonistically with the protein Vitellogenin**

- **Importance in colony function**
- **The transition from nest tasks to foraging is accompanied by many physiological changes in workers. One of these events occurs in the fat body.**
- **Nurses maintain high lipid stores in the fat body but undergo dramatic loss of lipid stores prior to the transition to foraging behaviour and remain lean for the remainder of their lives (Toth and Robinson, 2005).**
- **Loss of lipids minimises energy loss to the environment from the high attrition rate of foragers and increasing flight performance by lowering body weight.**
- **This makes evolutionarily sense, as foragers are stripped of transferable resources that otherwise would be lost to the colony when foragers die in the field.**

- **Consequences of lipid deficiency**

- **Lipid depletion due to malnutrition in the colony causes an early transition of nurse bees to foragers at a younger age and living shorter lives.**
- **Unbalanced diet of fatty acids also disturbs the capacity of bees to recognise unhealthy brood, which could negatively affect the hygiene and health of the colony.**
- **Lack of lipids results in a lower rate of egg production in the queen and of spermatozoa in the drone.**
- **Lower levels of lipids in the fat body compromise the survival of winter bees.**

## **Summary**

- **Honey bees need a balanced diet of carbohydrates, proteins, lipids, vitamins and minerals to be healthy and to live longer lives.**
- **Lipids are found in pollen and excess sugars are processed into lipids and stored in the fat body.**
- **Lipids are an important part of that diet as they provide**
  - **the energy required for reproduction**
  - **essential elements of brood food and royal jelly**
  - **regulation of the efficient life of the colony**
  - **ensure the survival of the colony in winter and during food shortages**
- **Lipids are vitally important in all stages of the life of the individual and in the efficient operation of that extraordinary superorganism**

**References/further reading:**

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**5.Turner et al., 1973; Kleinschmidt and Kondos, 1976, 1977) and workers live shorter lives**