

Honey Bee Nutrition

Photo by Kathy Garvey



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Presentation Outline

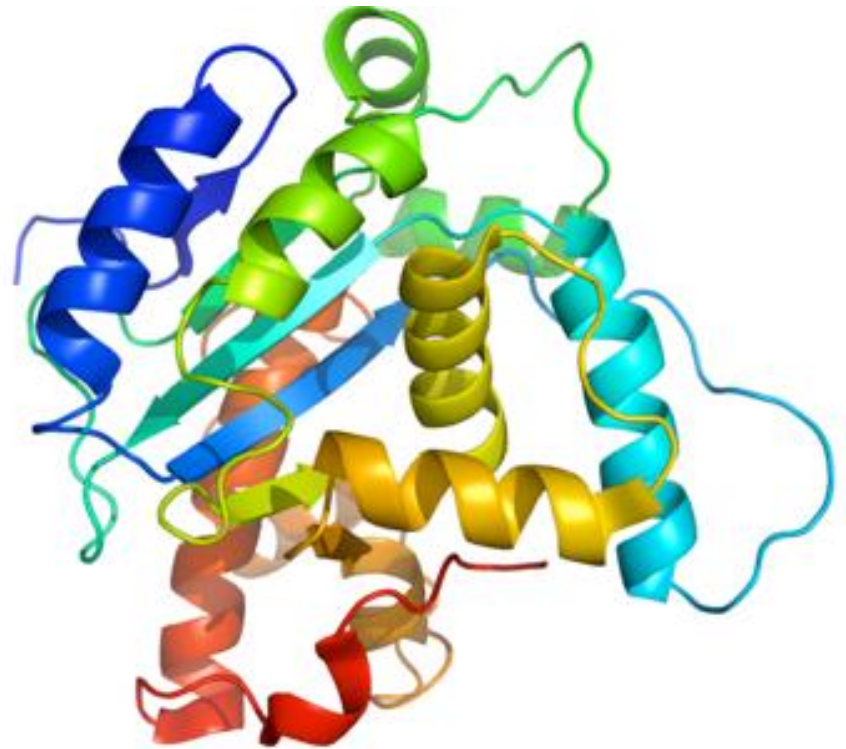
- I. Definition of Nutrition
 - II. Macronutrients
 - III. Micronutrients
 - IV. Honey Bee Enzymes
 - V. Physiological Effects of Good Nutrition
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Definition of Nutrition

- The provision, to cells and organisms, of materials necessary to support life
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Honey Bee Macronutrients

- Macronutrients are required in substantial amounts
- Proteins
 - Digestible and indigestible (soluble *versus* crude)
 - Specifically folded, very long chains of amino acids



Graphic by Prof. Laura Pozzi

Honey Bee Macronutrients

■ Proteins

- Range from 2.5 to 61 percent, by dry weight, in pollens
 - Most pollens contain 10-30 percent protein, with a mean around 20 percent
 - 20 percent is a good average for building pollen substitutes – tends to keep things “in balance”
 - protein concentration and free amino acids differ between freshly-collected and stored pollens generated from them
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Essential Amino Acids (*)

(Essential for children †)

- Alanine
- Arginine*††
- Aspartic acid
- Asparagine
- Cystine†
- Glutamic acid
- Glutamine
- Glycine
- Histidine*
- Isolucine*
- Leucine*
- Lysine*
- Methionine*
- Phenylalanine*
- Proline
- Serine
- Threonine*
- Tryptophan*
- Tyrosine†
- Valine*

Honey Bee Macronutrients

■ Carbohydrates

- Any of a group of organic compounds that includes sugars, starches, celluloses, and gums and serves as a major energy source in the diet
 - Honey bees can utilize only monosaccharides and disaccharides
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Sugars and Honey Bees

- Can digest and utilize
 - Glucose
 - Fructose
 - Sucrose
 - Trehalose
 - Maltose
 - HFCS
 - Lightly fermenting sugars
 - Glycogen
 - Small pectins
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Sugars and Honey Bees

- Cannot digest (dysentery)
 - ❑ Starch (do have some diastase – starch not poisonous)
 - ❑ Corn syrup (kitchen)
 - ❑ Turbino sugar
 - ❑ Dextrins (soda syrups)
 - ❑ Sorbose
 - ❑ Melezitose
 - ❑ (Fermenting sugars too far gone)
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Sugars and Honey Bees

- **Poisonous** to honey bees
 - Lactose
 - Galactose
 - Raffinose
 - Mannose (extremely)
 - Hydroxymethylfurfural (HMF)
 - Stachyose (from some soy bean varieties)
 - “Souring” syrup
 - alcohol of fermenting syrup converted to organic acids
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Long Chain Carbohydrates and Honey Bees

- Indigestible to honey bees
 - Digestible by intestinal microbes
 - Causes dysentery (diarrhea)
 - Major problem with trying to winter honey bee colonies on “honeydew” (dextrins)
 - Problem typical of feeding dark-colored soft drink syrups
 - Problem typical with molasses and “Sugar in the Raw,” etc.
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Honey Bee Macronutrients

- Lipids – not too well studied in honey bees, but definitely required
 - Range from 1-20% in pollens; usu. <5%, and <0.5% sterols
 - Saturated fats
 - Butyric acid (C4)
 - Caproic acid (C6)
 - Caprylic acid (C8)
 - Capric acid (C10)
 - Lauric acid (C12)
 - Myristic acid (C14)
 - Pentadecanoic acid (C15)
 - Palmitic acid (C16)
 - Margaric acid (C17)
 - Stearic acid (C18)
 - Arachidic acid (C20)
 - Behenic acid (C22)
 - Lignoceric acid (C24)
 - Cerotic acid (C26)

Honey Bee Macronutrients

- Lipids
 - Monounsaturated fats
 - Myristol
 - Pentadecenoic
 - Palmitoyl
 - Heptadecanoic
 - Oleic acid
 - Eicosen
 - Erucic acid
 - Nervonic acid
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Honey Bee Macronutrients

- Lipids

- Polyunsaturated fats

- Linoleic acid – essential fatty acid
 - α -linolenic acid – essential fatty acid
 - Stearidonic acid
 - Arachidonic acid
 - Timnodonic acid
 - Clupanodonic acid
 - Cervonic acid
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Honey Bee Macronutrients

■ Lipids

- Terpenoids (isoprenoids)
 - converted to sterols and steroids
 - eucalyptol
 - limonene
 - pinene
 - citral
 - menthol
 - camophor
 - ginger
 - cannabinoids
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Honey Bee Macrominerals (?)

- Calcium
 - Chloride
 - Magnesium
 - Phosphorus
 - Potassium
 - Sodium
 - Iron
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Honey Bee Trace Minerals (?)

Boron

Iodine

Zinc

Cadmium

Lead

Cobalt

Lithium

Chloride

Manganese

Chromium

Molybdenum

Copper

Nickel

Fluoride

Selenium

Important Organic Acids

- Acetic acid
 - Citric acid
 - Lactic acid
 - Malic acid
 - Choline
 - Taurine
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Honey Bee Micronutrients

- Micronutrients are required, but in very small amounts
 - Vitamins
 - Water soluble – fleeting in animal systems and usually non-toxic in reasonable amounts
 - Vitamin B₁ (thiamin)
 - Vitamin B₂ (riboflavin)
 - Vitamin B₃ (niacin)
 - Vitamin B₅ (pantothenic acid)
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Honey Bee Micronutrients

■ Vitamins

- Water soluble – fleeting in animal systems and usually non-toxic in reasonable amounts
 - Vitamin B₆ group
 - pyridoxine
 - pyridoxal
 - pyridoxamine
 - Vitamin B₇ (biotin)
 - Vitamin B₈ (ergadenylic acid)
 - Vitamin B₁₂ (cyanocobalamin)
 - Choline
 - Vitamin C (ascorbic acid)
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Honey Bee Micronutrients

■ Vitamins

- Fat soluble – long lasting in animal systems and can accumulate to toxic levels
 - Vitamin A (retinol) (from β -carotene)
 - Vitamin D
 - Vitamin E (tocopherol)
 - antioxidant that protects Vitamins A and C
 - Vitamin K
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Honey Bee Micronutrients

■ Carotenoids

- Tetraterpenoid organic pigments
 - Essential to animals (plant-produced)
 - Xanthophylls have oxygen
 - lutein (antioxidant; blue light absorption)
 - zeaxanthin (yellow color in corn)
 - Carotenoids have no oxygen
 - absorb blue light (UV shield)
 - antioxidants
 - carotenes (carrots)
 - lycopene (tomatoes) ((prostate cancer??))
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More Honey Bee Micronutrients

- Chlorophyll
 - Curcumin (tumeric)
 - ginger family
 - Indol-3-carbinol
 - Isothiocyanates
 - Lignans
 - Phytosterols
 - 24-methylcholesterol (algae, canola oil)
 - Resveratrol
 - Isoflavones
- Polyphenols
 - Bioflavonoids
 - Organic acids
 - Phenolic acids
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Classical Description of Nectary Type

- Floral nectaries (FN)
 - Attract pollinators
 - protect pollinators with antimicrobial proteins in nectar
 - probably synthesized by microbes
 - likely source of beneficial microbes used to process and preserve bee bread
- Extra-floral nectaries (EFN)
 - Attract plant defenders
 - alkaloids and phenols deter nectar robbers

Nectars

- Nectars are the primary source of carbohydrates for honey bees
 - Nectars also are sources of minute quantities of nutrients often attributed to pollens
 - Nectar can be used as a water substitute
 - To dilute thick honey and brood food for easy consumption
 - To dissolve pollen grains from pollen pellets to be eaten (drunk)
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Nectars

- Nectars from the same flowers can vary in sugar content during the day – depends upon flower shape
 - Faster evaporation
 - dish-shaped flowers: apple and almond
 - Slower evaporation
 - enclosed nectar sources: alfalfa or trefoil
 - Dehydrated and stored as honey for future consumption
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Chemical Composition of Nectar

- Nectar is primarily water that contains sugars secreted by nectar glands
 - Sugar concentrations can range from 0 to 72%, but usually averages below 20%
 - Some flowers hold a very constant concentration, while some flowers are quite variable
 - *Aloe* - <10%
 - Carraway - > 66.5%
 - *Clintonia* (Blue-beard Lily) – 4 to 72%
 - *Echium* (Viper's Bugloss) – 2 to 62%
 - Weather, especially relative humidity, affects the moisture content of nectars
 - when it is very hot and dry, nectar can become so viscous that honey bees will not collect it
 - rain, dew, high soil moisture and high humidity can dilute nectar so that it is no longer attractive to foragers

Chemical Composition of Nectars

- Normally, nectar sugars are various concentrations of sucrose, glucose and fructose
 - Other sugars leak through from phloem sap:
 - Monosaccharides: **mannose**, arabinose, xylose
 - Disaccharides: maltose, melibiose
 - Trisaccharides: **raffinose**, melezitose
 - Tetrasaccharide: **stachyose**
(glucose+fructose+two **galactose**)
 - Oligosaccharides: honeydews (amylodextrin, erythrodextrin, achodextrin, etc.)
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Chemical Composition of Nectars

- Sixteen proteins have been found in nectars
 - All 9 (10?) essential amino acids have been found in nectars
 - Some non-protein amino acids have been found
 - anti-feedants for seeds and plant tissues
 - not toxic to honey bees
 - Other repellents and anti-feedants include: alkaloids, coumarins, saponins
 - Some narcotics have been found, including oxycodone
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Chemical Composition of Nectars

- pH of nectars vary from 3 to 10, but often are on the acid side
- Beta-acetoxy fatty acids and diglycerides have been found in some nectars – some look milky
 - Cotton extra-floral nectar has palmitic, stearic, palmitolenic, olenic, linoleic, and linolenic acids and phospholipids
- Phenolic compounds are found in nectars
 - Attractive and repellent odors, and nectar fluorescence

Chemical Composition of Nectars

- Most nectars have one or more alkaloids
 - Protection against herbivores
 - nicotine, anabasine (nicotine-like), caffeine, amygdalin (laetrile or “Vitamin B₁₇,” converted to cyanide)
 - Most nectars contain terpenoids
 - Essential oils that act as attractants or repellents (anti-feedants)
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Honey Bee Enzymes

- Diastase (amylase) – from hypopharyngeal glands
 - Reduces starch to dextrans and sugars
- Invertase (saccharase)
 - Converts sucrose to glucose and fructose
- Glucose oxidase
 - Converts glucose into gluconic acid
 - acidity of honey
 - Converts glucose into hydrogen peroxide

Honey Bee Enzymes

- Catalase (from nectars)
 - Decomposes hydrogen peroxide
 - Proteolytic enzymes
 - Produced in the midgut epithelial cells
 - endocrine cells remain intact and leak out enzymes
 - holocrine cells rupture and release enzymes
 - Mostly serine proteases
 - trypsin, chymotrypsin, elastase (elastin in pollen grains involved with pollen tube growth)
 - Pectinases and some others produced by gut microbes
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Take Home Message

- Honey bee nutrition is extremely important to the bees' physical wellbeing
 - Malnutrition impacts:
 - larval development
 - pupal development
 - adult brood food production
 - length of adult life
 - a major factor in colony population size
 - functioning of the immune system
 - functioning of the detoxification system
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Synthesized Diets for Honey Bees

- When honey bees do not have enough natural food available, they should be fed
 - When bees are short on either nectar or pollens, feed both
 - All commercial pollen substitutes are beneficial when fed to malnourished colonies
 - Some are better than others – see articles by Randy Oliver in the American Bee Journals: July/August 2014
 - No currently formulated substitute supplies all the nutrients found in a good mix of pollens
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Produce Positive Results, but Not Like Mixed Pollens



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