Biology of the Colony

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Eusociality

Photograph © Alex Wild 2004

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Eusocial: True Sociality

Found mainly in two orders:

Hymenoptera
(some bees and wasps,
<u>all</u> ants)

Isoptera
(<u>all</u> species)

Eusocial Insects

Features (by definition):

1. **Overlap of generations**
2. **Division of labor** (Caste system) – not all individuals reproduce
3. **Cooperative rearing** of young

Eusocial Insects

<u>May</u> also show

- **Trophallaxis (Ritual feeding)**
- **Complex chemical communication (pheromones)**
- **Nest**
  - **Often with controlled atmosphere**
- **Specialized reproductive biology**
  - **Production of new colonies vs. production of new individuals**

- Rare (2% of species), but highly successful (some tropical areas >3/4 of biomass)

Trophallaxis - a way of exchanging food and chemical messages

Termite nests

Eusociality

- Some individuals reduce their own lifetime reproductive potential to raise the offspring of !others

How did eusociality evolve?

• **Mystery: not in an individual's self interest to give up reproducing!**

Different theories: Controversial

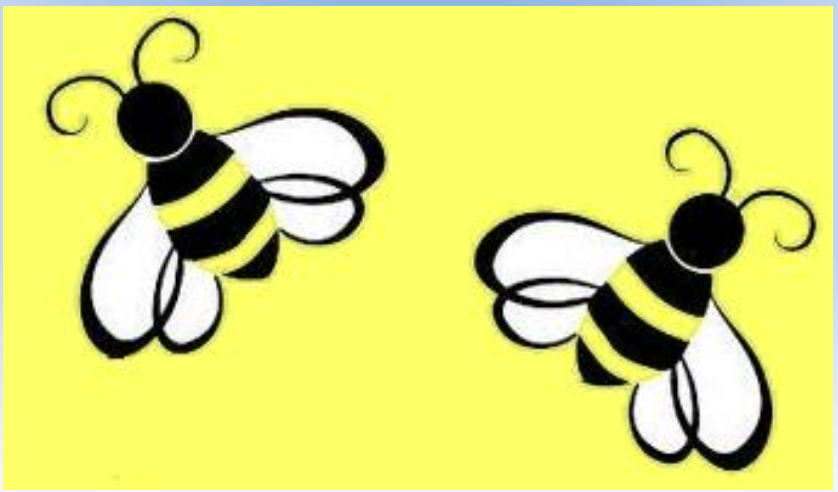
Hamilton (1964): kin selection (inclusive fitness)

- Haplodiploid reproduction (all Hymenoptera, also eusocial thrips)

•**Kin selection** refers to apparent strategies in evolution that favor the reproductive success of an organism's relatives, even at a cost to their own survival and/or reproduction.

They're of the same blood: The importance of relatedness

- Sisters are more related to each other than they are to their own mother or father



How did eusociality evolve?

- Group selection
  - Formation of a group
  - Persistence and cohesion of the group, defensible nest
  - Spreading eusocial alleles
  - Spreading of others traits that favor the group
  - Natural selection acting on a group

Mechanisms of Social Organization

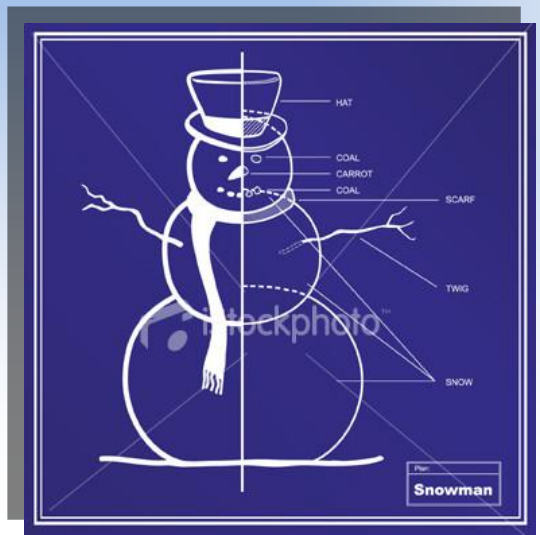
Social organization by social insects was long held as an example by the aristocracy and various religions as a model to how human societies should be organized

Mechanisms of Social Organization

Centralized

- Following a leader
- Using a plan, blueprint or recipe
- Using a template or mould

http://www.fatherlovesaj.com/leader%20logo.jpg



Insect societies are well organized, but how do they achieve this?

Proverbs 6: 6-8- "Go to the ant thou sluggard: consider her ways, and be wise. Which having no guide, overseer of ruler, provideth her meat in the summer, and gathereth her food in the harvest".

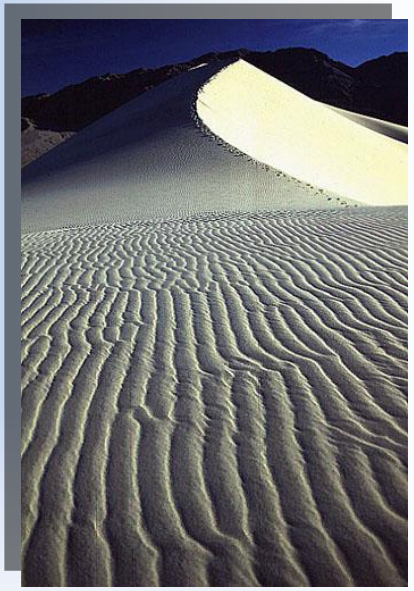
In insect societies no one is in charge.

Mechanism of Social Organization

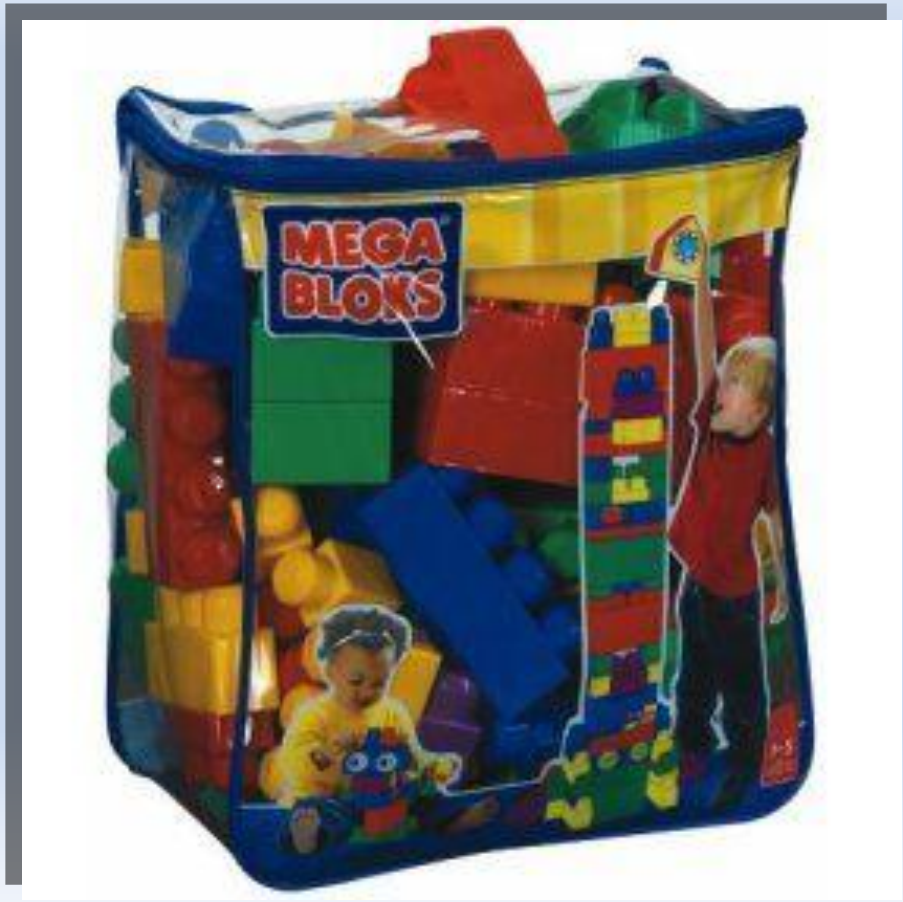
Self –organization or De-centralized

- Global pattern of organization arises from the interactions of many individuals whom follow simple rules in response to local conditions. No one individual is in charge.

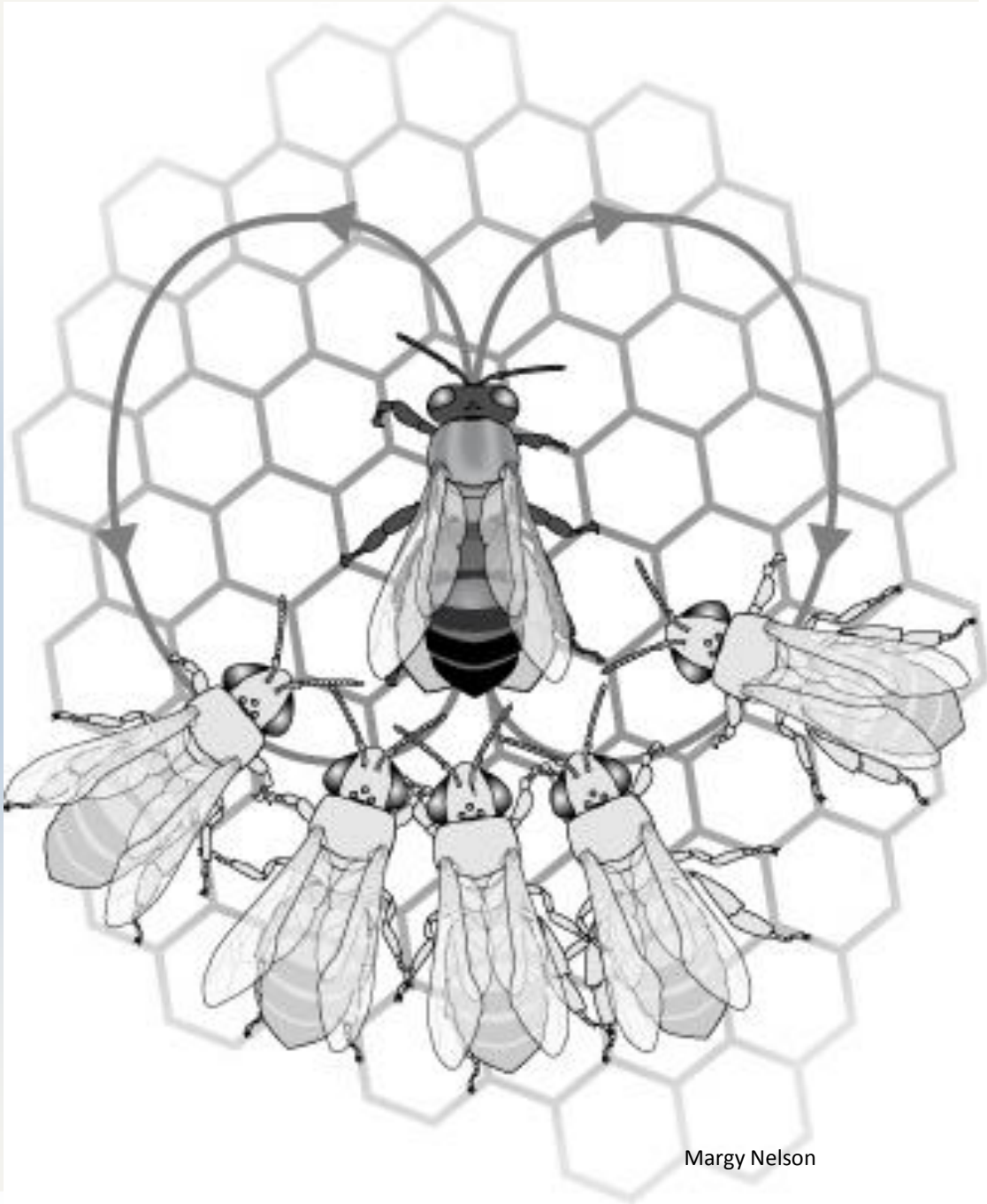
- Ex: cells in a multicellular organism, grains of sand in a sand dune, social insect colonies



Activity



In what ways can sociality benefit insects?

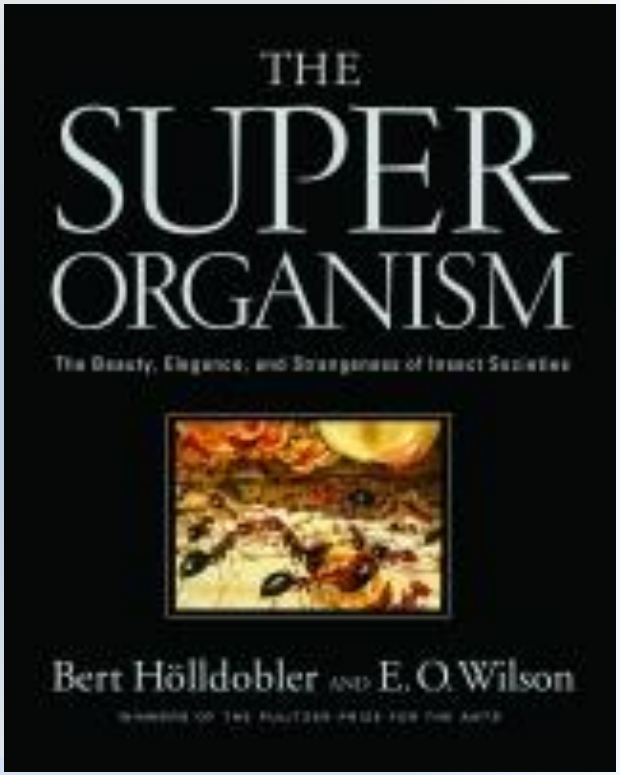


Insect sociality

- **Benefits of sociality:**
  - Utilization of large and more diverse resources
  - Group defense against predators
  - Existence as perennial, long-lived organisms

“Super-organism”

- Intake resources
- Waste disposal
- Defense
- Reproduction
- Environmental control



They use **social design to solve ecological problems** normally faced by single organisms- origin of the concept of “super-organism”

Who are the bees in your colony?

Sex determination

x

x

Unfertilized eggs

Fertilized eggs

Fertilized eggs

1n

1n

2n

X

2n

2n

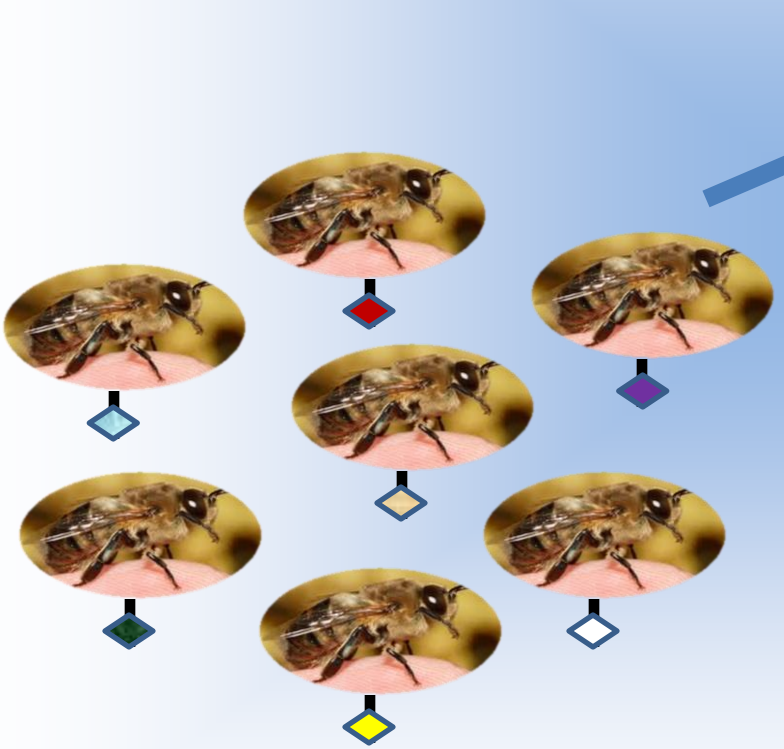
2n

Sex Determination

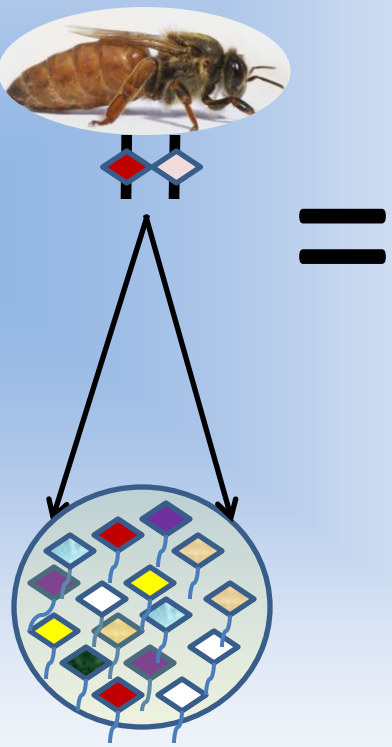
- If an egg is heterozygous at the sex loci= Become a female
- If an egg is homozygous at the sex loci the individual will be a diploid drone
- If the egg is unfertilized (therefore haploid) the individual will become a viable haploid drone

Basic Biology

Mating genetics



(actually about 17 drones)



Leads to a number of subfamilies in the colony

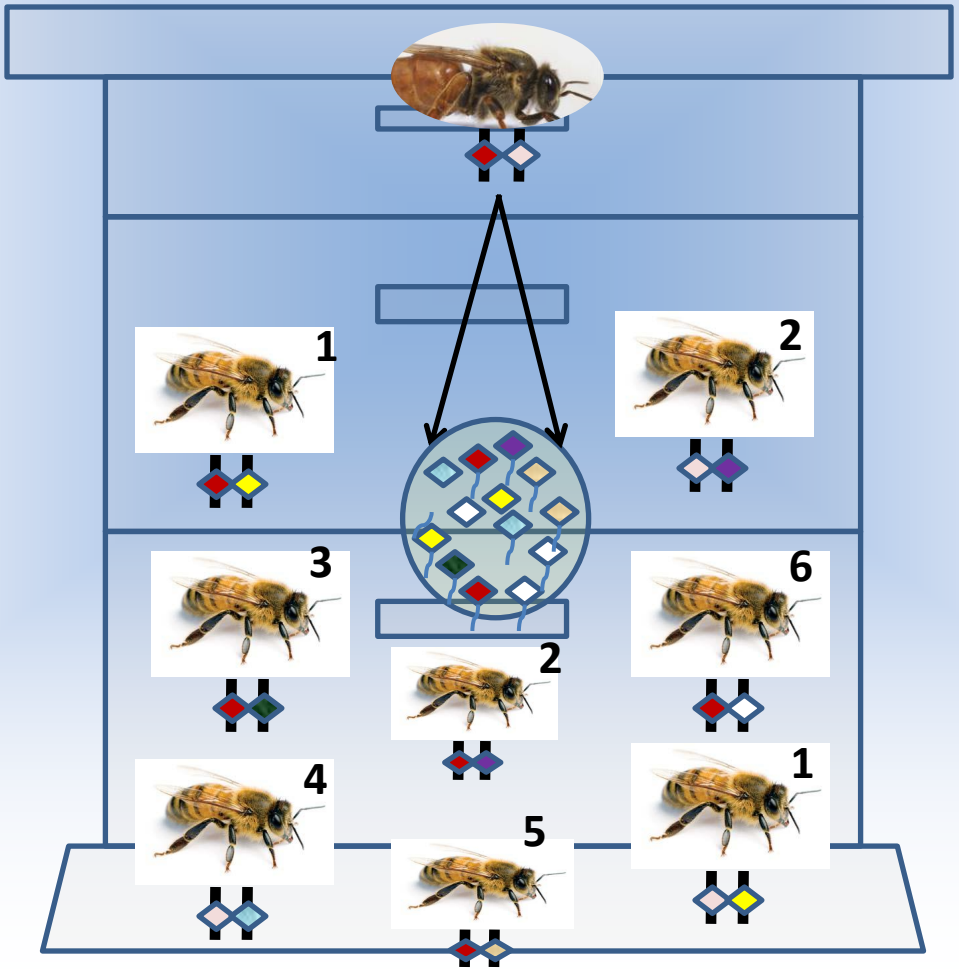
Spermatheca full of stored sperm

(actually 4-7 million sperm)

Basic Biology

Colony genetics

Leads to a number of subfamilies in the colony



6 subfamilies present in this hive

Haplodiploidy

- **Haplodiploidy:** Viable drones come from unfertilized eggs, females from fertilized eggs

Biology of the Colony

Swarming

Colony fission: natural swarming

Splitting is managerially equivalent to swarming:
the natural process by which colonies reproduce

~50% workers
& parental queen

Parental colony

Daughter colony

- Swarming has been shown as an acquired evolutionary technique that reduces pests and diseases within honey bee populations
- Occurs in mid to late spring when bee populations are high and flowering is more intense

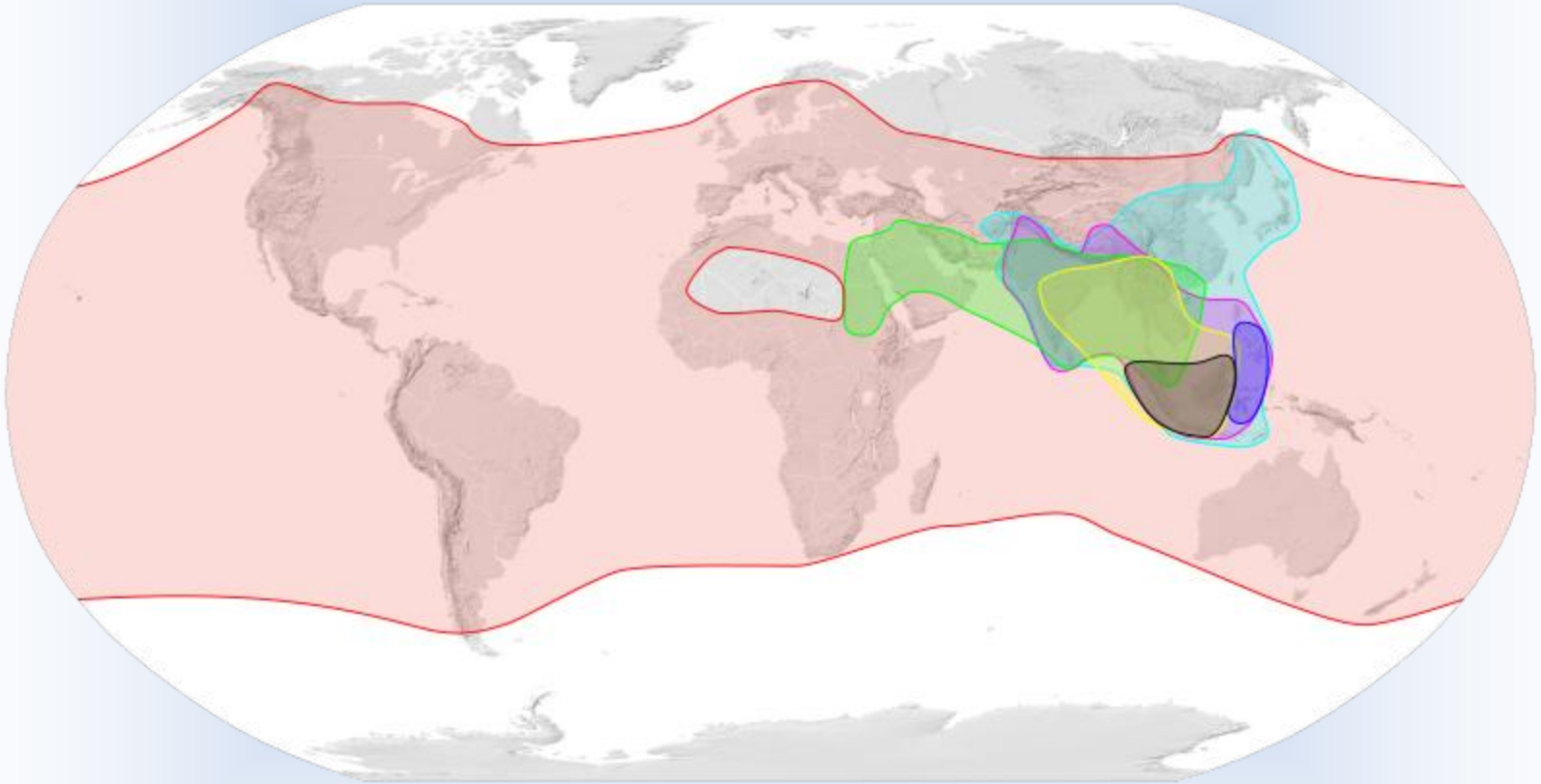
A Cavity nester

- Location dependent on amount of available cavities and the ability to thermoregulate

Photo Joseph Nicolay

Thermoregulation

Current *Apis* species distribution

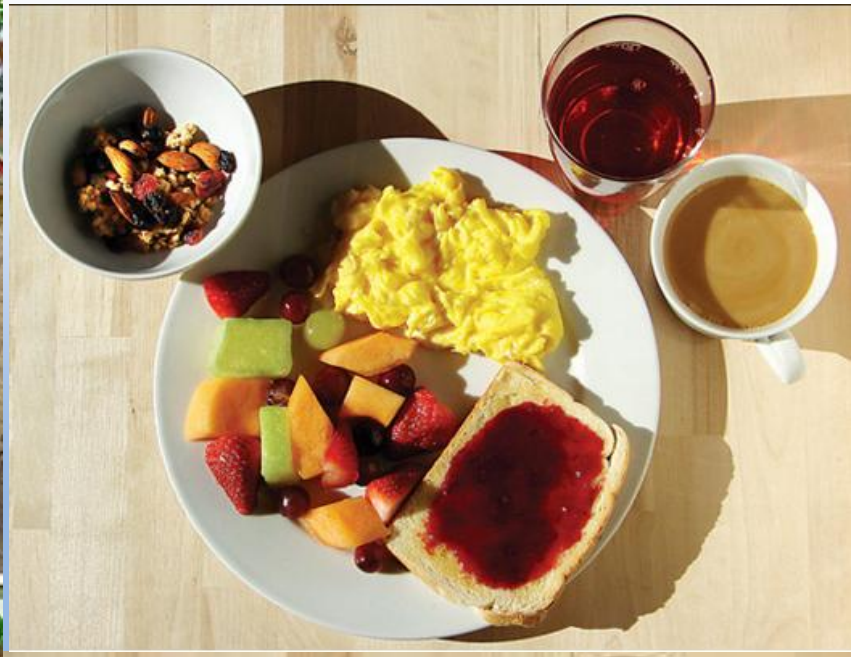


Pollination

Bee-dependent crops account for $47.1 billion every year, of which $14.6 billion is attributable to honey bee pollination


Your produce choices
with bees


Your produce choices
without bees



Communication

- Honey bees are eusocial
- Prof von Frisch
  discovered their
  communication basics
- A bee discovers a food source….
  she returns home to tell her sisters

  where it is, how far, & how good !

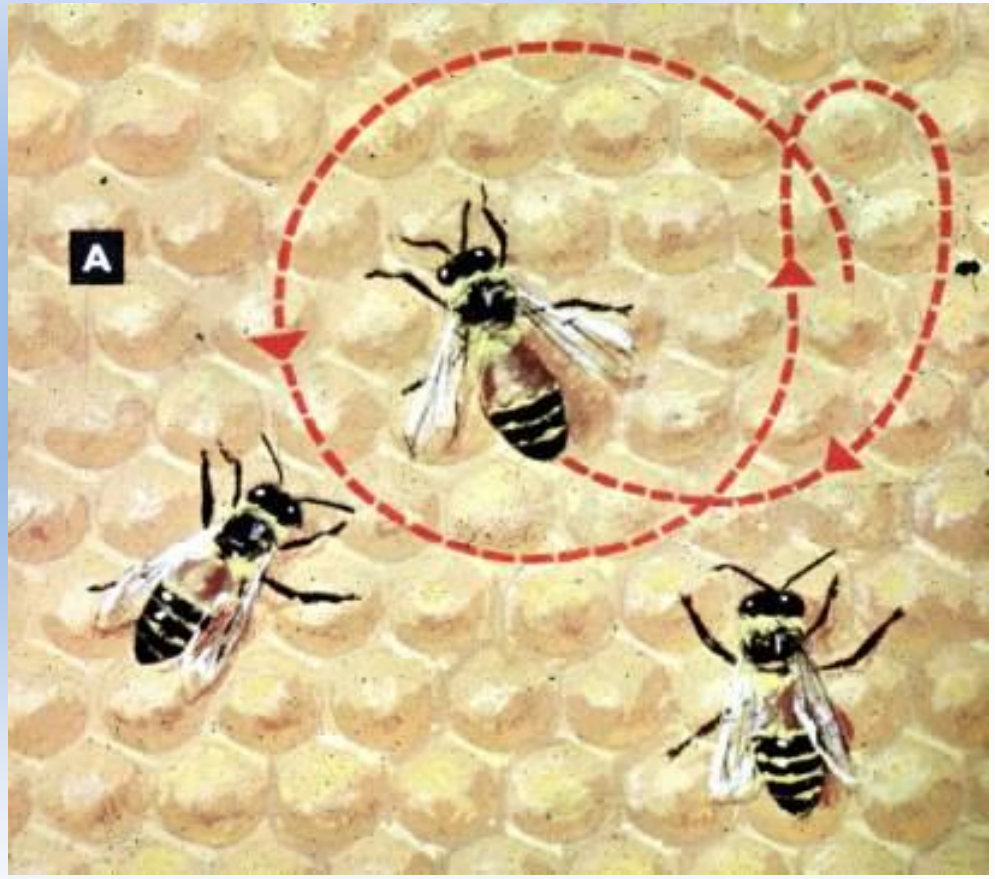
Round Dance

Quick short steps
in narrow circles
On beeswax comb

Food close

Odor & taste clues

Richness clues



Wagtail Dance

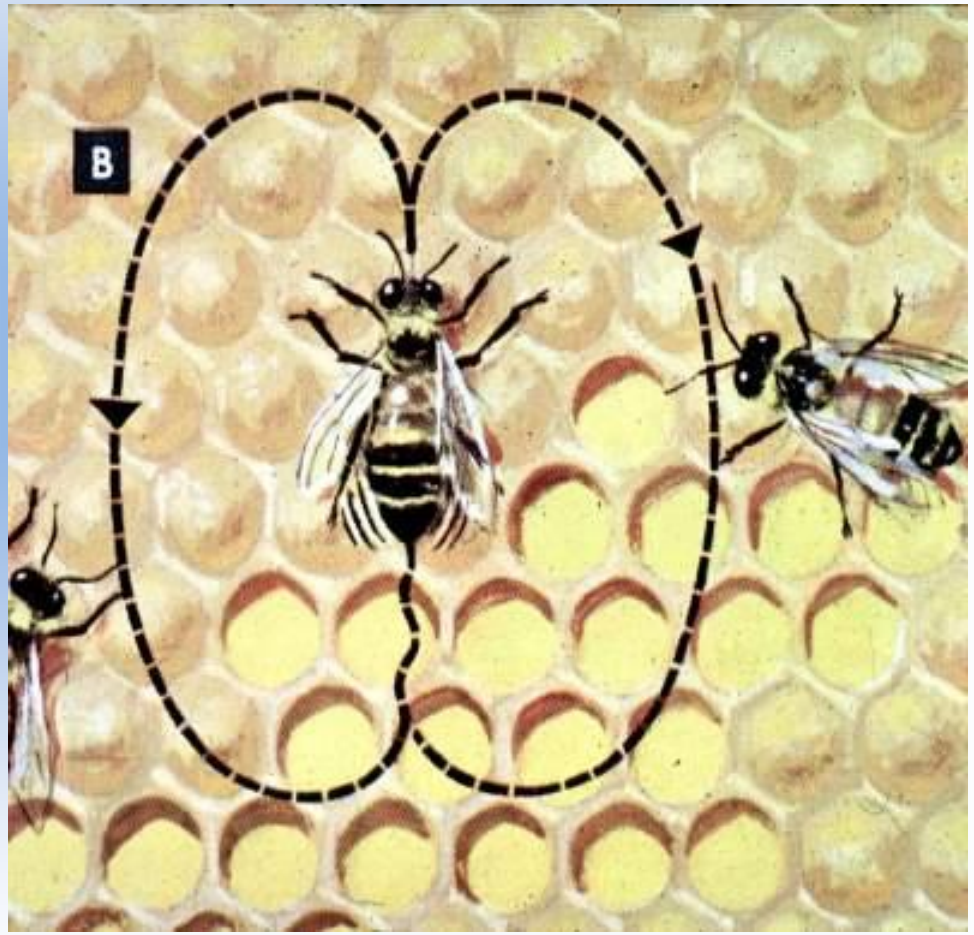
Bee makes ½ circle, straight run while waggling Abdomen then ½ circle again

Distance

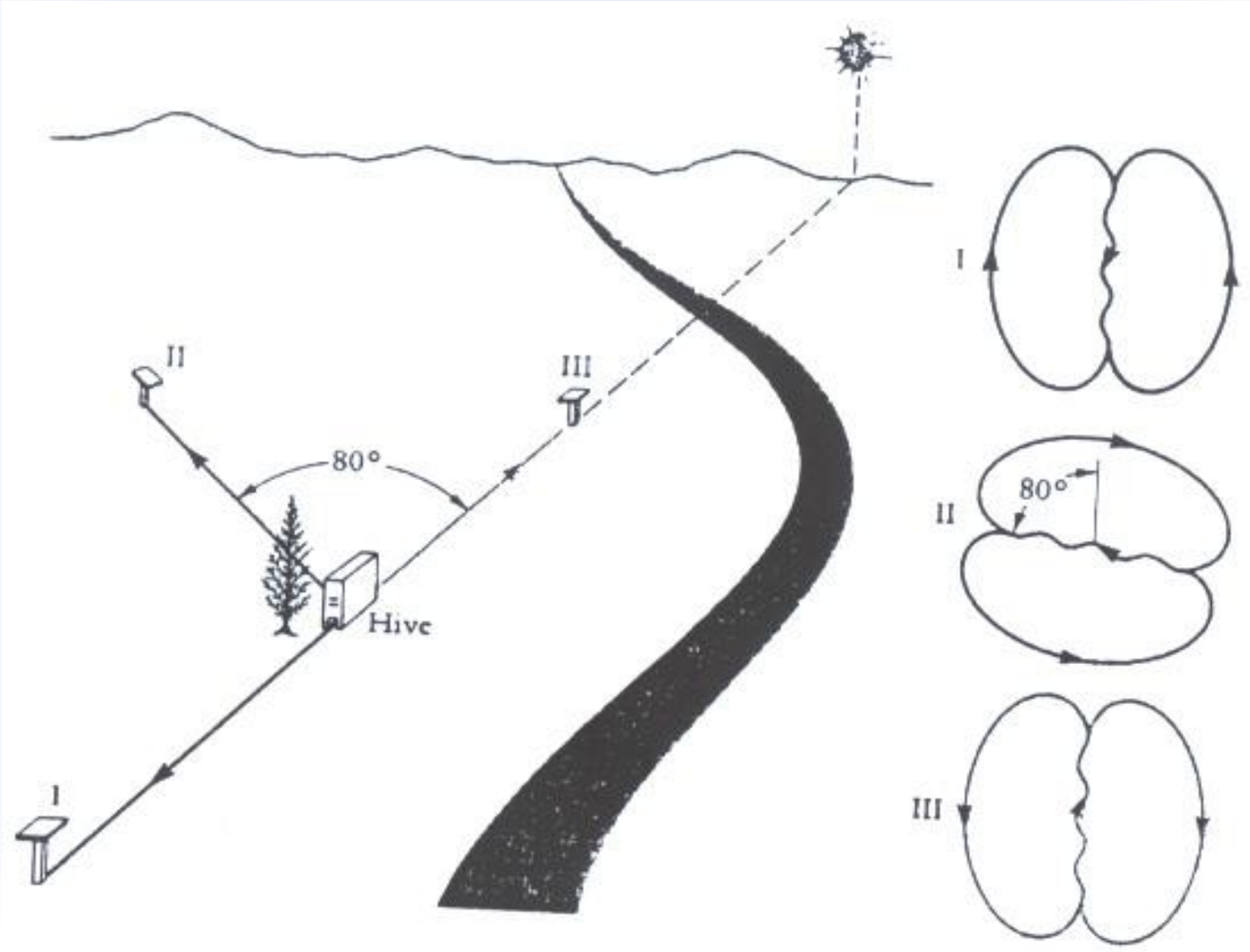
Direction

Odor & taste clues

Richness clues



Wagtail Dance



Taste and smell

- The number of dancing bees and the frequency of dance can relay quality and quantity of resource

Dialects

- Different subspecies have different variations of the dance
- Different dances for different distances
- Different subspecies have trouble communicating location to one another

Colony Communication

Pheromones of the Queen Honey Bee

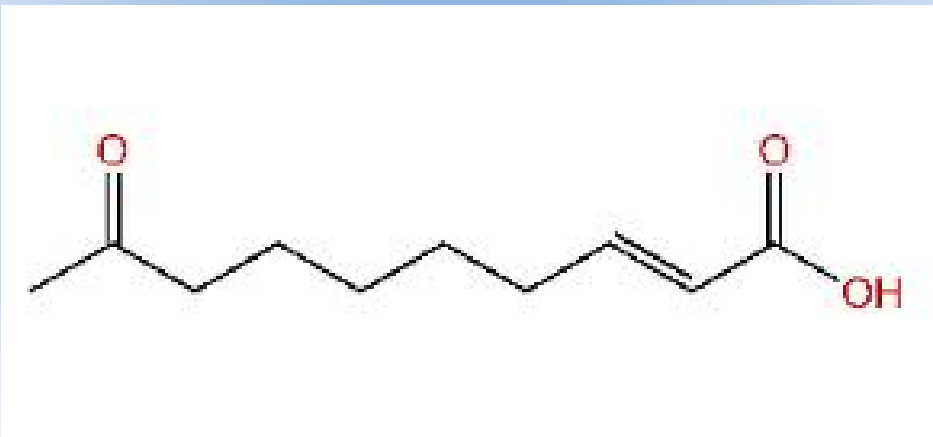
Pheromone	Source
Queen substance (QMP)	mandibular glands
Foot-print pheromone	Arnhart (tarsal) glands
Tergal pheromone (abdominal)	Tergite glands
Feces pheromone	Hindgut
Egg marking pheromone	Dufor's gland?
Queen attractant scent	Koschevnikov gland
Queen cell pheromone	immature queen / cell

Queen Substance

Source: Mandibular glands

Primary component:

9-oxo-*trans*-2-decenoic acid



Mixture of 5 compounds; blend important

QMP

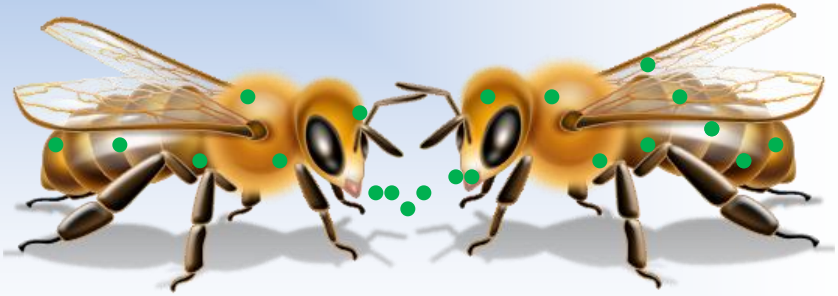
- Virgins and mated queens have different QMP profiles

QMP

- Queens with more mates have more attractive QMP profile

Queen Substance Dispersal

- Queen pheromone

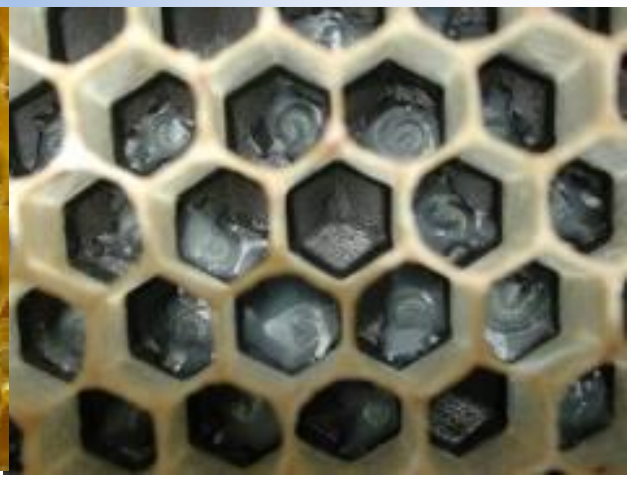


Retinue Formation

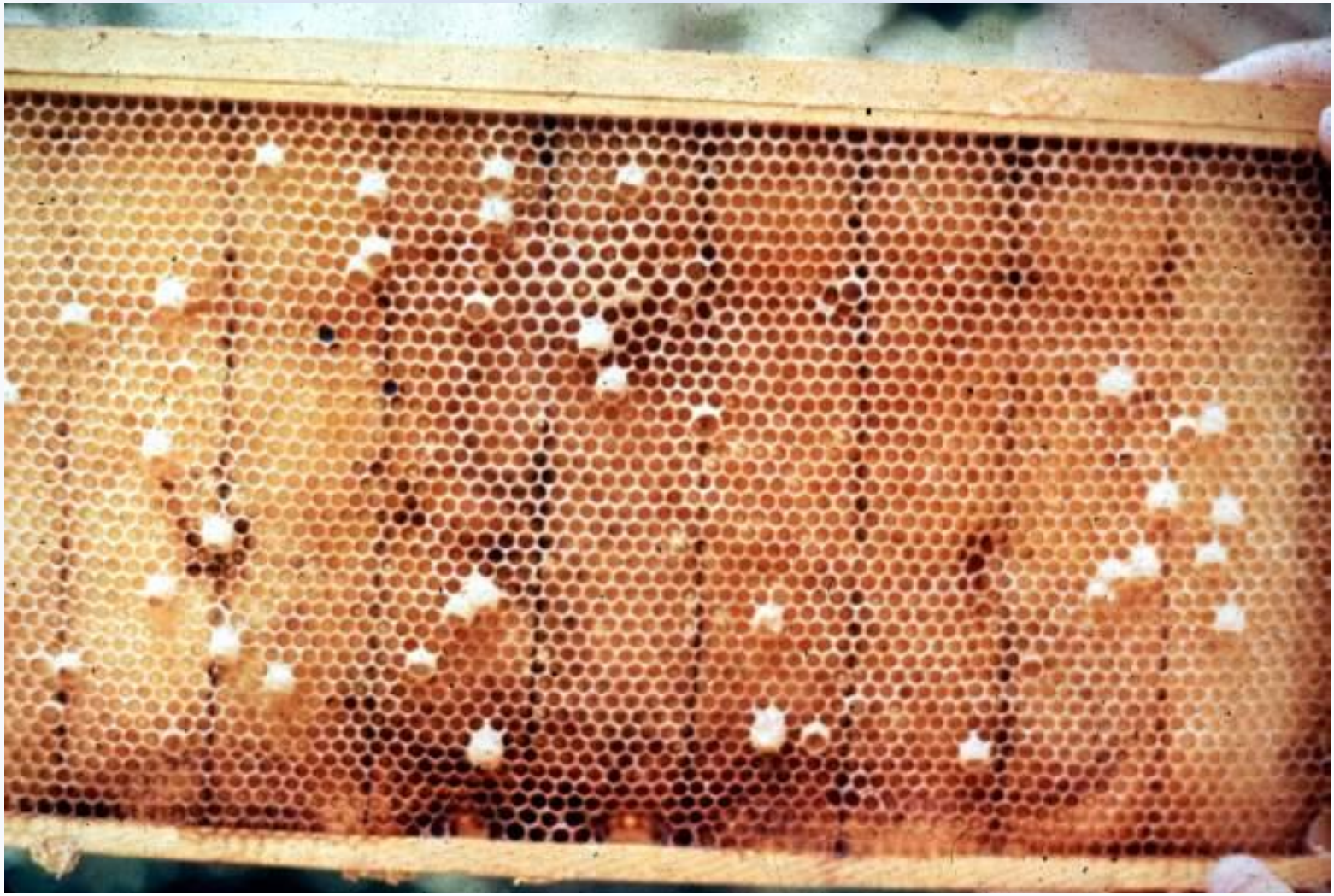
- Mandibular gland pheromone complex
  - Mixture important, single components do not have activity

Queen Inhibition of Queen Rearing

- Queen mandibular gland complex- major inhibitor (exception)
- Additional pheromone from tergite glands may help suppress queen rearing
- Possible “fecundity” signal from young brood



Inhibition of rearing replacement queens



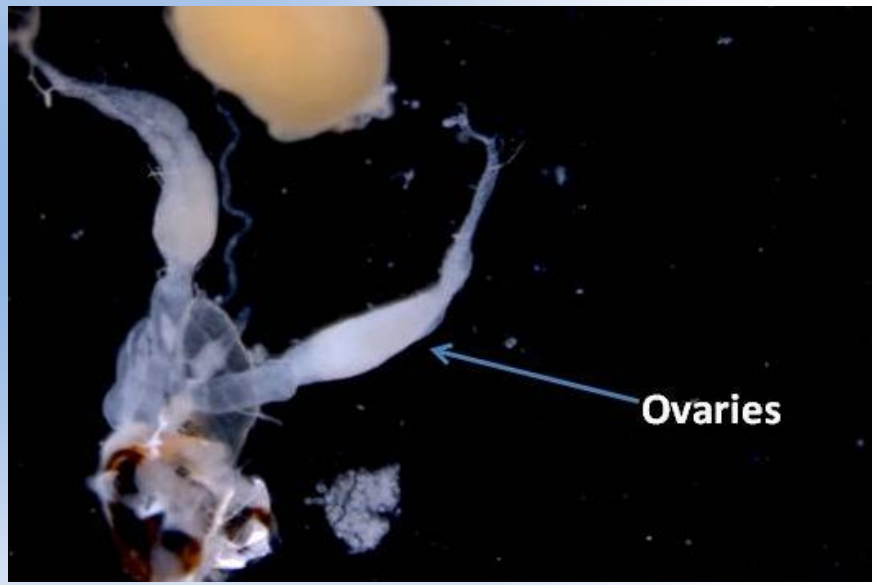
Sex attraction

Swarm Stabilization

Stimulation of foraging/brood rearing

Participates in suppression of worker ovaries

Queen



Worker

Egg Pheromone

- Queen produced

Function: discrimination of queen-laid versus worker-laid eggs

Aid to worker policing of worker-laid eggs

Queen Cell Pheromone

❖Present on queen pupae: methyl linoleate, methyl linolenate, methyl oleate

❖Functions:

- Recognition of queen cells
- Serve as part of a feed-back control system governing the production of queen cells

Worker Pheromones

- Orientation
  - nasonov gland

Mixture of 7 terpenoids: E- & Z- citral, nerol, nerolic acid, geraniol, geranic acid & farnesol

Worker pheromones

- Orientation
- Alarm
  - worker mandibular gland
    - 2 heptanone
  - worker sting gland
    - Iso-pentyl acetate

Worker Pheromones

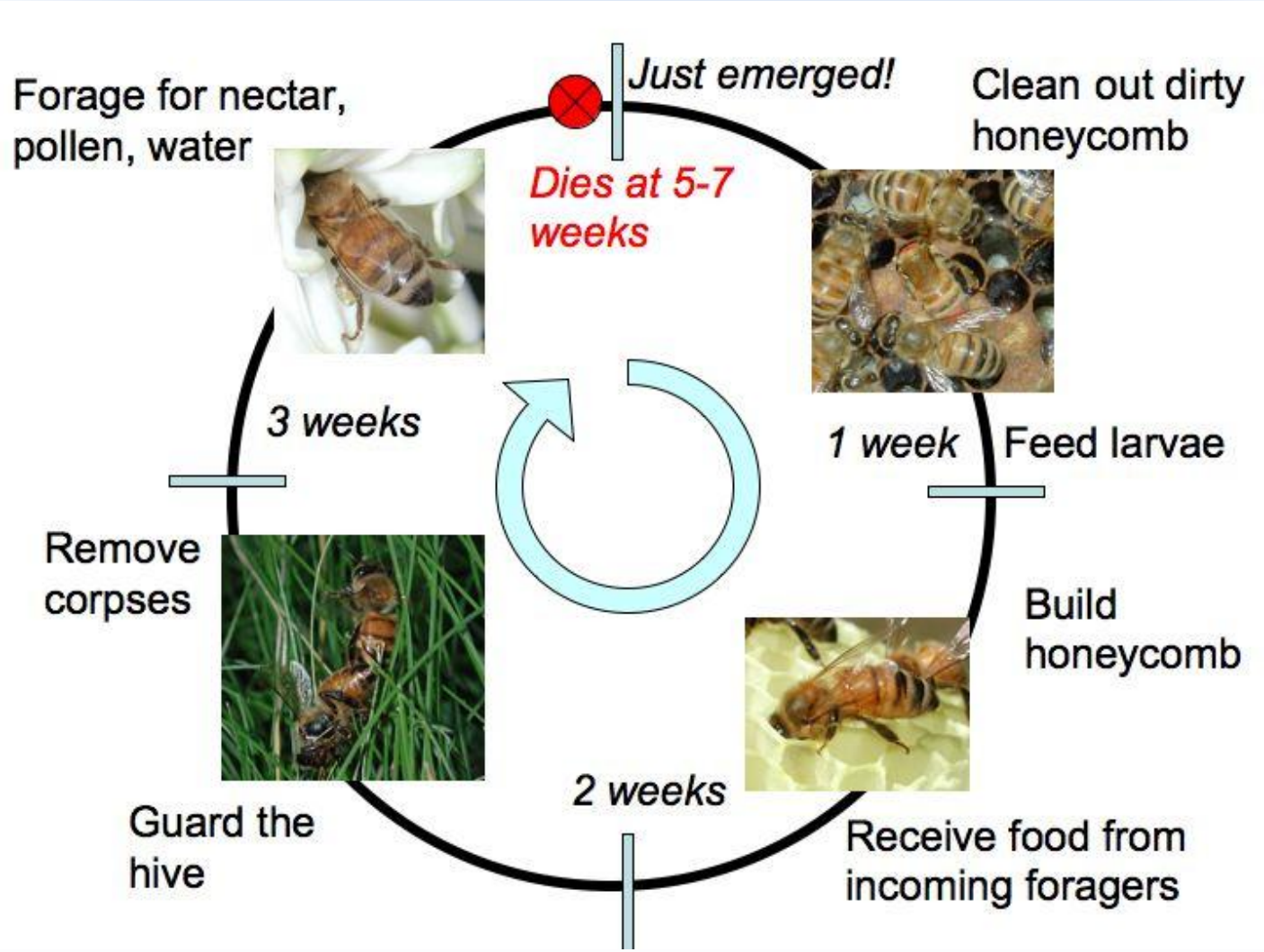
- Orientation
- Alarm
- Trail pheromone
- Brood pheromone
- Beeswax comb
- others

Hive Odor

Guard bee

Age based polyethism

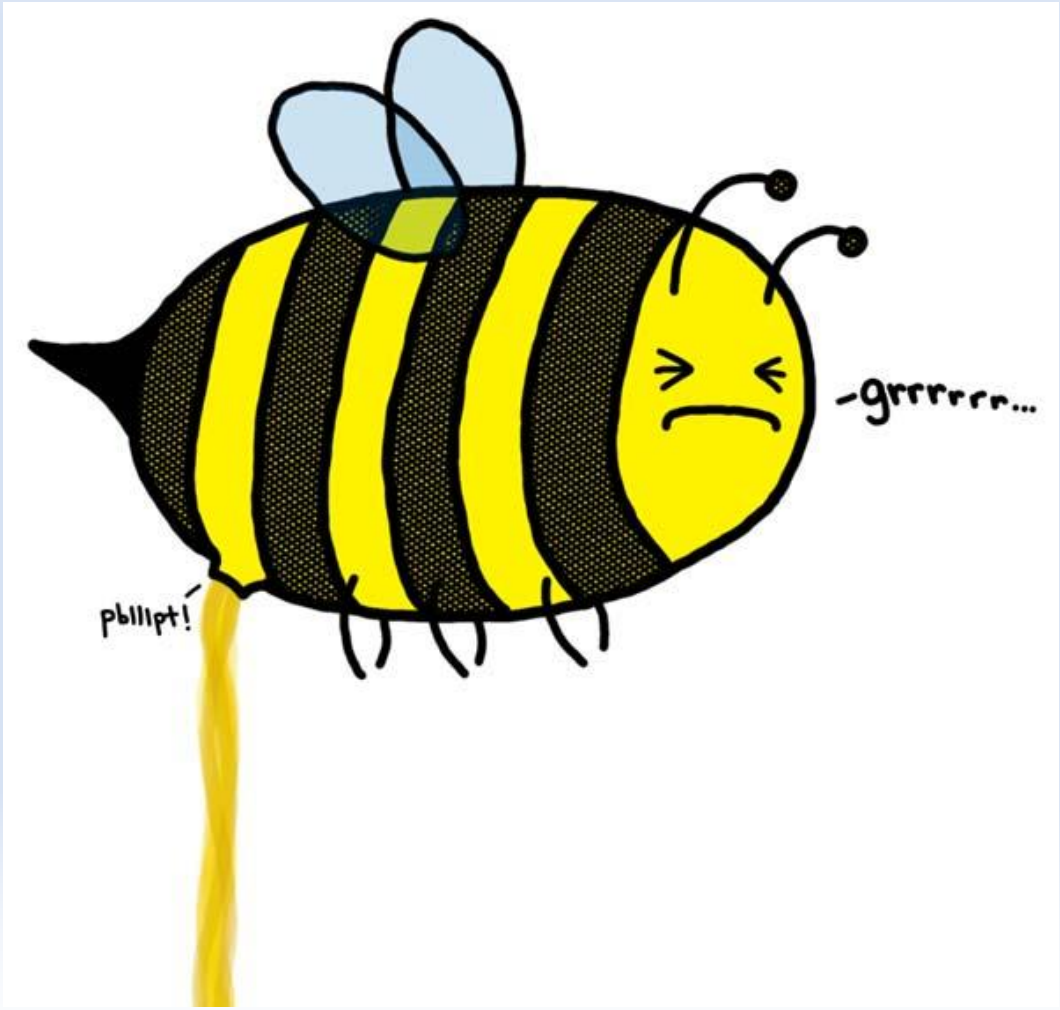
Division of Labor in Worker Bees



Colony Requirements

- Nectar
- Pollen
- Water
- propolis

From Nectar to Honey



From Nectar to Honey

- Nectar is 80% water, whereas honey is only 19% water

- To make 1 pound of honey, a colony of bees collects nectar from over 1 million flowers


Vertical stripes are very slimming.