

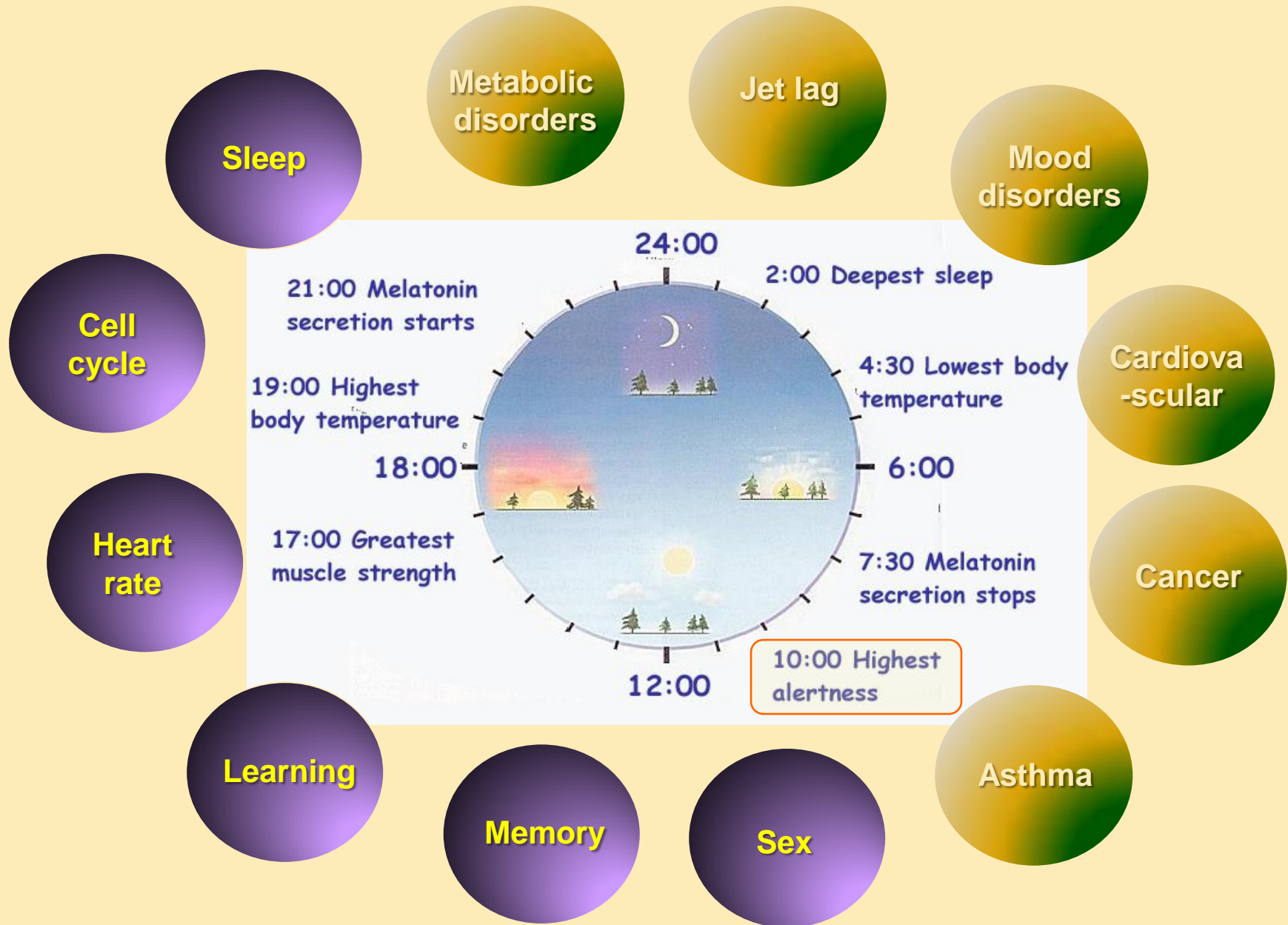
The social clock of the honeybee

Guy Bloch



The A. Silberman Institute of Life Sciences
Department of Ecology, Evolution, and Behavior

The circadian system has a central role in human health

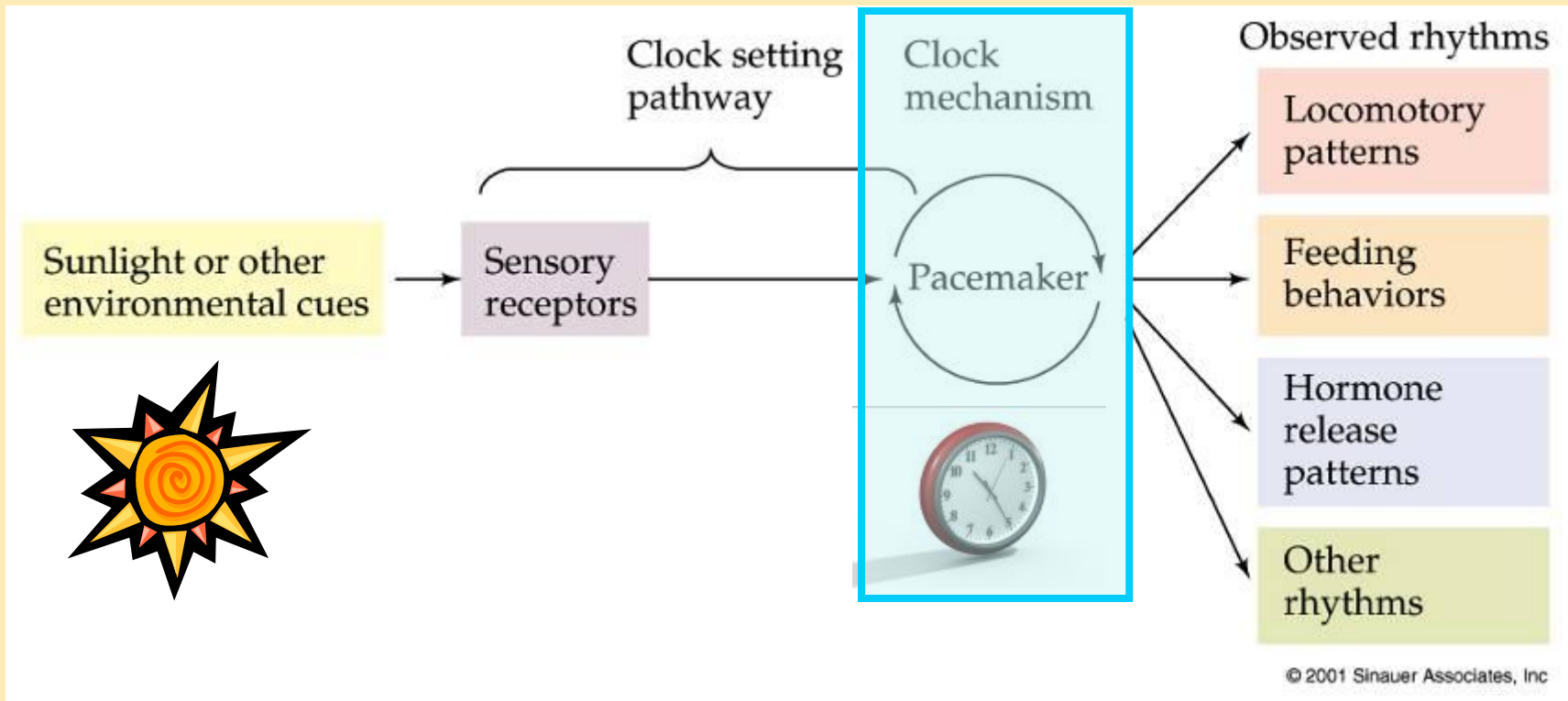


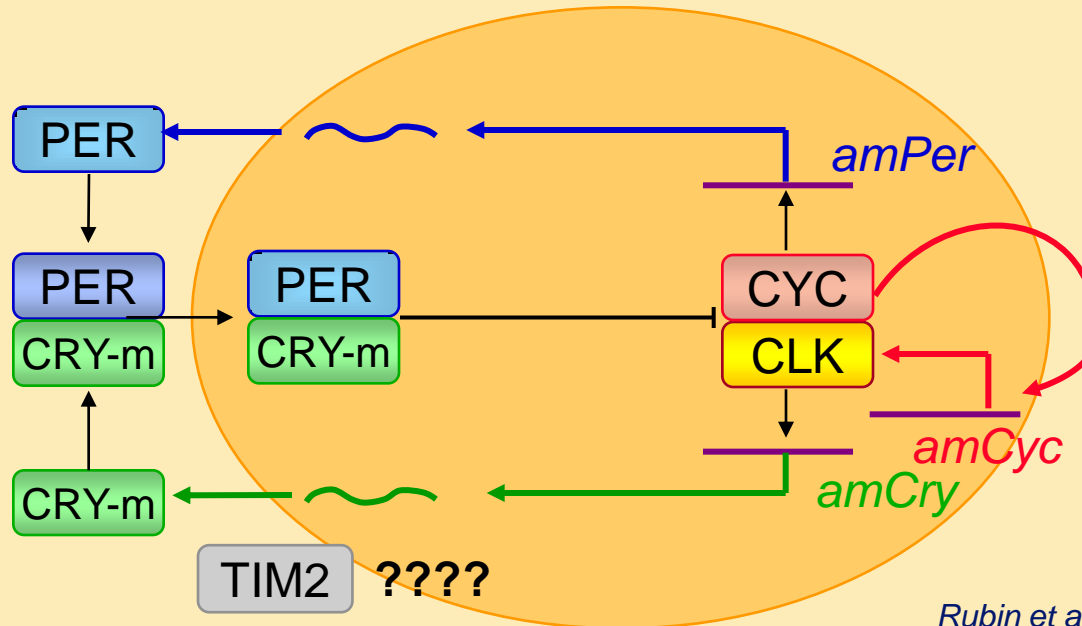
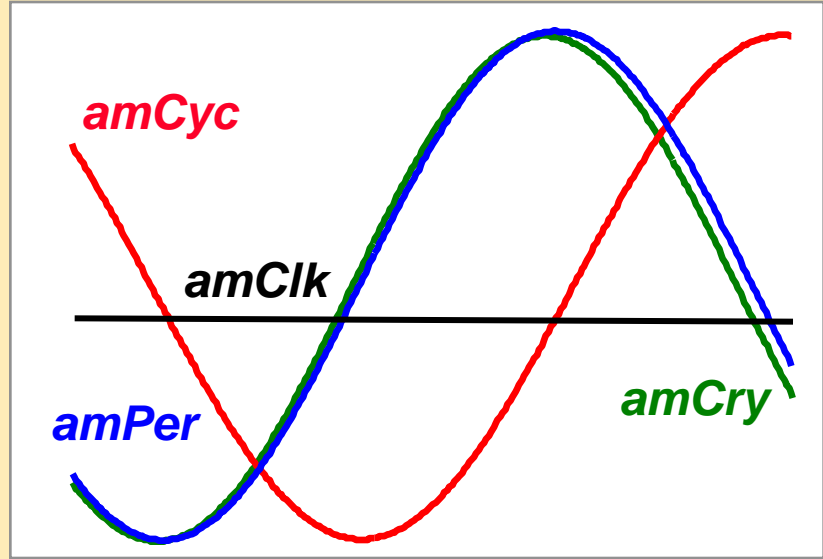
The organization of the circadian system

Input pathways

Core oscillator

Output pathways





The interplay between the clock and social behavior in bees

- Task-related plasticity in circadian rhythms
- Social entrainment (synchronization)
- Plasticity in circadian rhythms and maternal behavior/physiology in queens
- Social influences on the ontogeny of circadian rhythms



The interplay between the clock and social behavior in bees

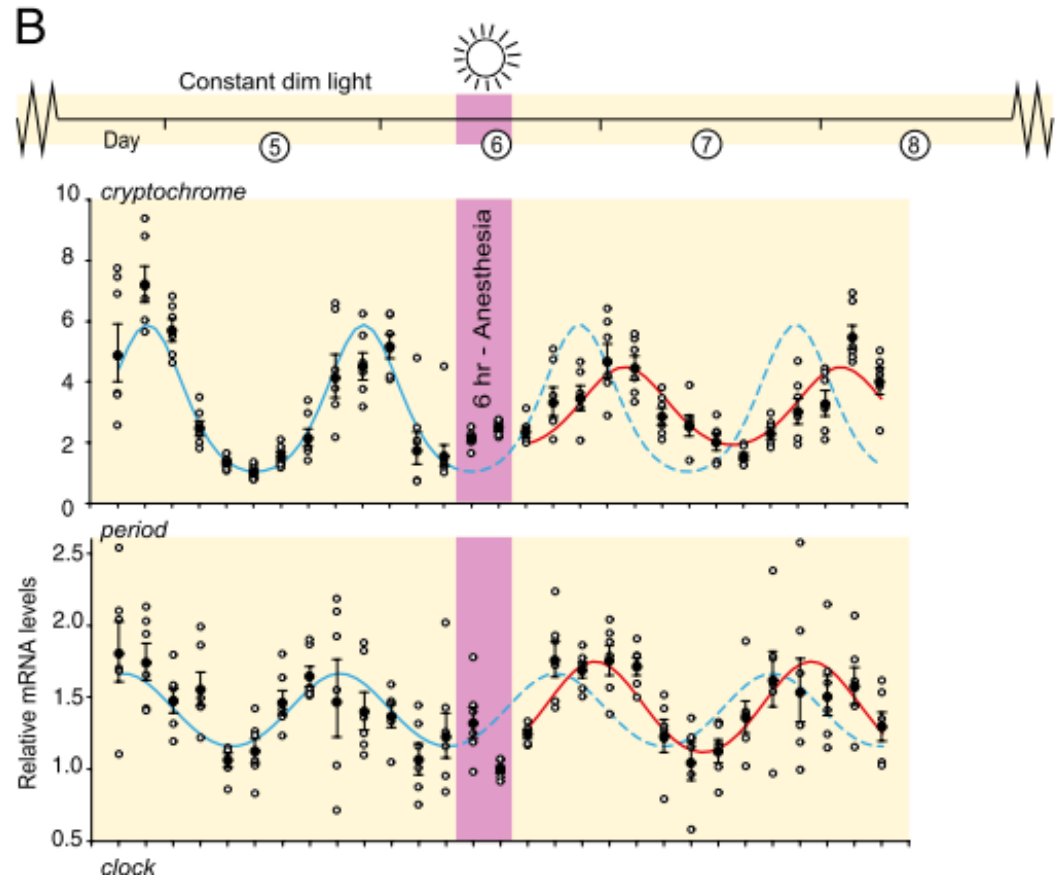
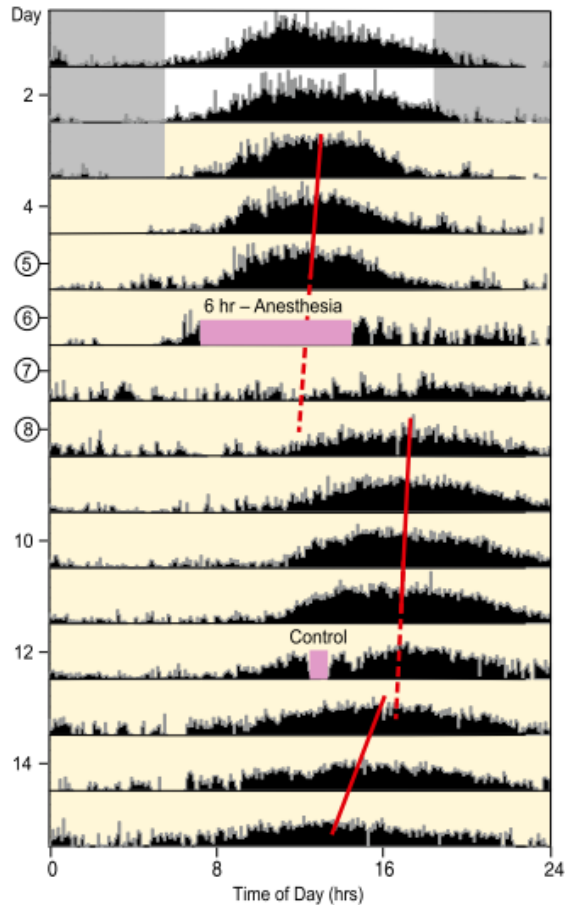
- **Task-related plasticity in circadian rhythms**
- **Social entrainment (synchronization)**
- Plasticity in circadian rhythms and maternal behavior/physiology in queens
- Social influences on the ontogeny of circadian rhythms

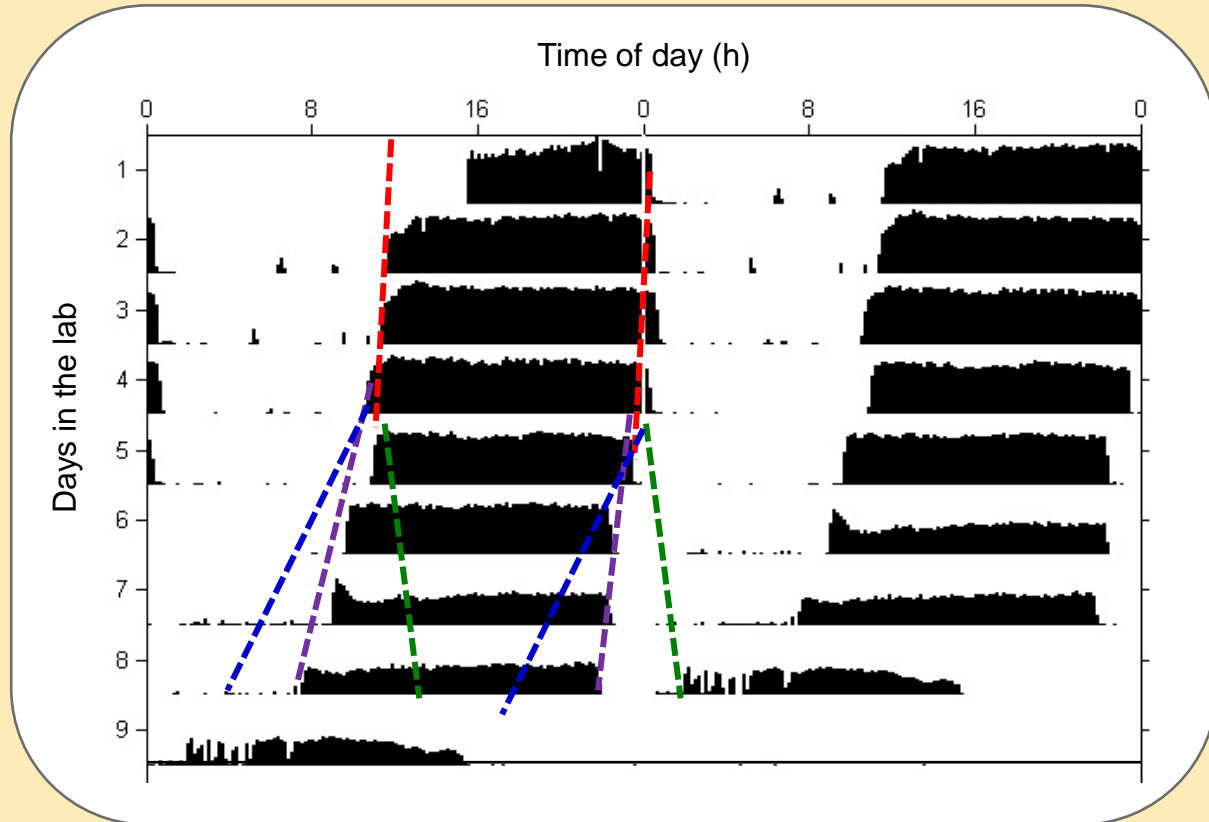
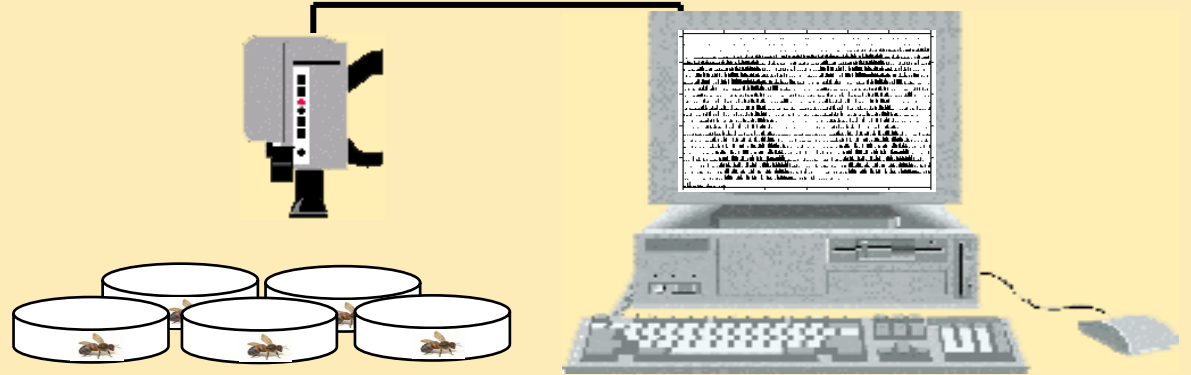


Social synchronization of activity rhythms

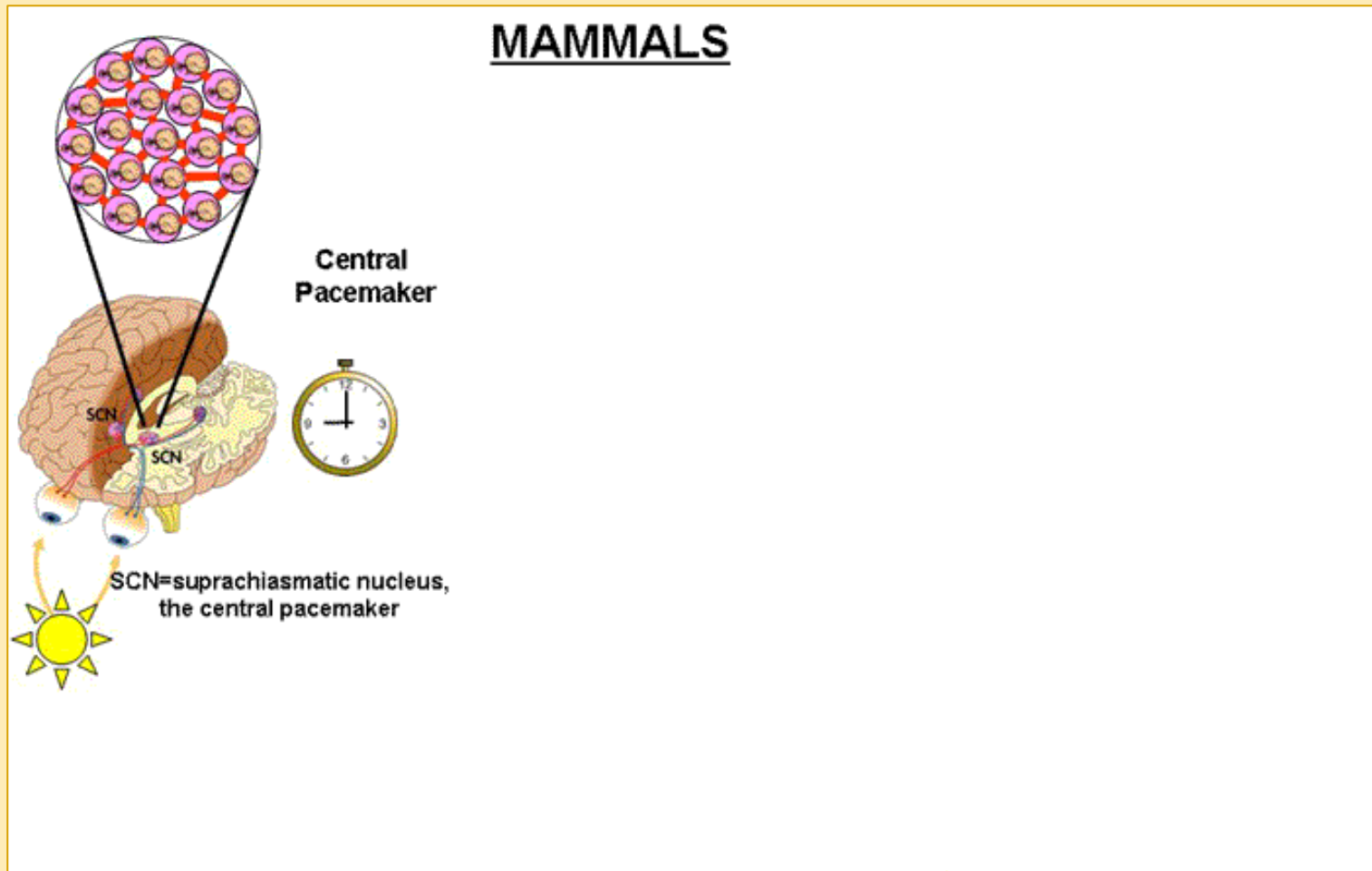


Hive-activity rhythms and clock gene expression





How nest bees are synchronized to a common phase?



How bees are synchronized to a common phase?

a.



b.



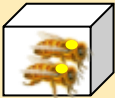
Foragers



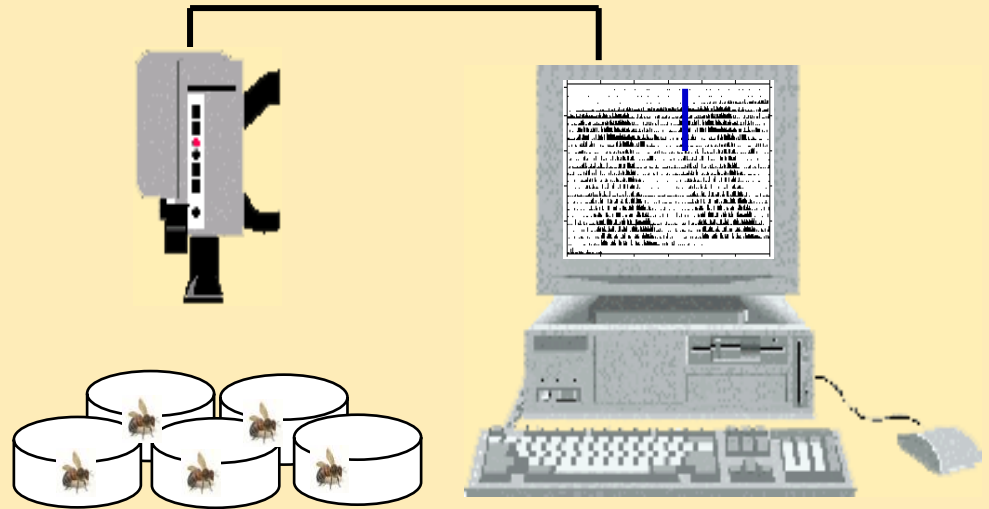
48h in a colony



48h in a cage



48h in isolation



Colony

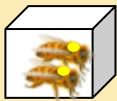
Foragers



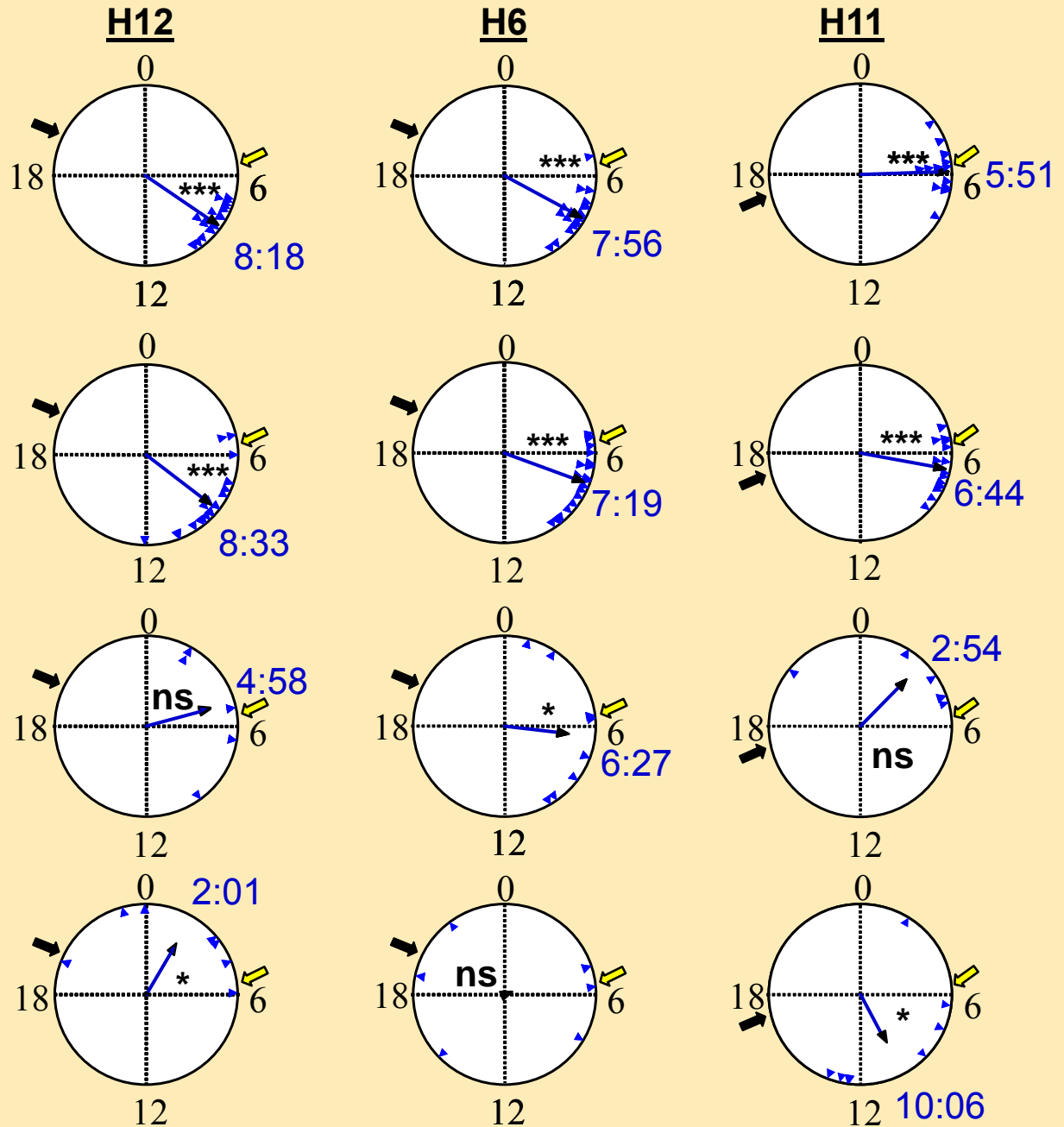
48h in a colony



48h in a cage

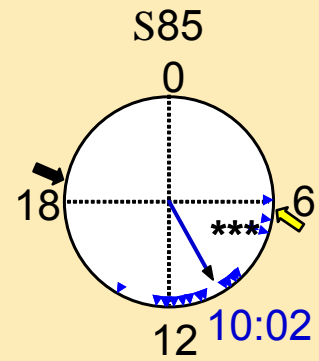
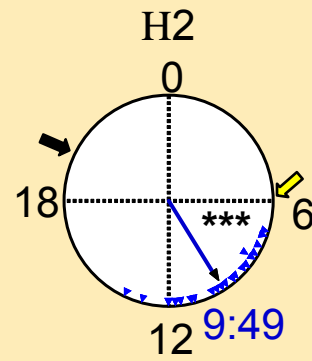
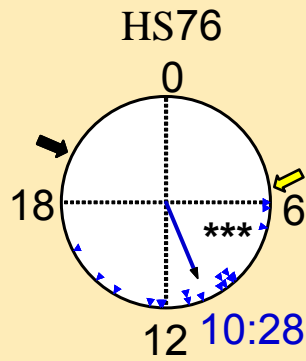


48h in isolation

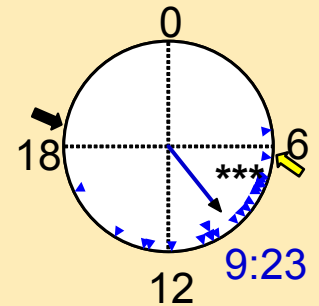
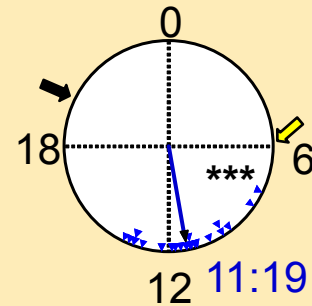
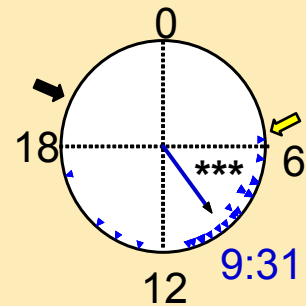


Colony

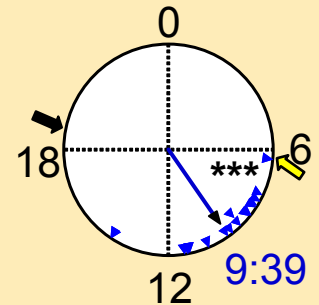
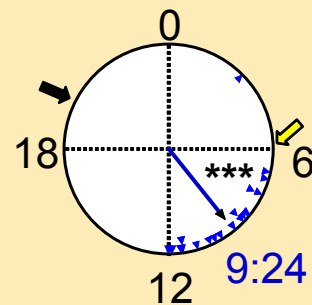
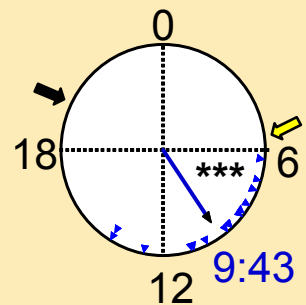
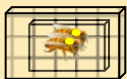
48h in a colony



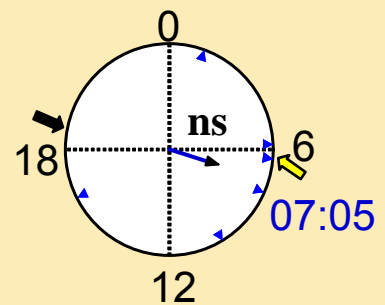
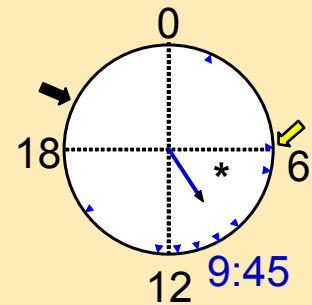
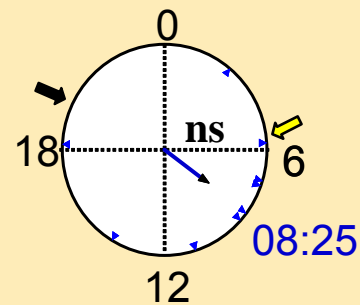
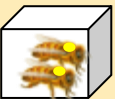
48h in SM

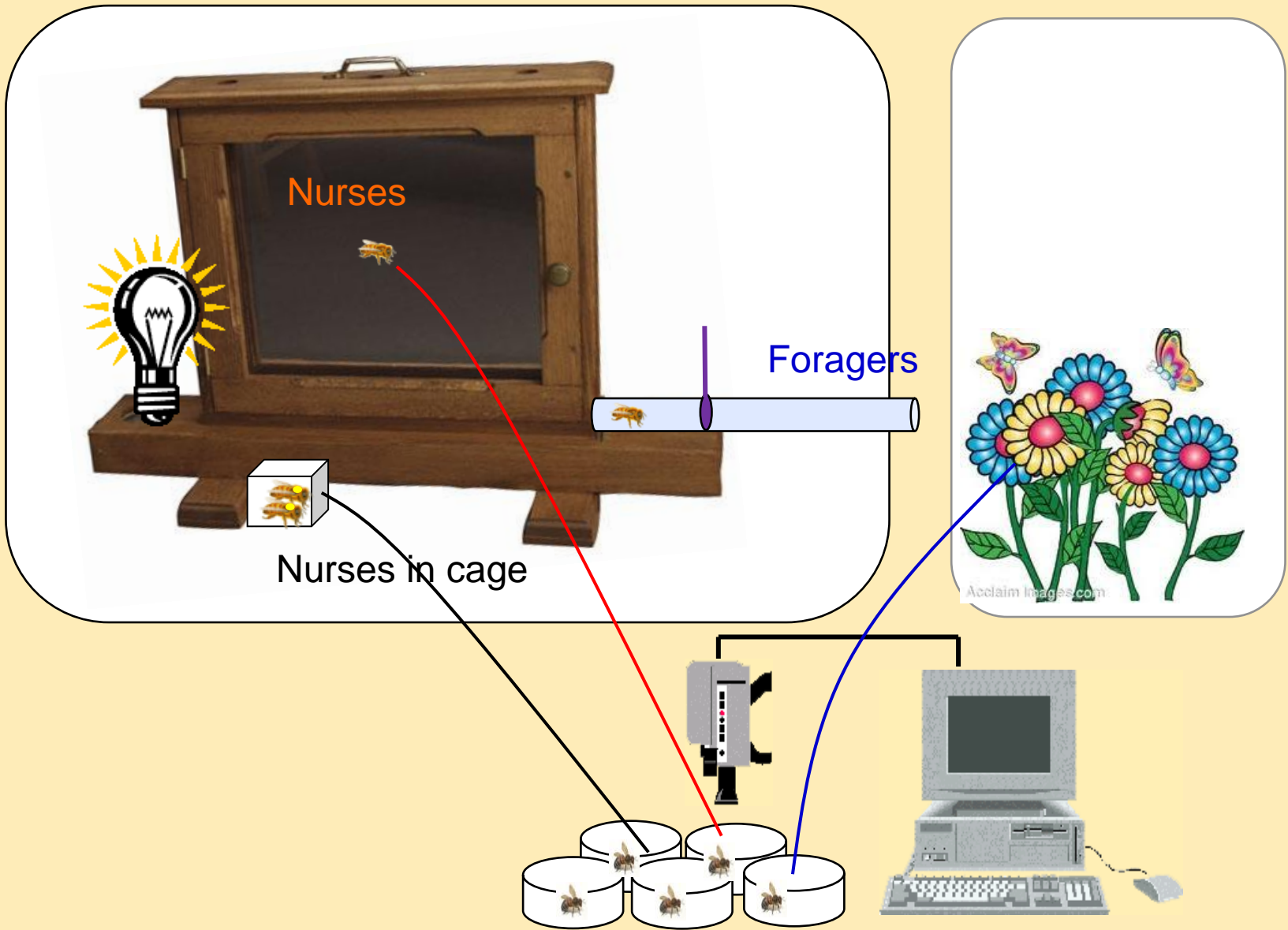


48h in DM



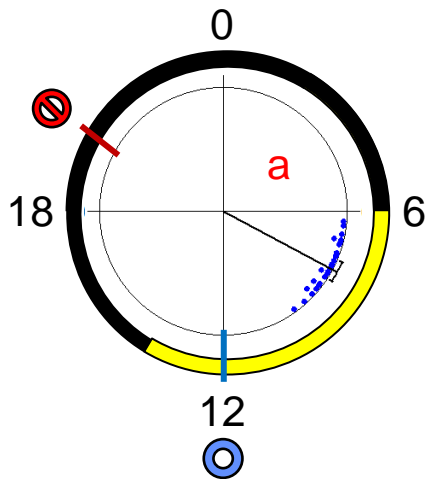
48h in cage



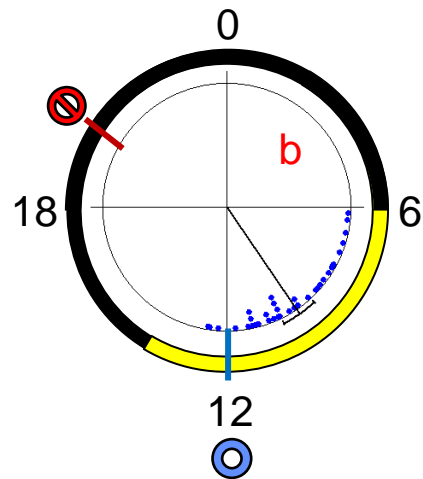


Onset

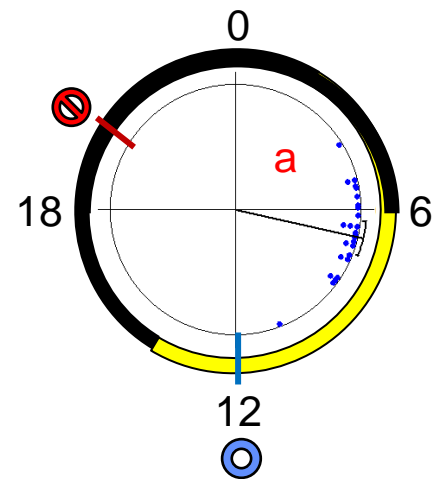
Foragers



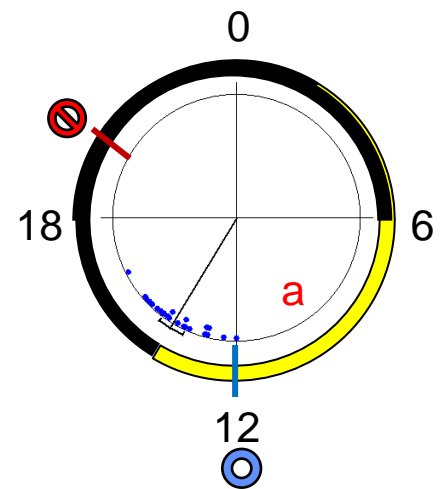
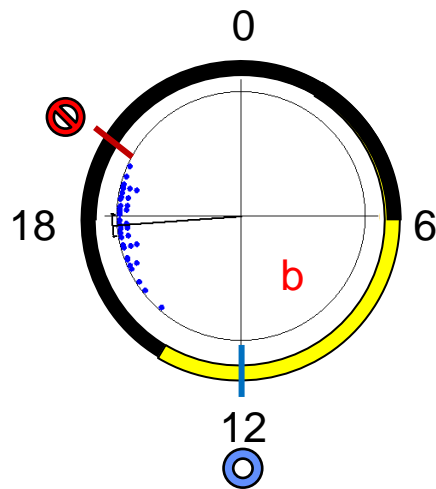
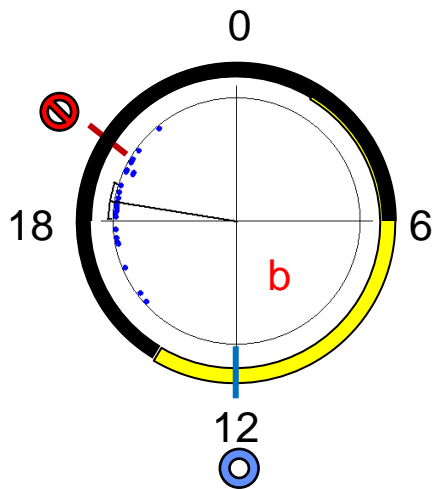
Nurses





Nurses in cage



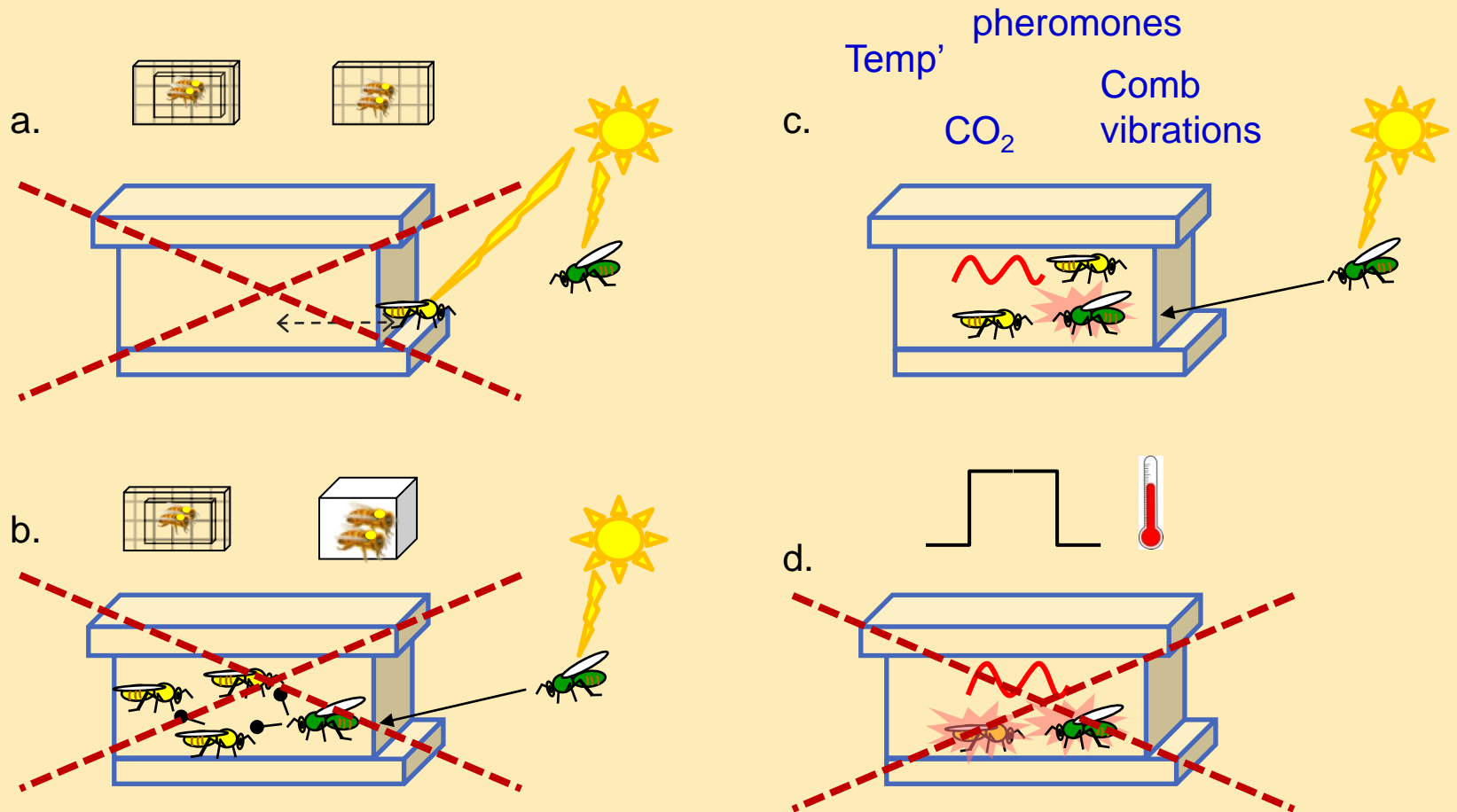
Offset



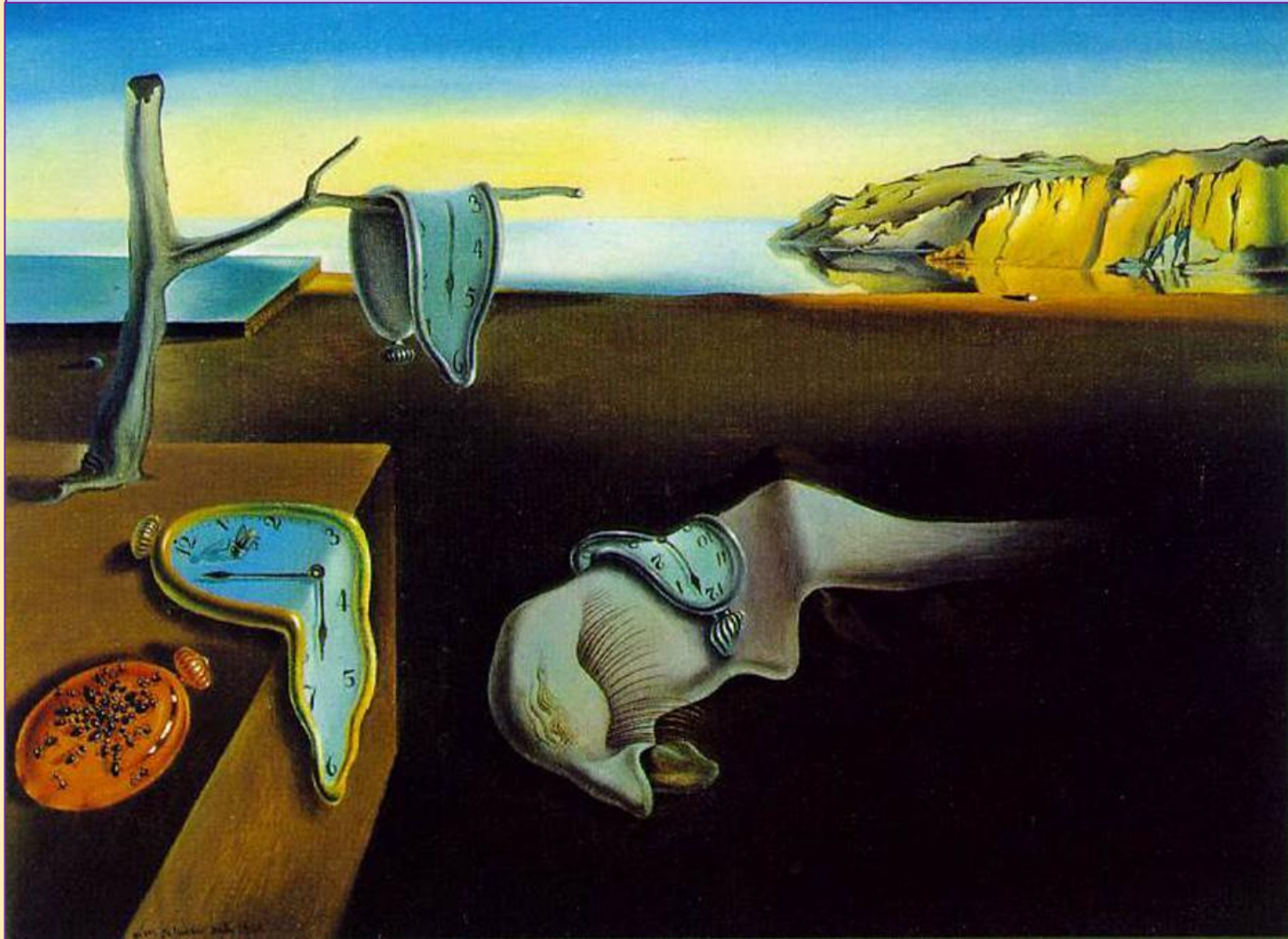
  Open \ close hive entrance

 light: dark

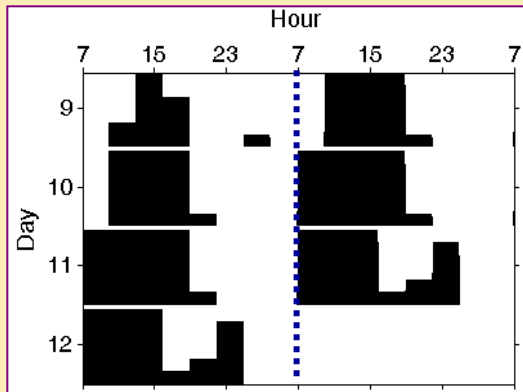
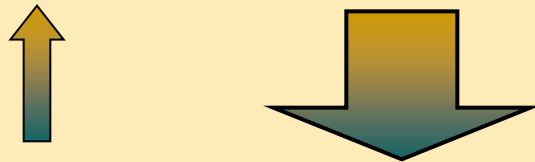
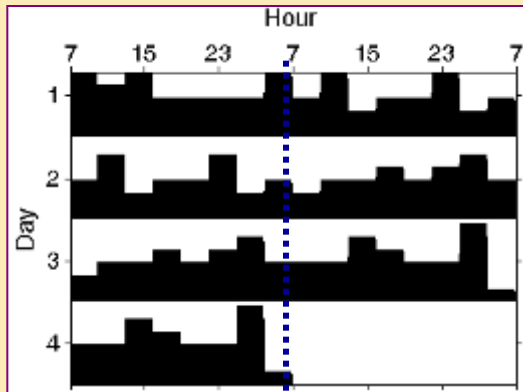
How bees are synchronized to a common phase?

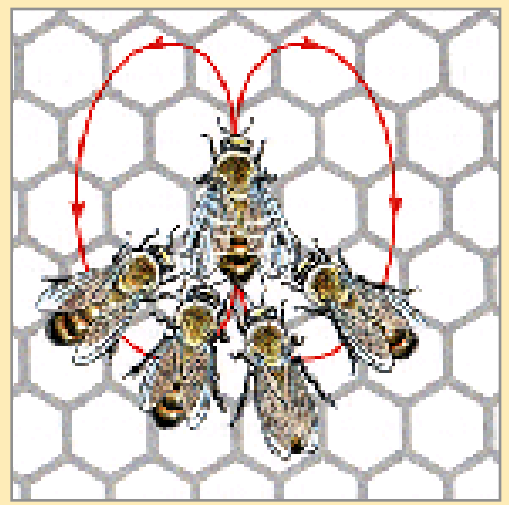
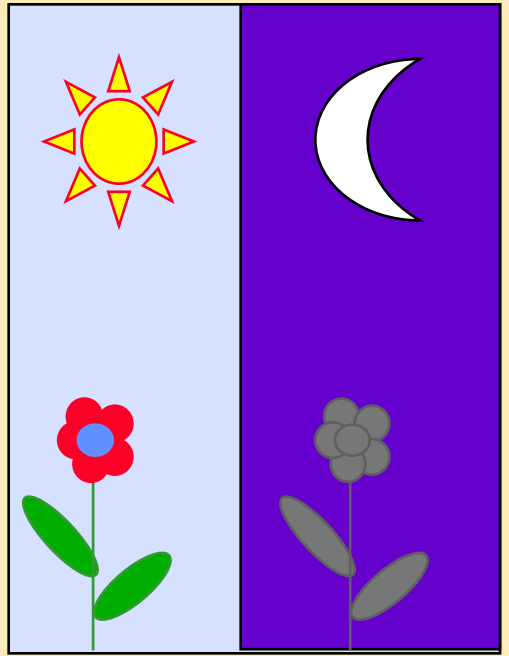


Socially regulated plasticity in circadian rhythms



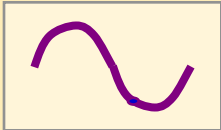
Division of labor and plasticity in circadian rhythms





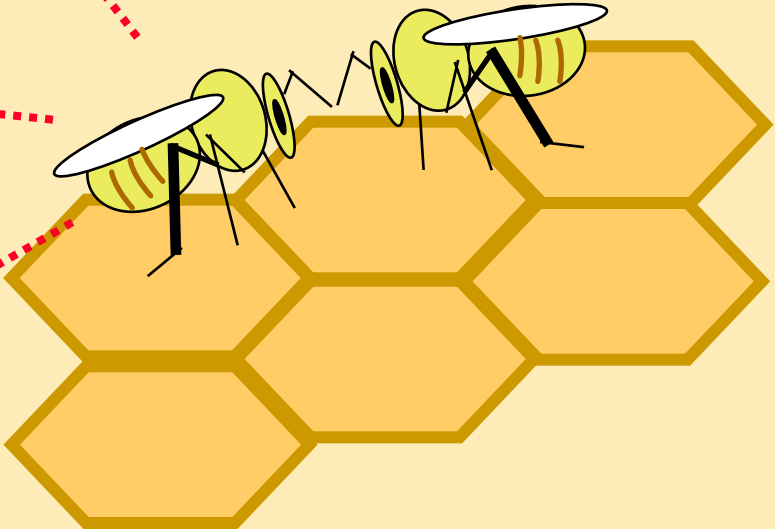
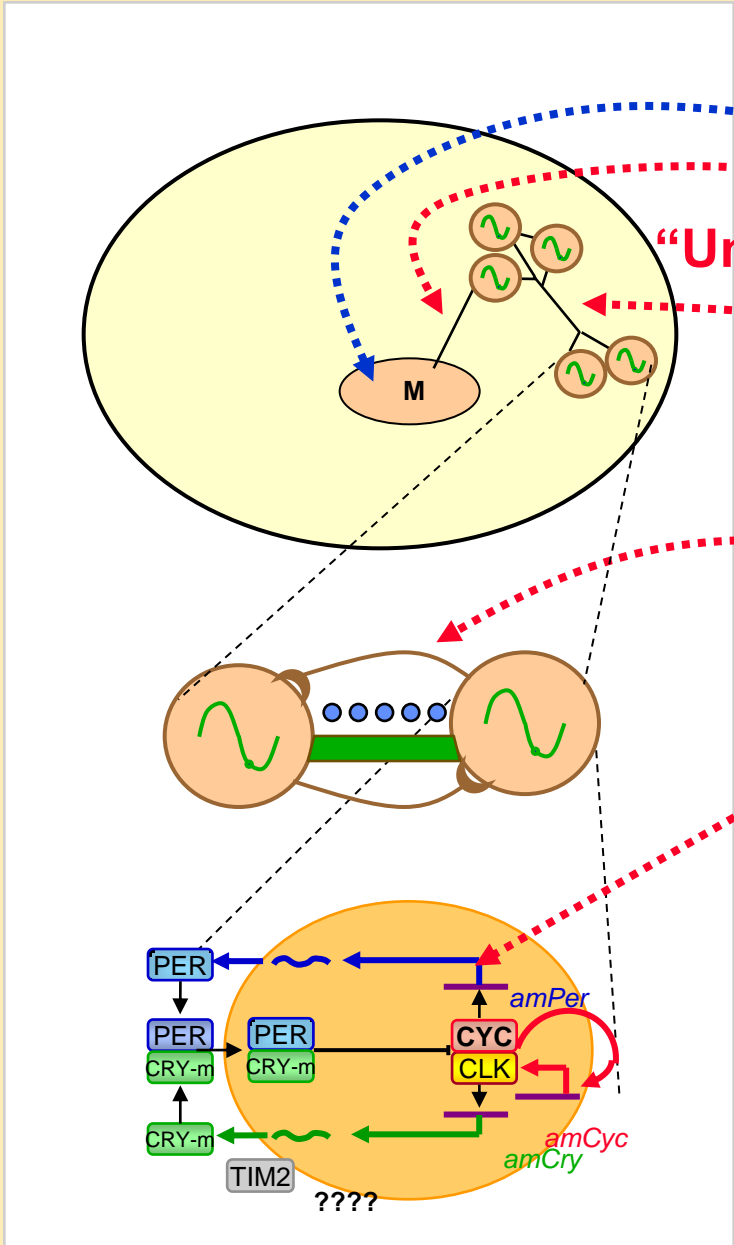


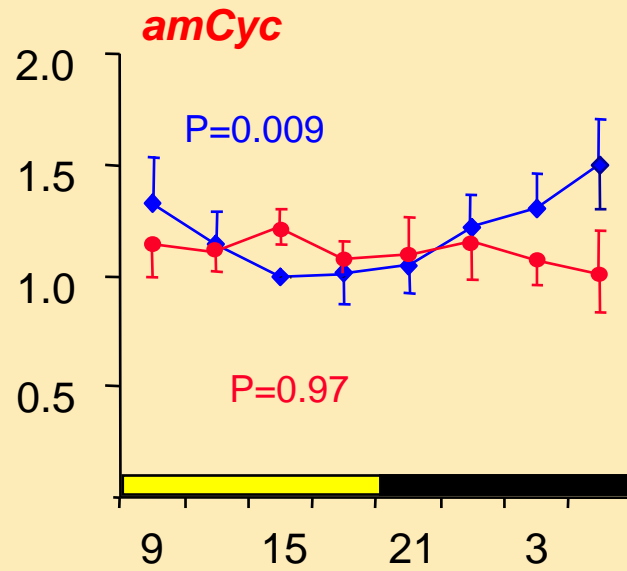
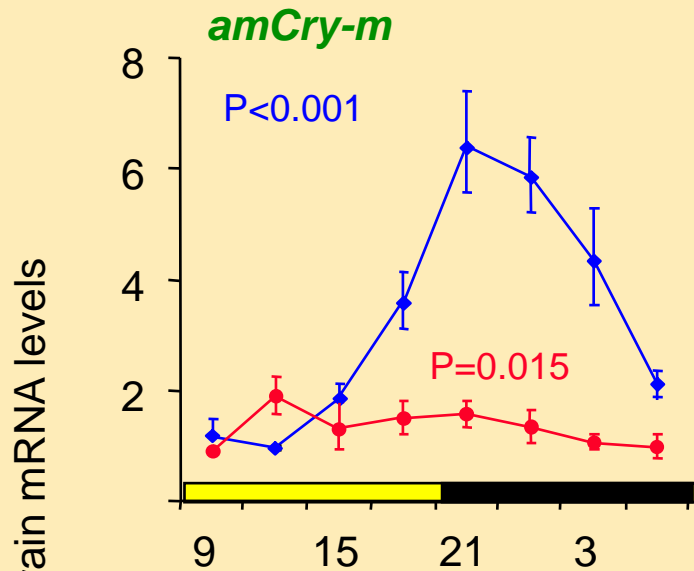




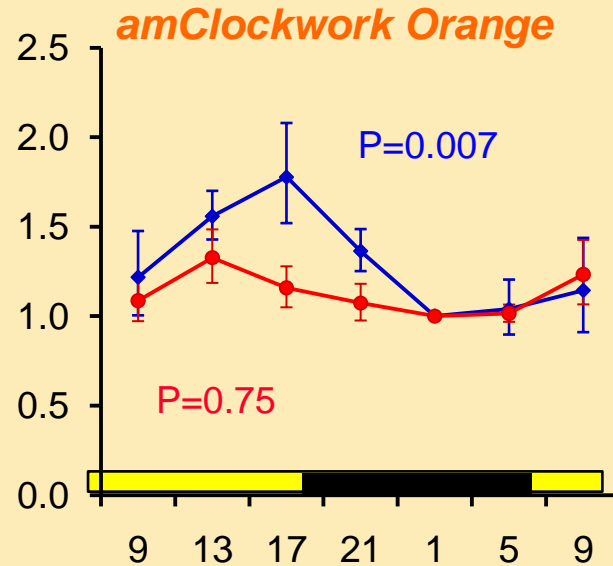
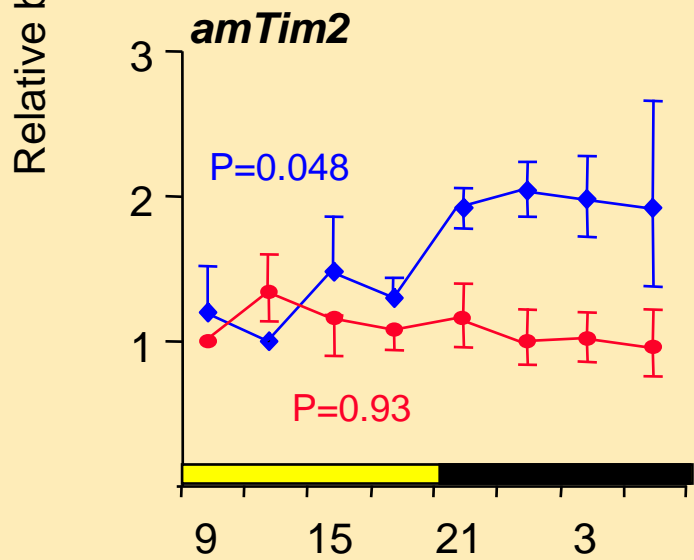
“Masking”

“Uncoupling”



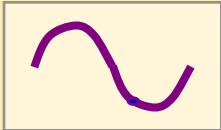


Nurse
Forager



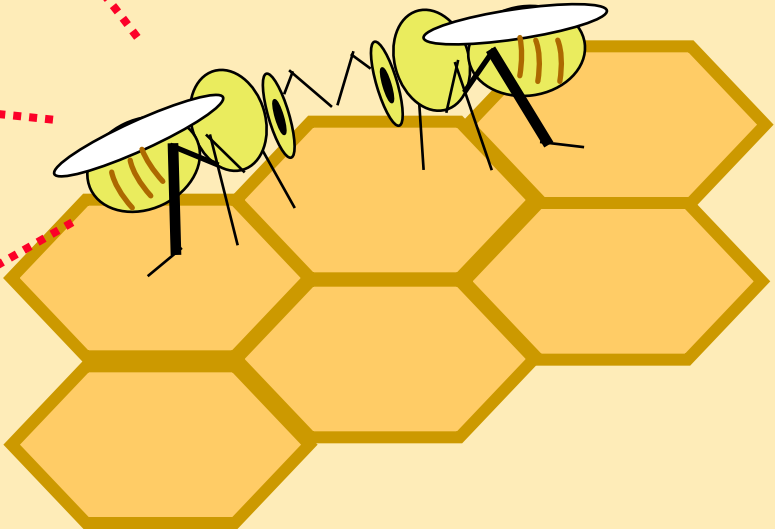
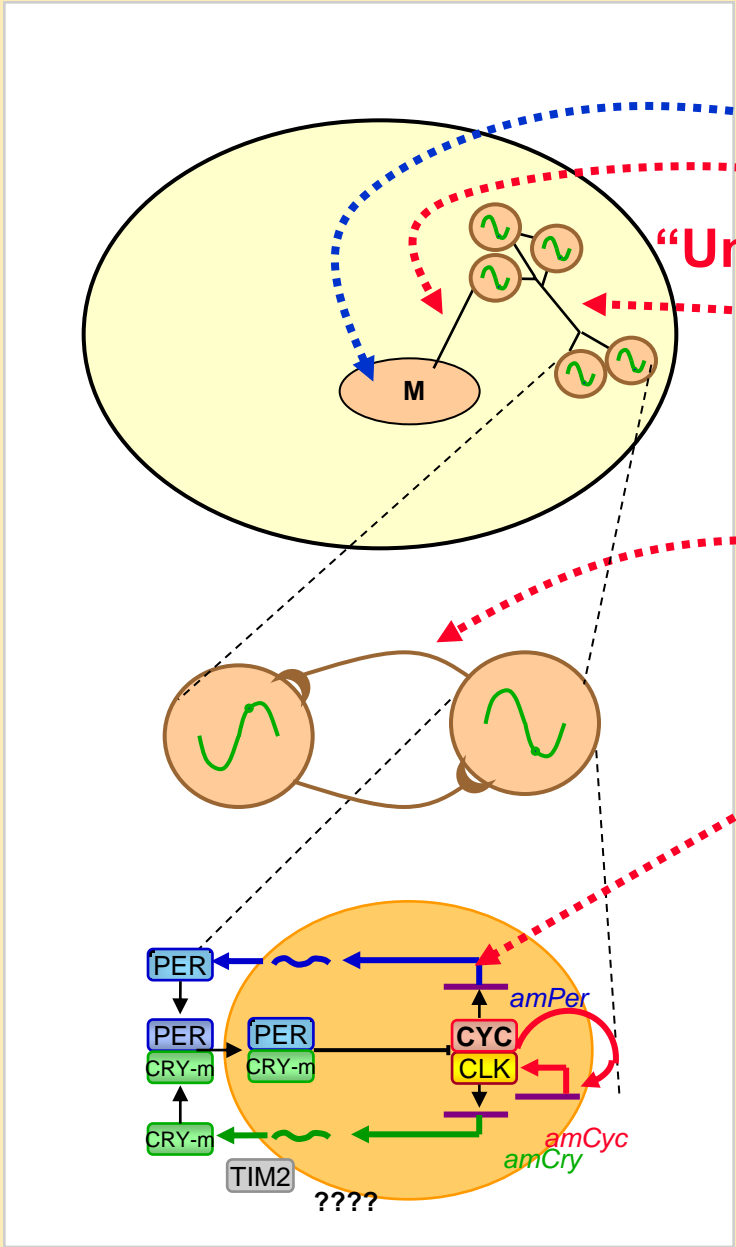
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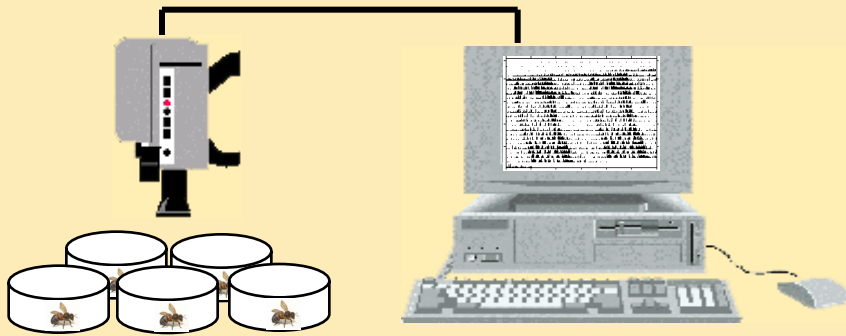
Time of day (h)



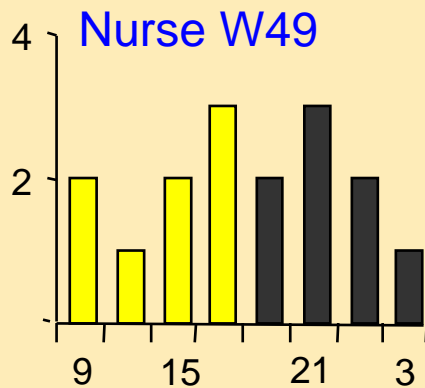
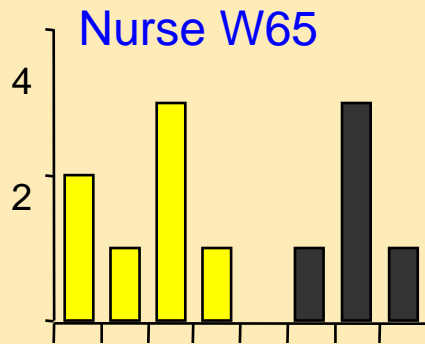
“Masking”

“Uncoupling”





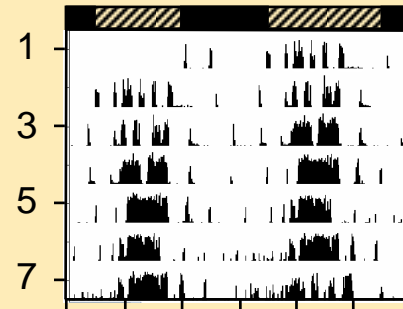
Brood care activity (No. scans active)



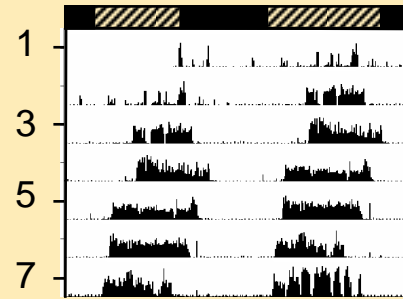
Time of day (h)

Days in DD

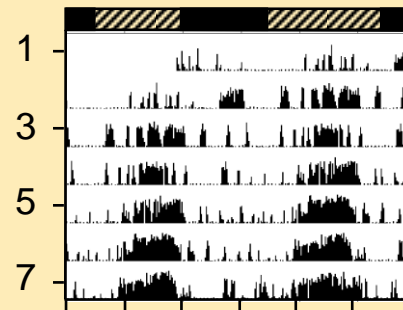
Forager



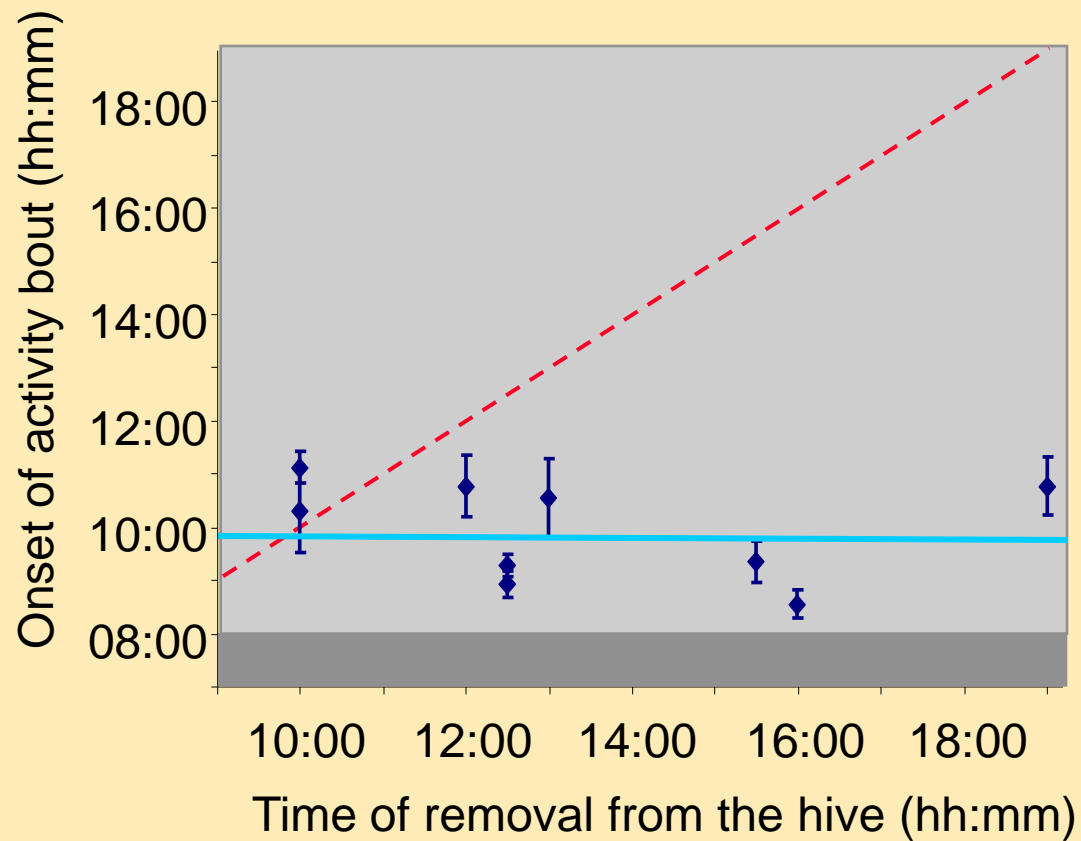
Days in DD



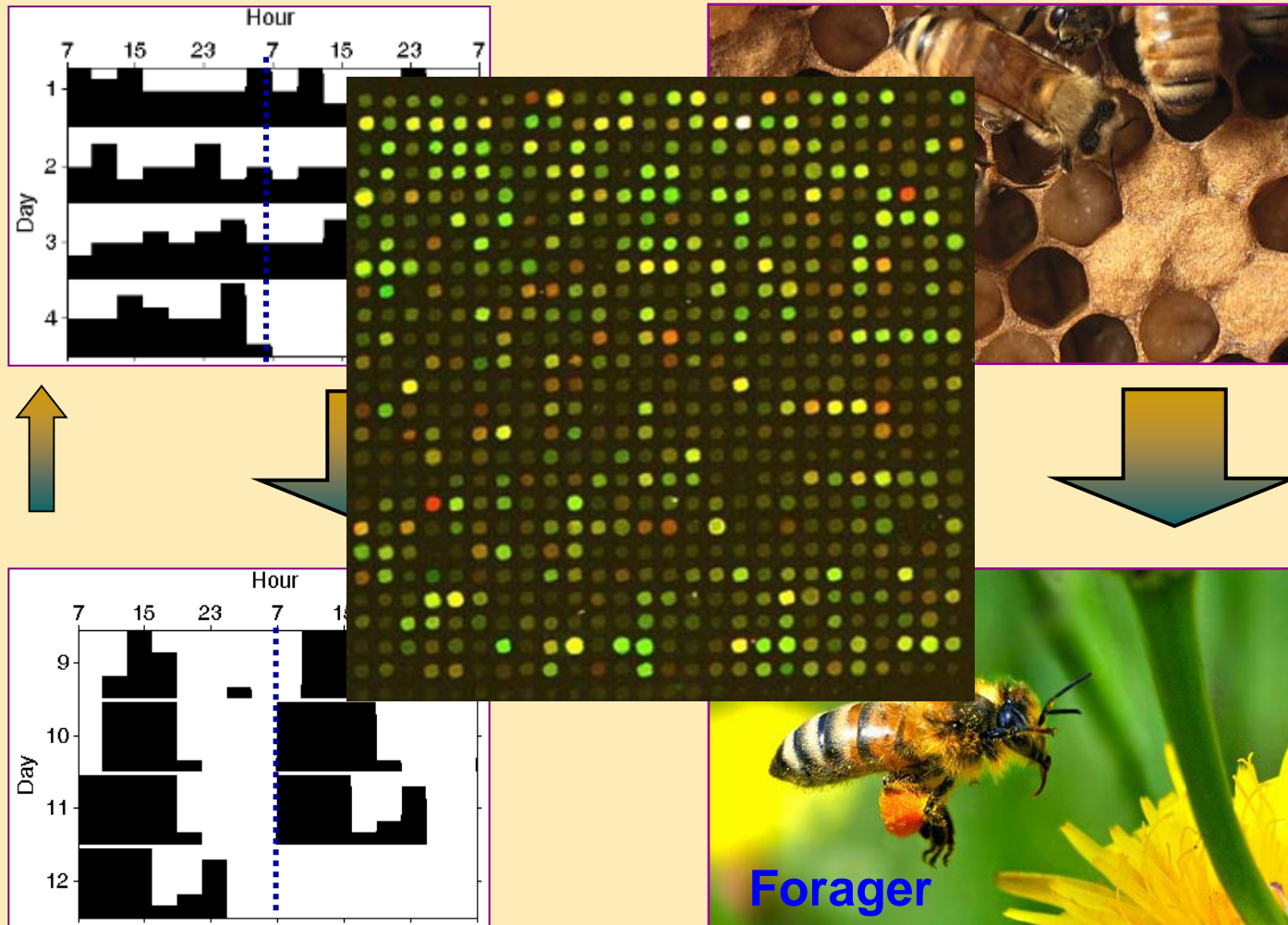
Days in DD



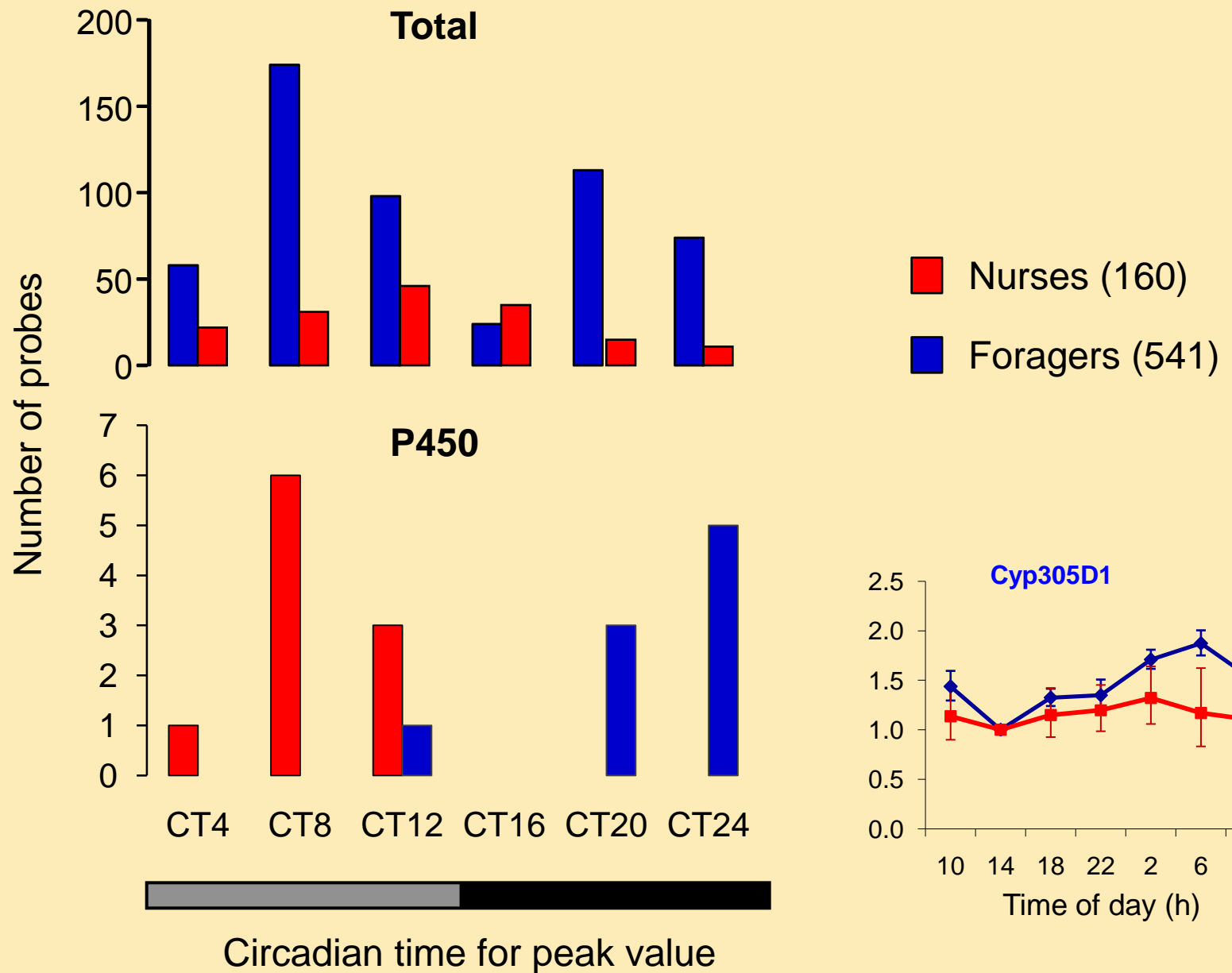
8 16 0 8 16 0



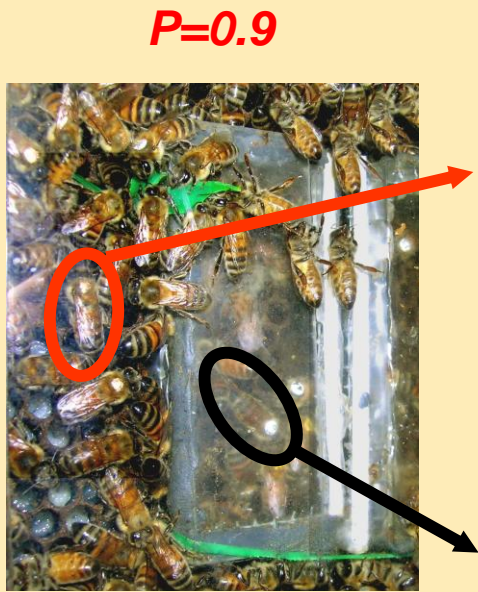
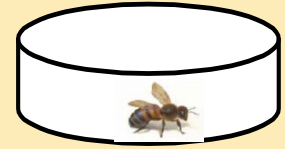
Division of labor and plasticity in circadian rhythms



Moore et al. 1998; Bloch and Robinson 2001

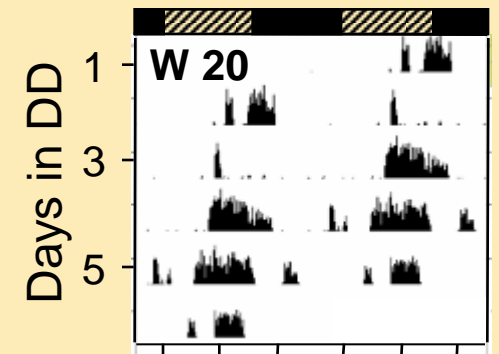
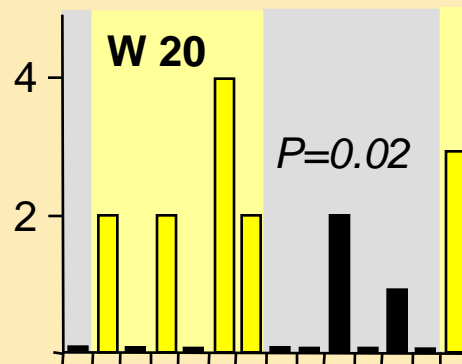
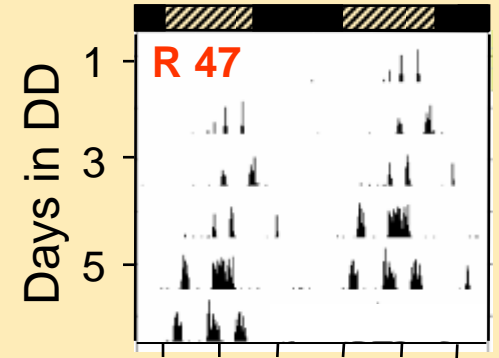
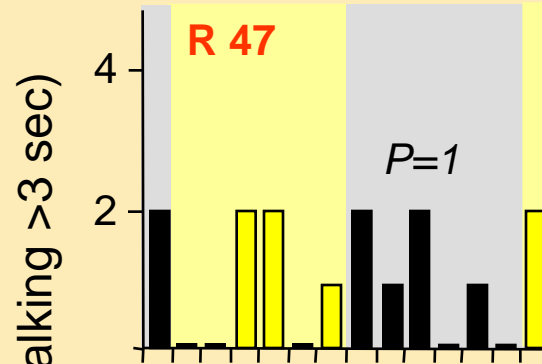






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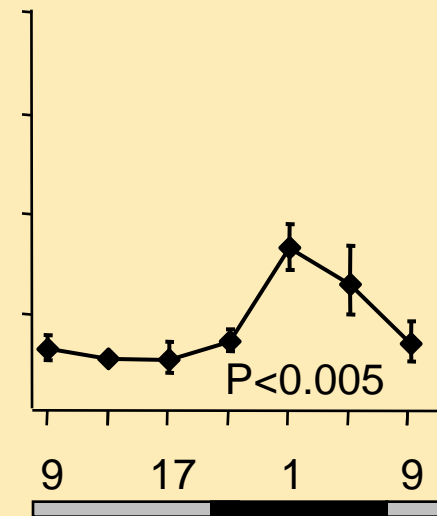
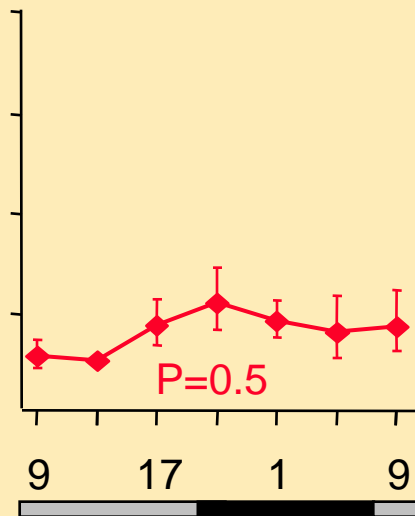
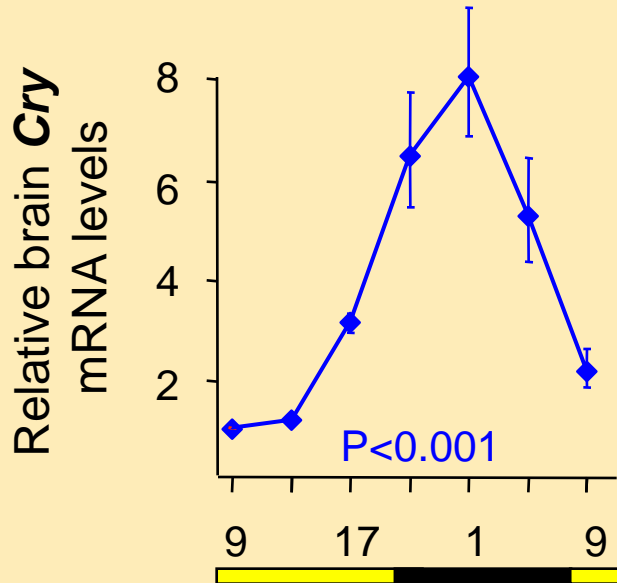
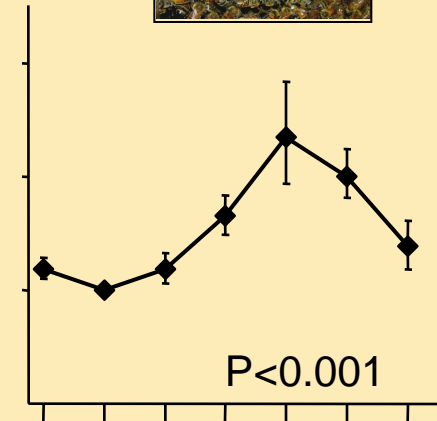
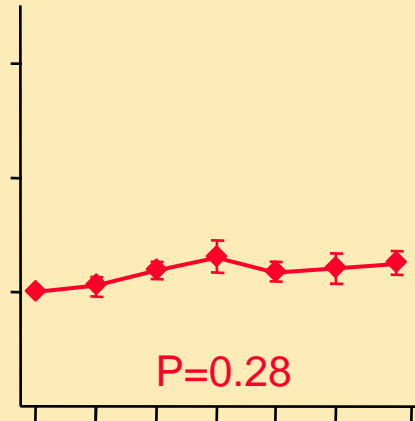
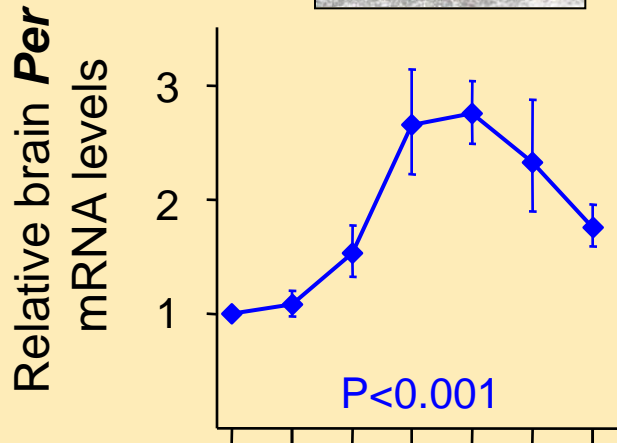
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Time of day (h)

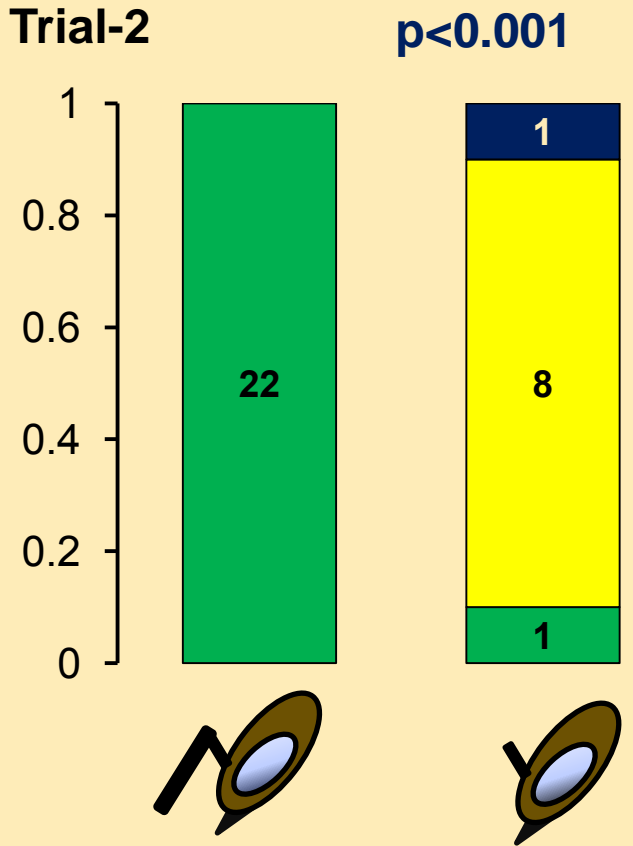
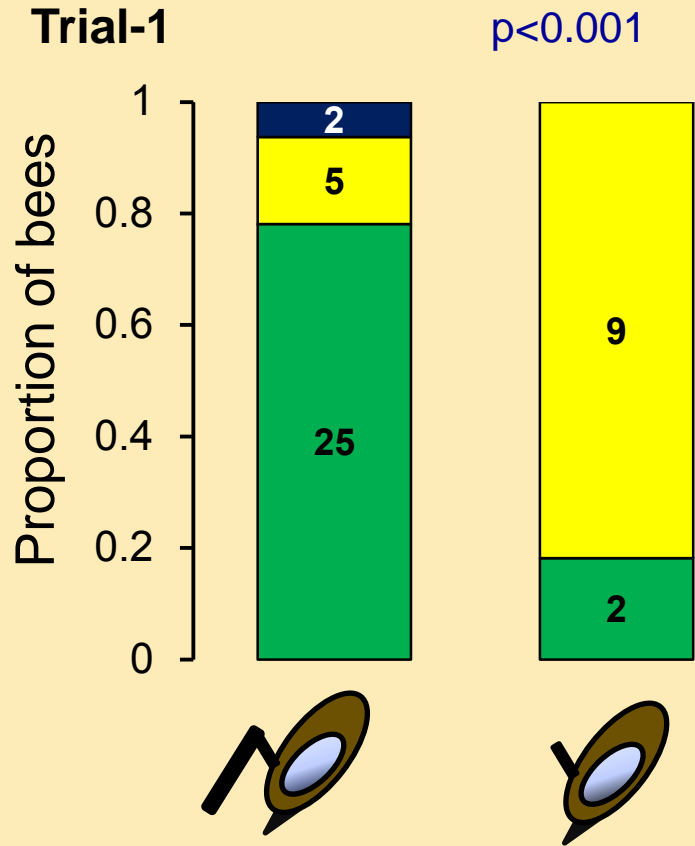
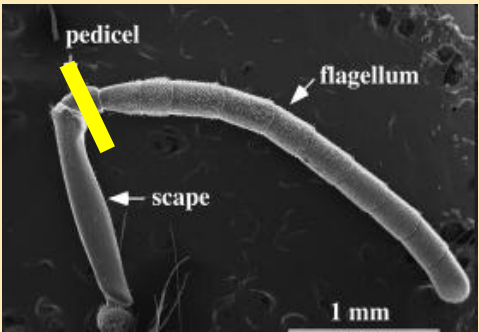
Time of day (h)

Colony S 77



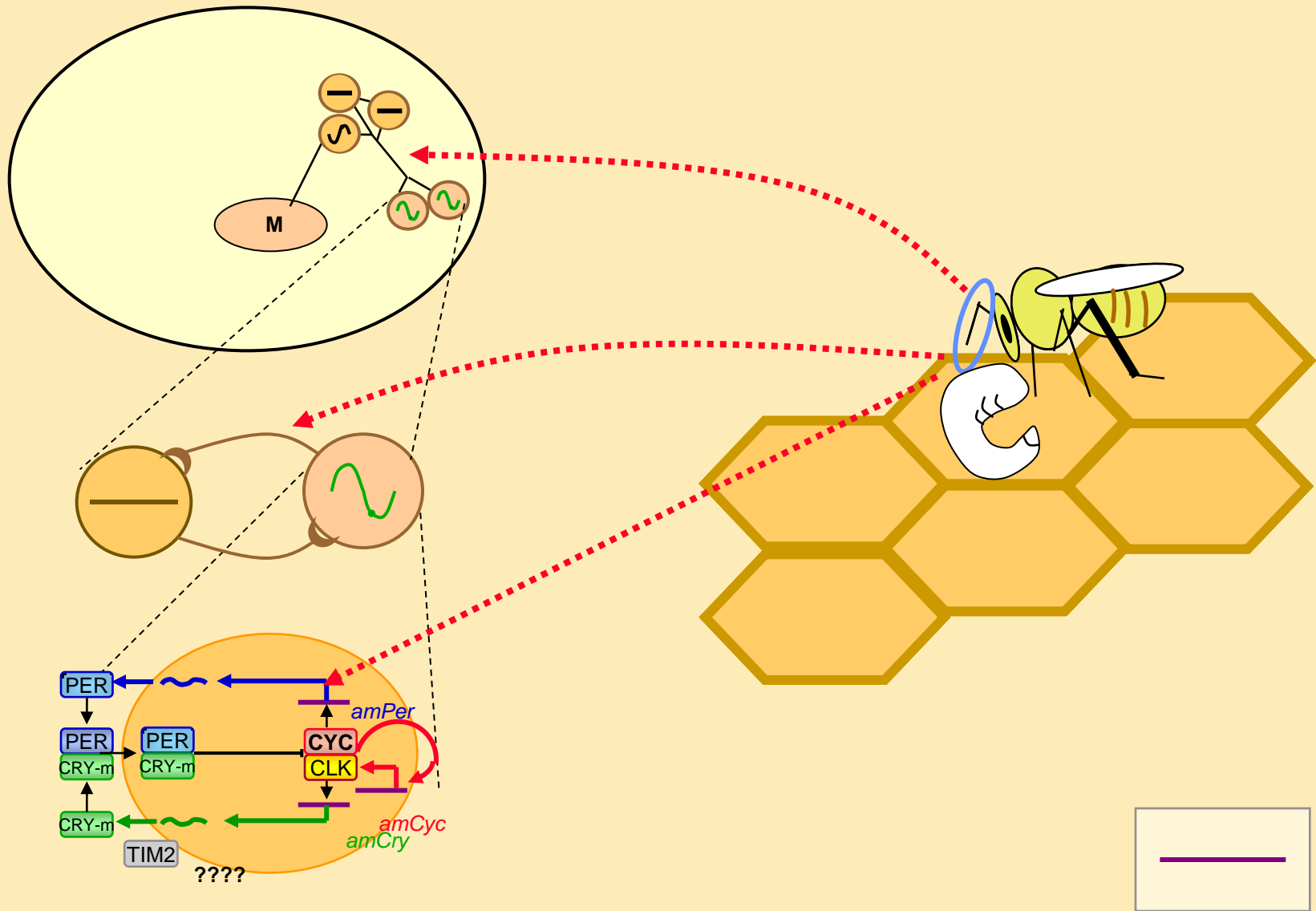
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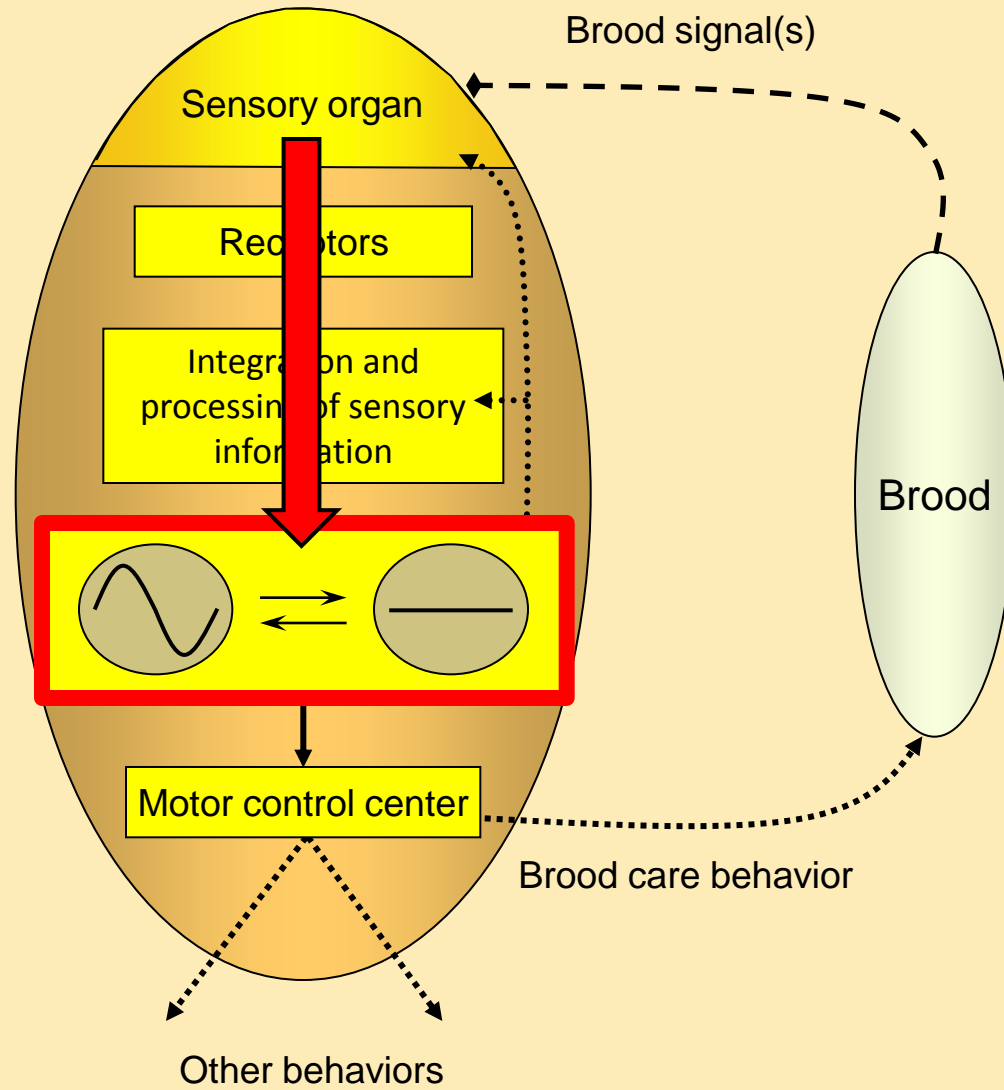
Time of day (h)



3X2 Fisher Exact test

Nagari and Bloch, JIP 2012





HUJI

Financial support

**Raphael Nir
Mira Cohen**

**Yair Shemesh
Ada Eban-Rothschild
Elad Rubin**



**Taro Fuchikawa
Muki Nagari**

**Joseph and Belle
Braun Senior
Lecturership**

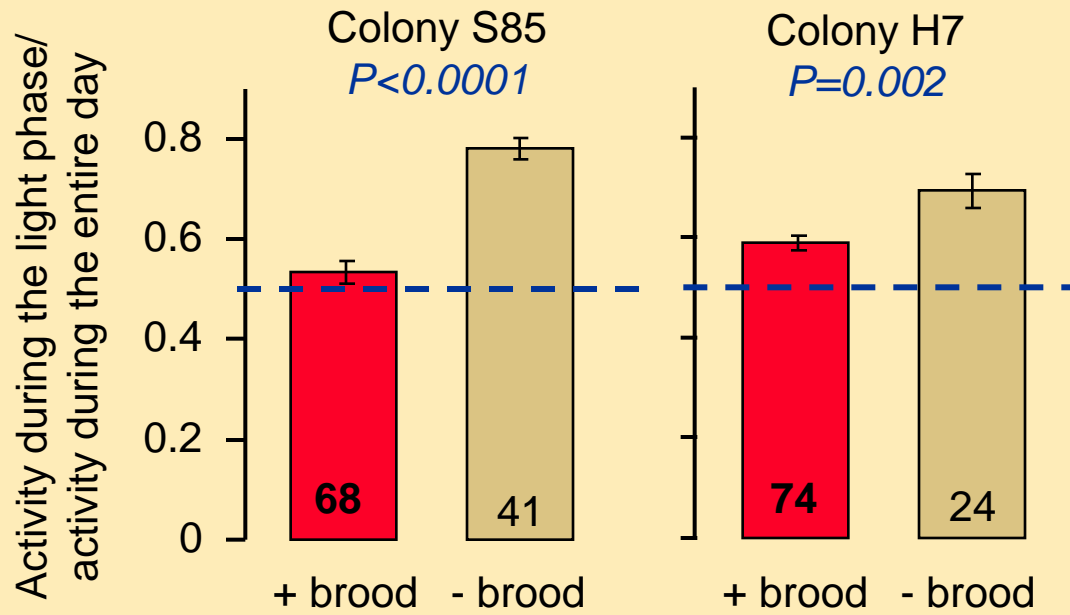
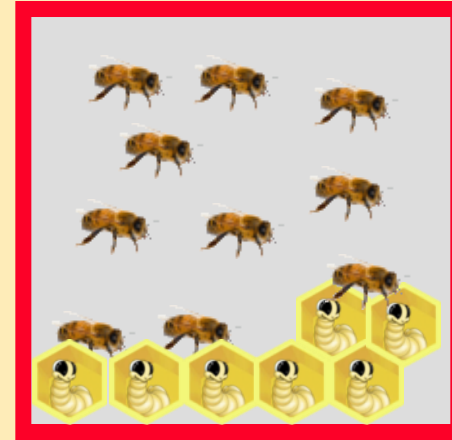
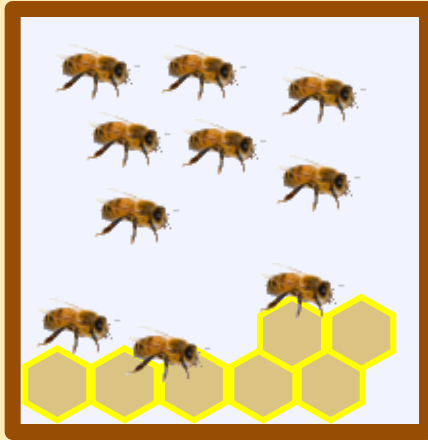
**Avital Kayam
Shi Yerushalmi**

UIUC

**Gene E. Robinson
Sandra Rodriguez-Zas
Hugh M. Robertson**

**Additional
Graduate and
undergraduate
students**

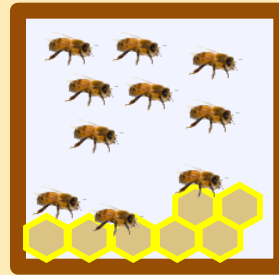




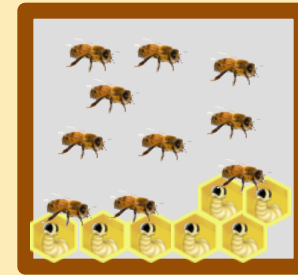
Foragers



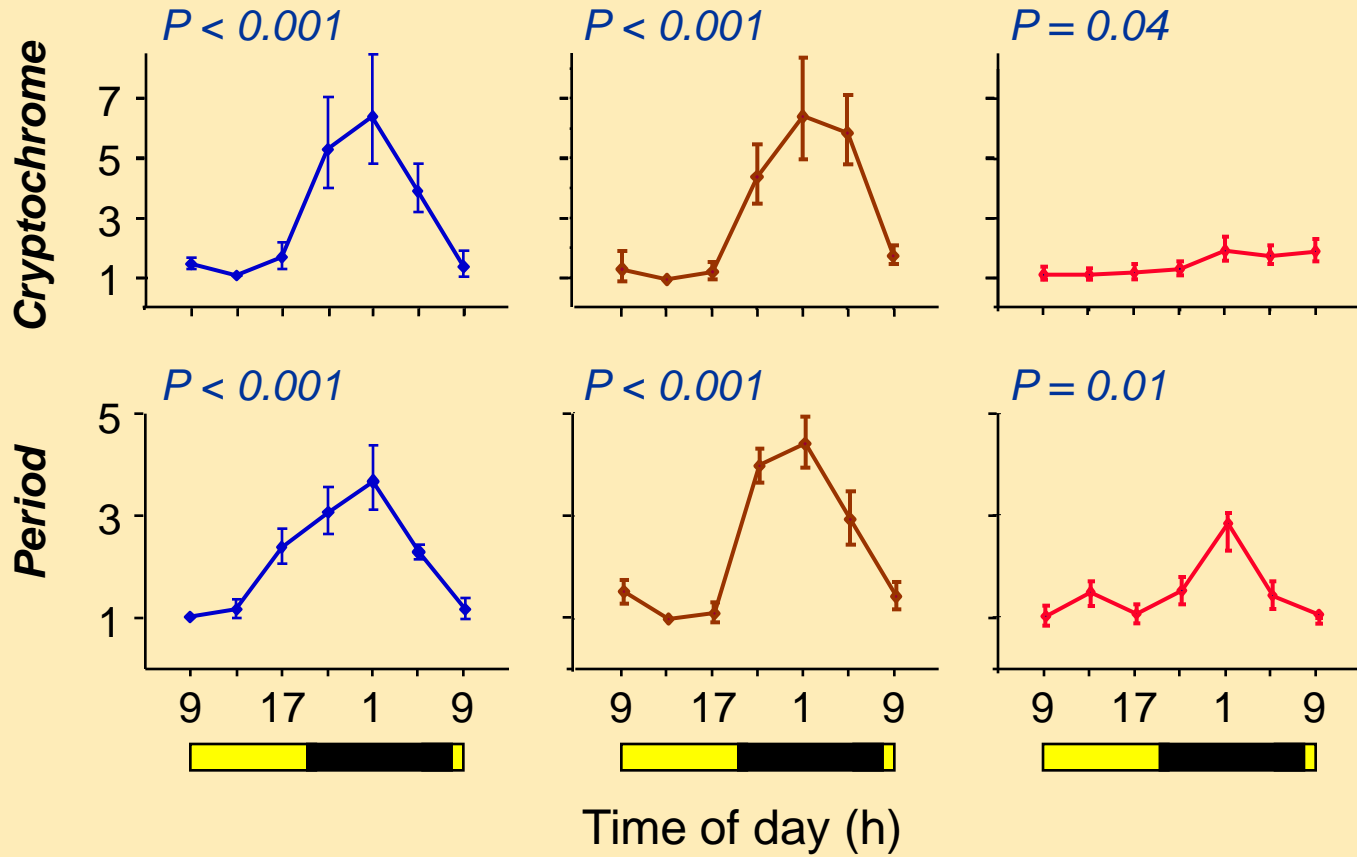
-brood



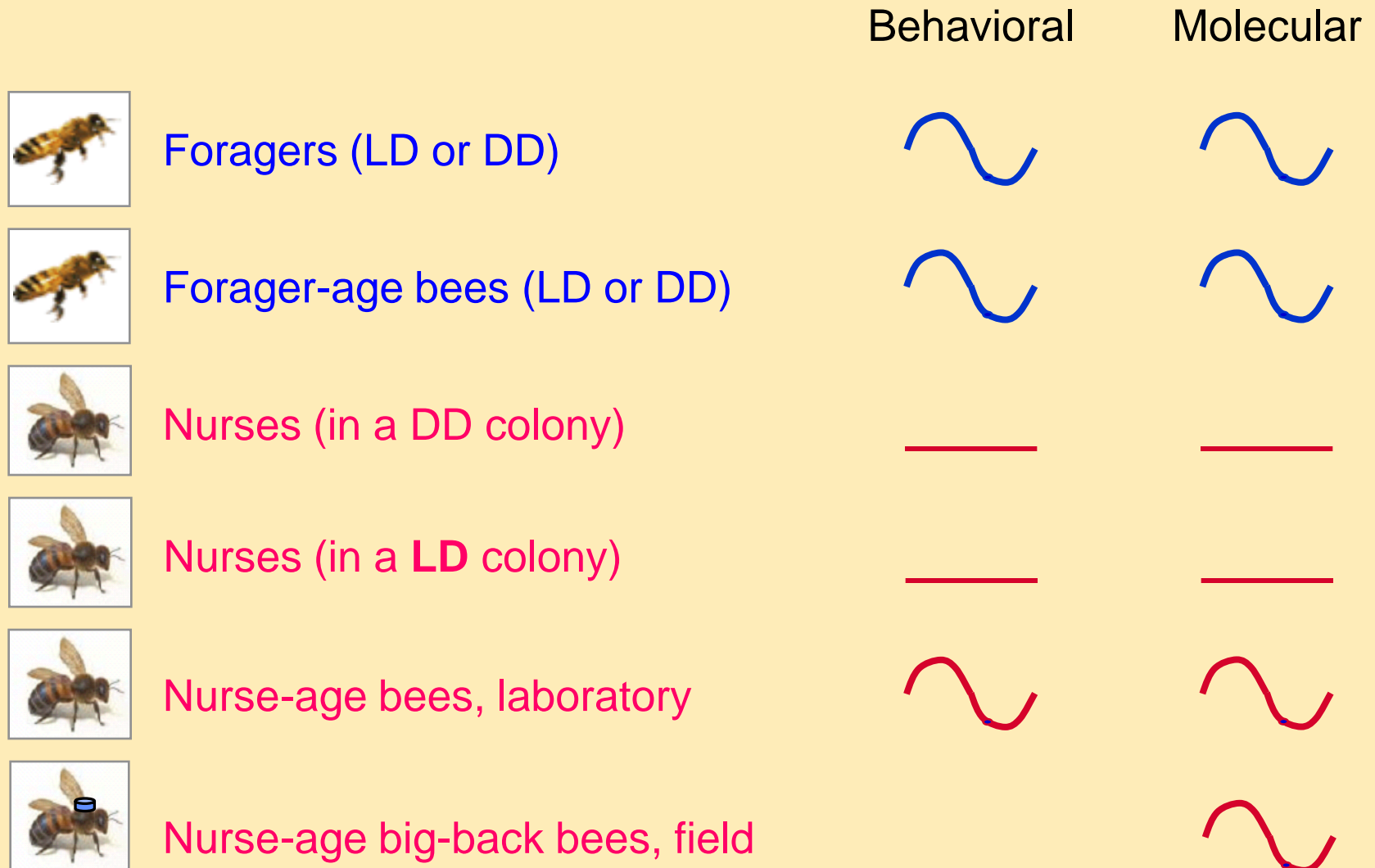
+brood

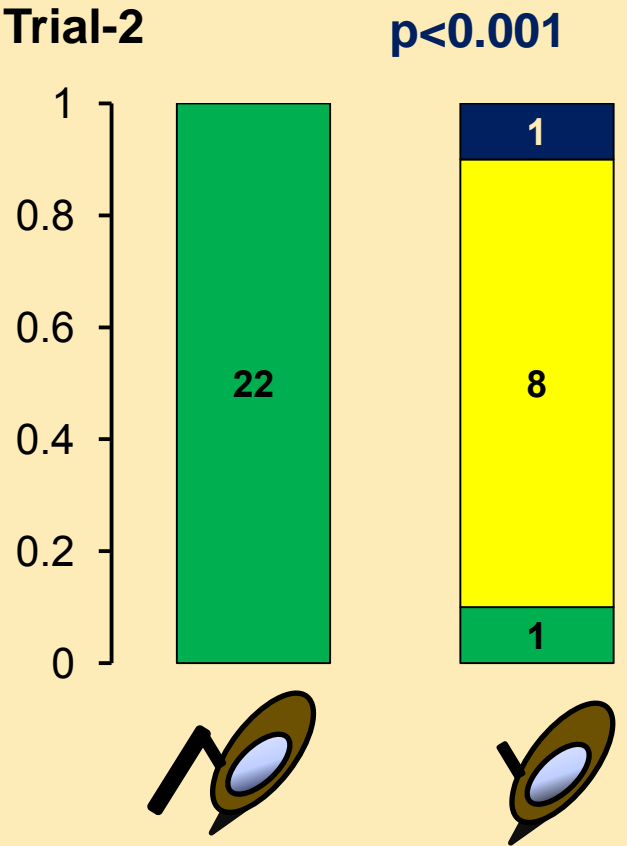
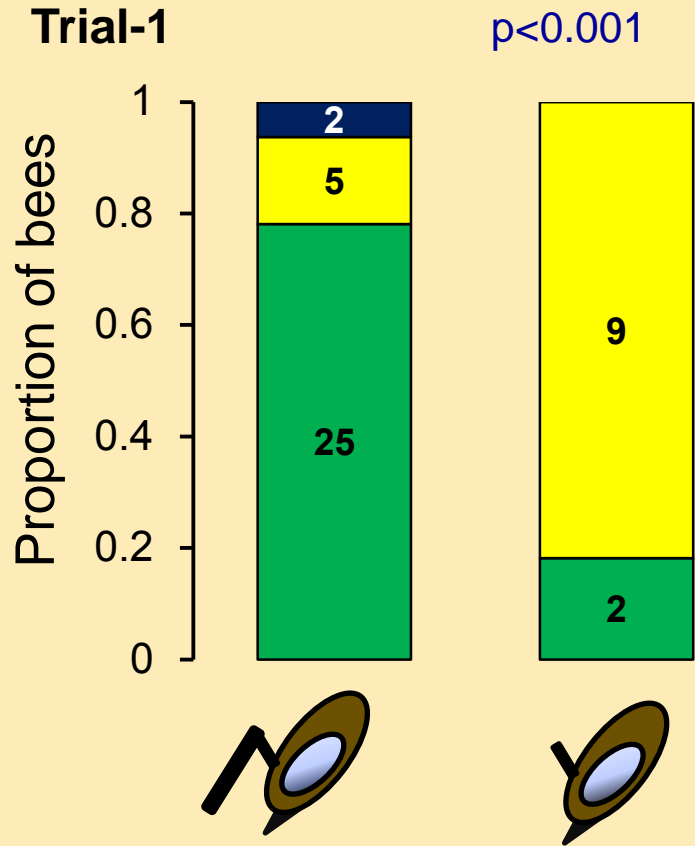
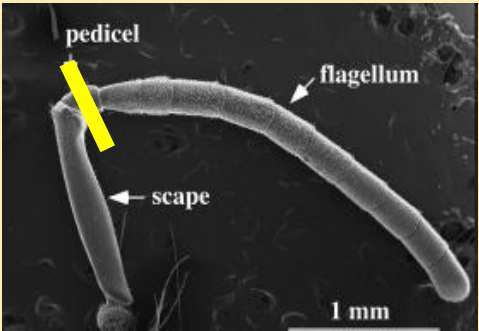


Relative brain mRNA levels



Division of labor and plasticity in the behavioral and molecular circadian rhythms





3X2 Fisher Exact test

Nagari and Bloch, unpublished

Brood care

Brood

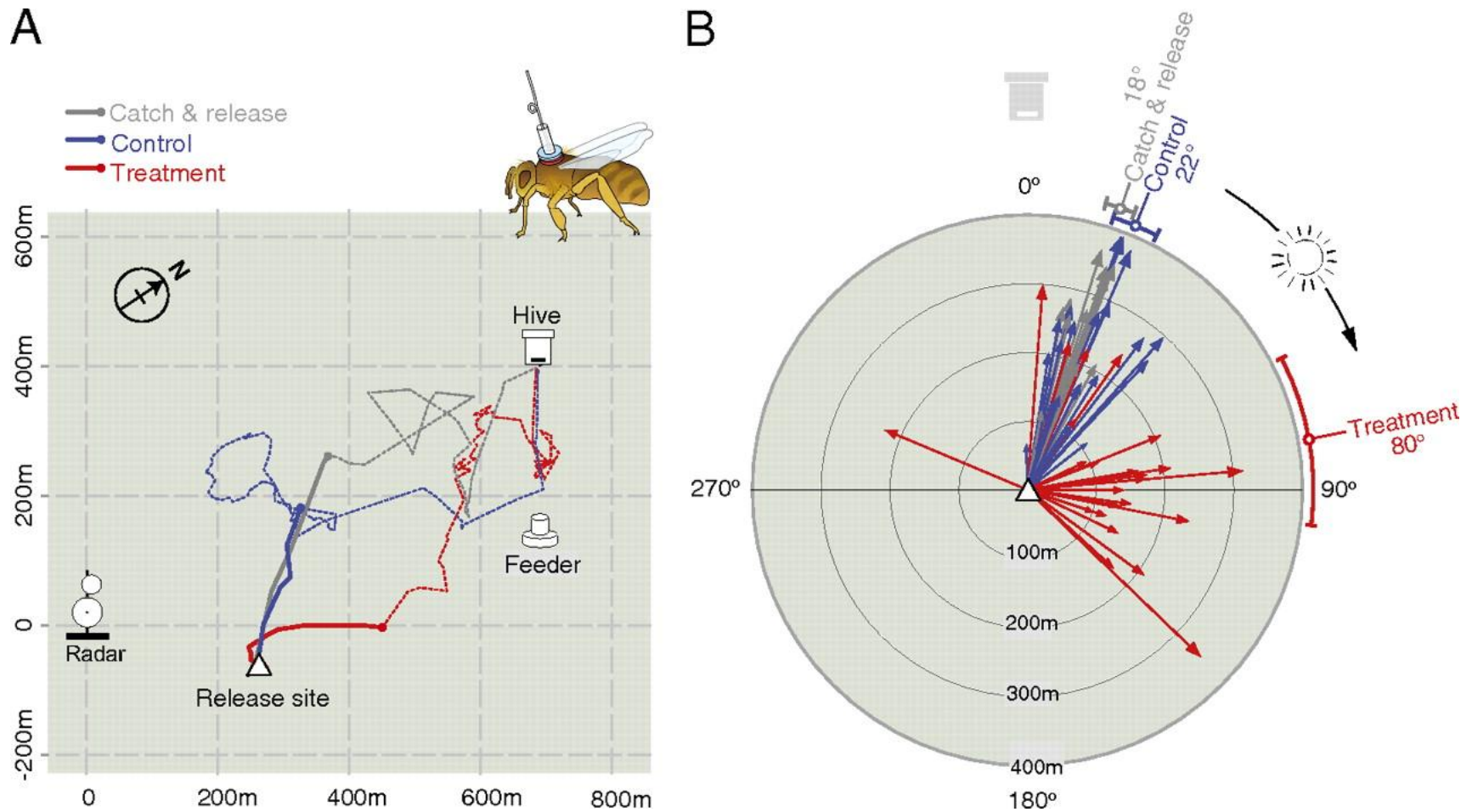
A caged bee

Mesh





Flight paths of individual bees tracked by harmonic radar



Cheeseman J F et al. PNAS 2012;109:7061-7066