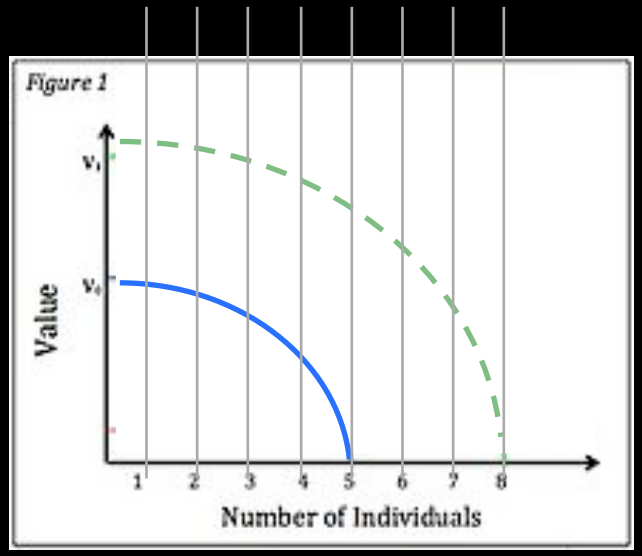
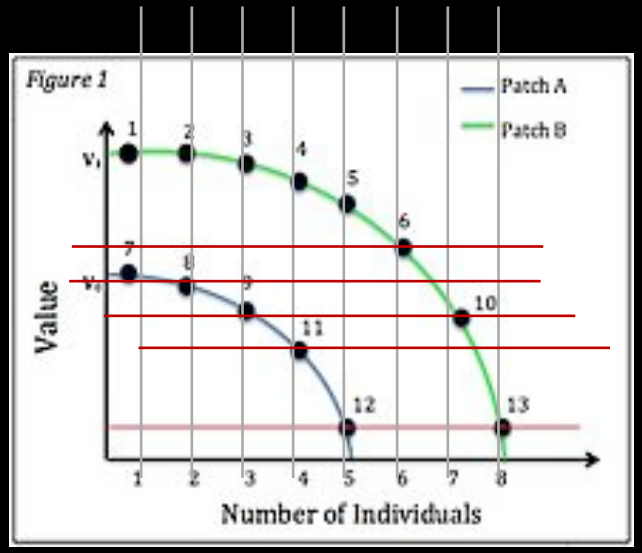
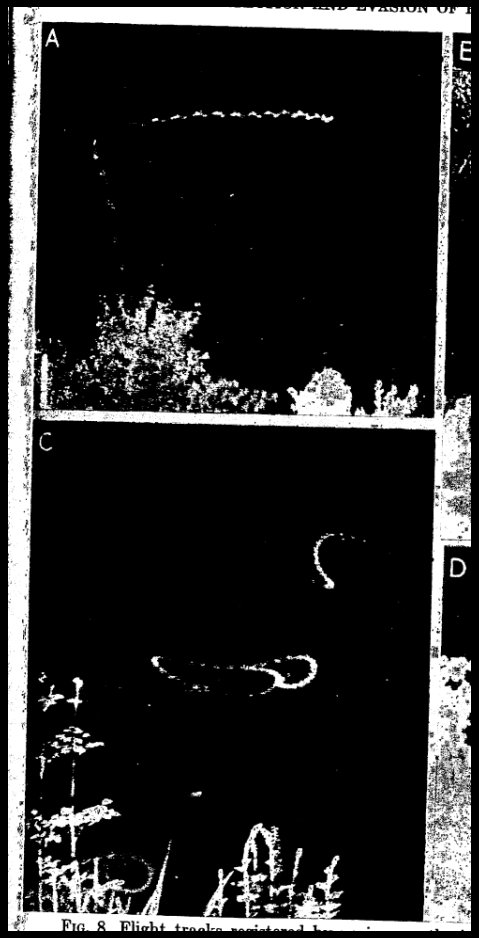


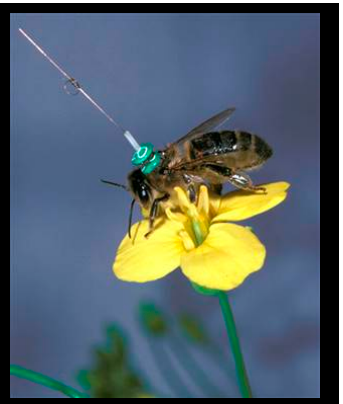


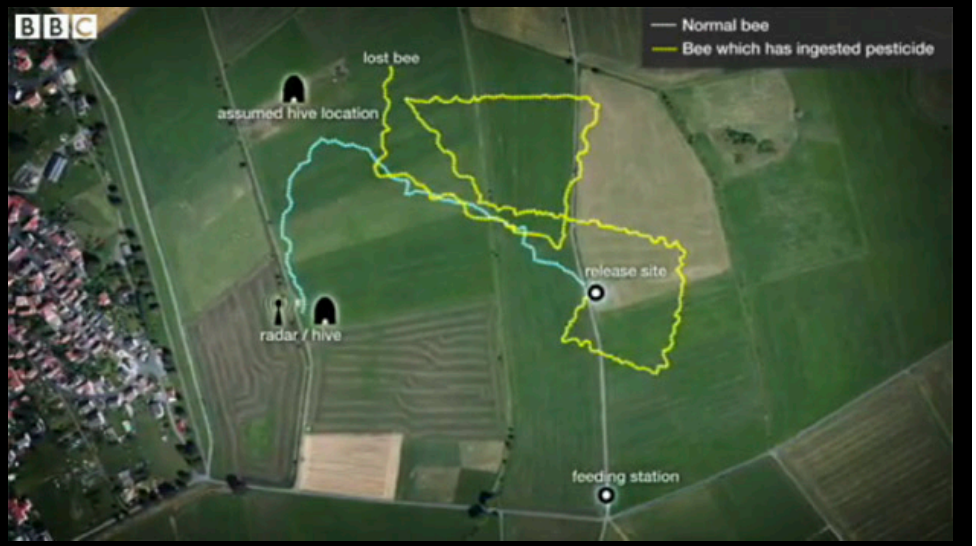
Ideal Free Distribution

1) Each patch quality that is determined by the amount of resources available
2) Individuals are free to move
3) Individuals are aware of the value of each patch (ideal)
4) Increasing the number of individuals reduces the patch quality
5) All individuals are competitively equal

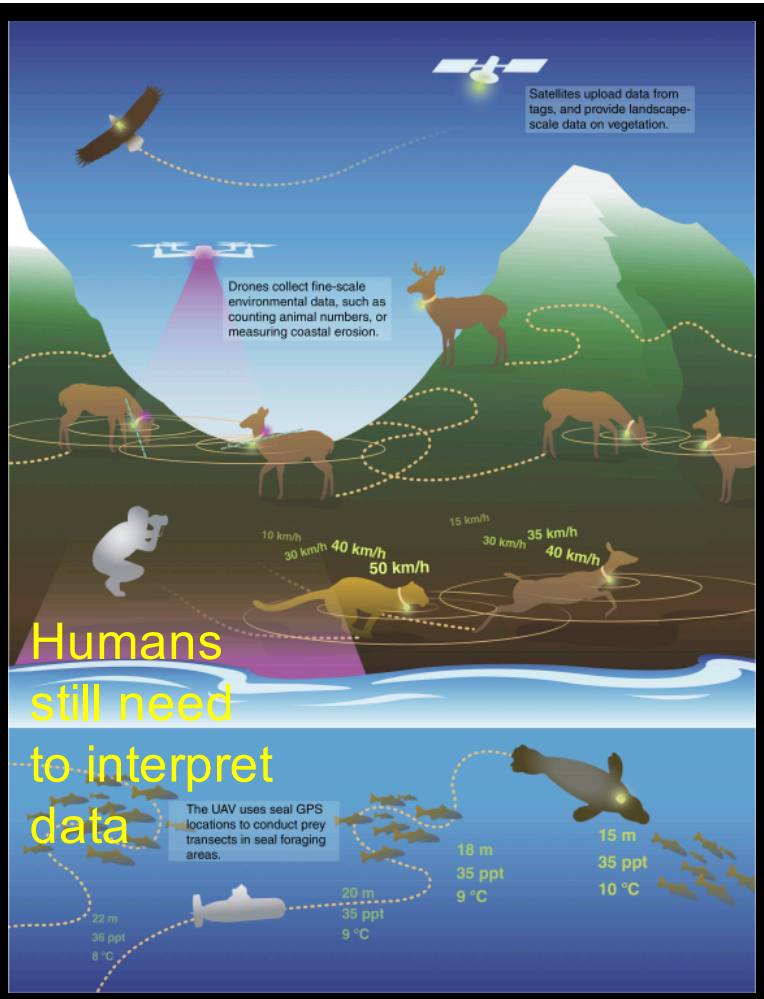


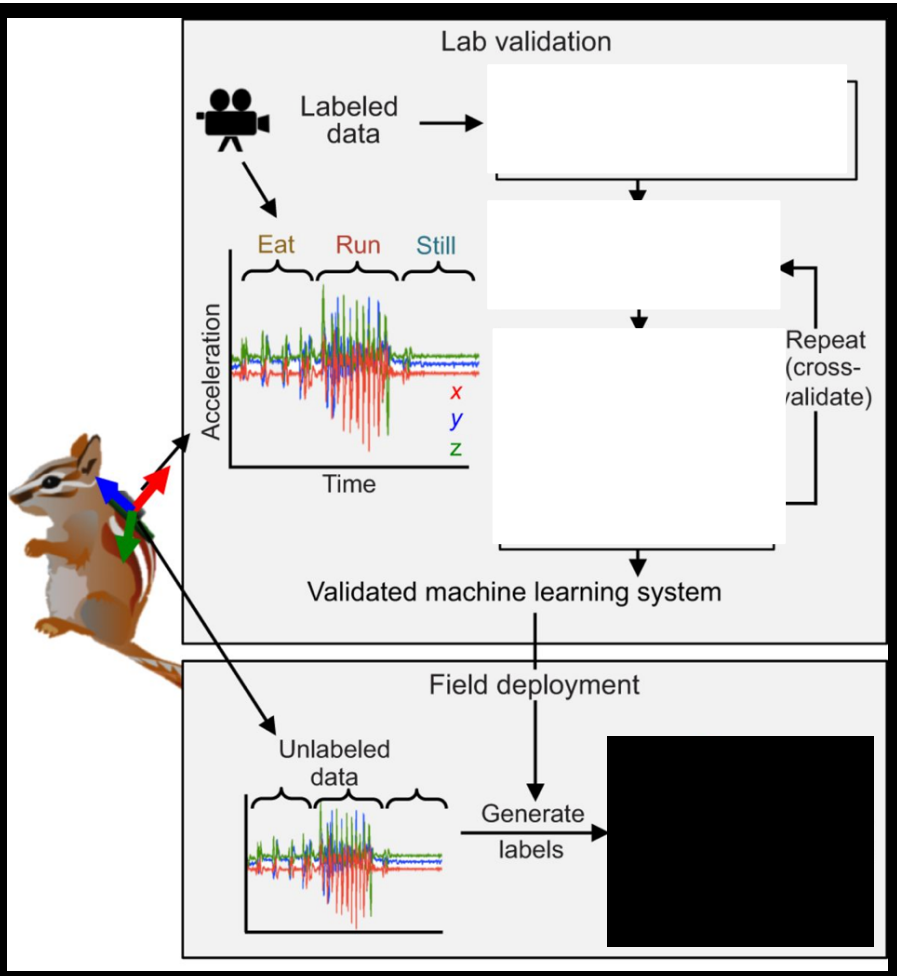
Strobe light tracking (1961)

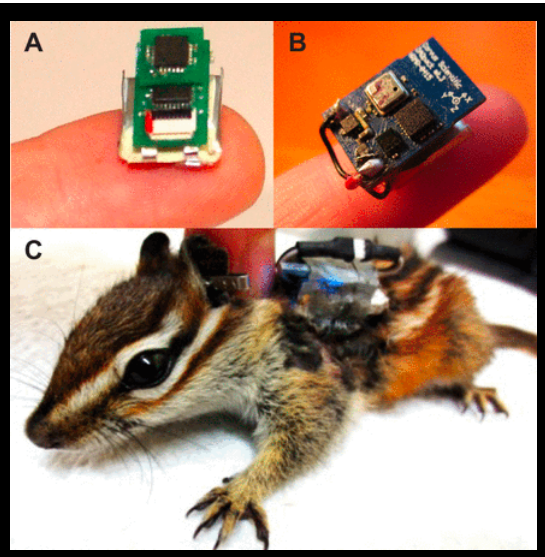


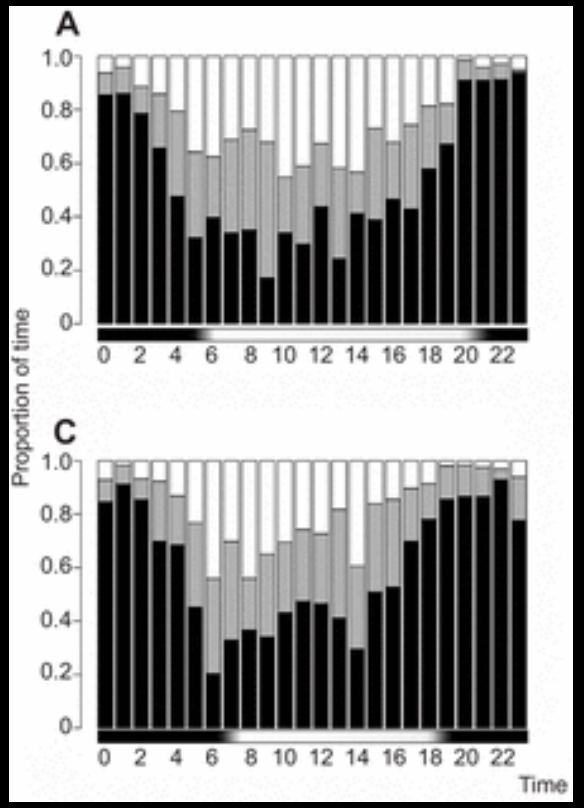


Harmonic Radar


Satellites upload data from tags, and provide landscape-scale data on vegetation.
Drones collect fine-scale environmental data, such as counting animal numbers, or measuring coastal erosion.
10 km/h
30 km/h
40 km/h
50 km/h
15 km/h
30 km/h
35 km/h
40 km/h
Humans still need to interpret data
The UAV uses seal GPS locations to conduct prey transects in seal foraging areas.
22 m
36 ppt
8 °C
20 m
35 ppt
9 °C
18 m
35 ppt
9 °C
15 m
35 ppt
10 °C





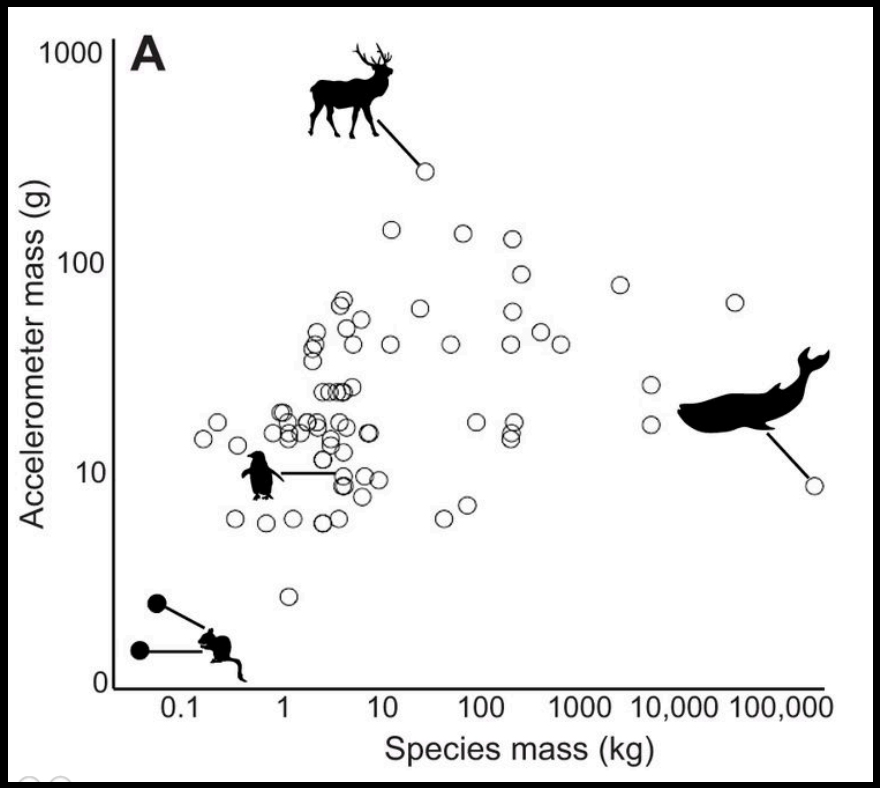


METHODS & TECHNIQUES

Using accelerometers to remotely and automatically characterize behavior in small animals

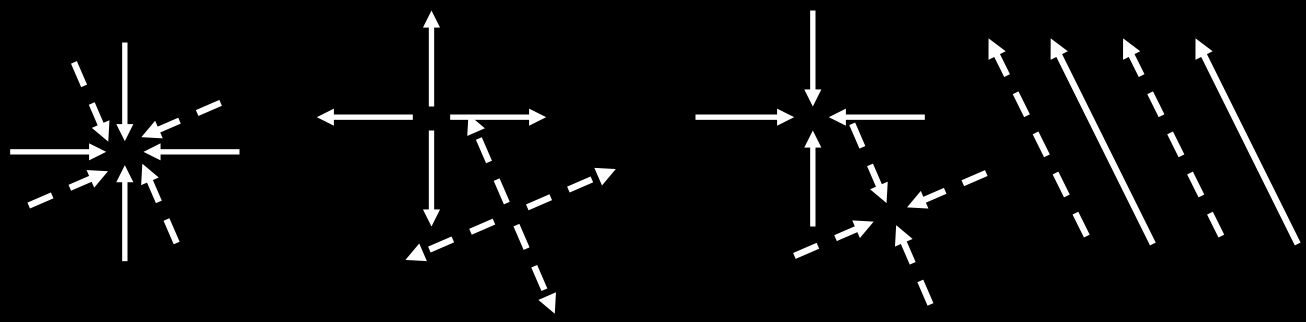
Talisin T. Hammond, Dwight Springthorpe, Rachel E. Walsh, Taylor Berg-Kirkpatrick

Journal of Experimental Biology 2016 219: 1618-1624; doi: 10.1242/jeb.136135



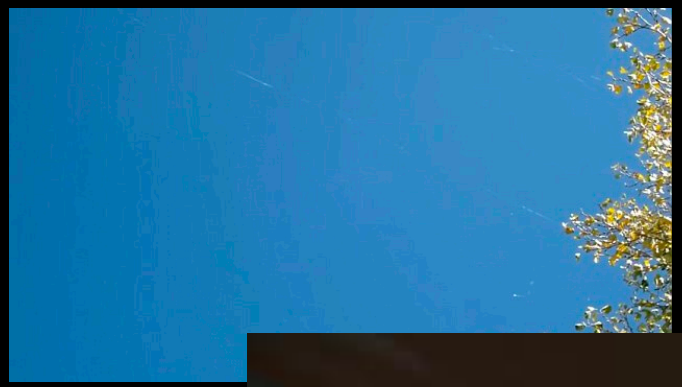
Platform Transmitter Terminals (PTTs) used for satellite-based tracking.

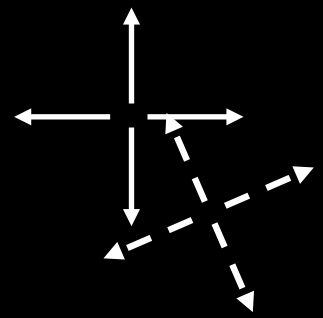
Why animals move



hunting dispersal homing migration

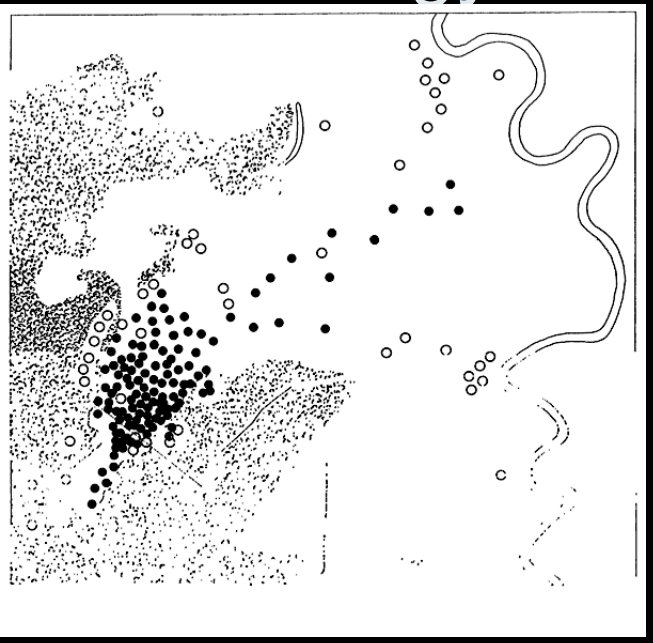
Hitching strategy - undirected





dispersal

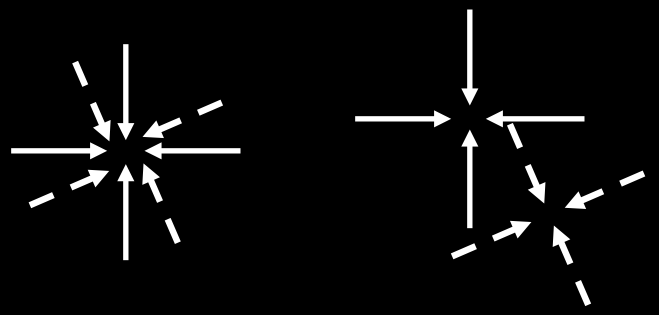
Taxis Strategy – following a direct measure of the goal



Seasonal Migration of Predators and Prey--A Study of Pythons and Rats in Tropical Australia

Thomas Madsen; Richard Shine

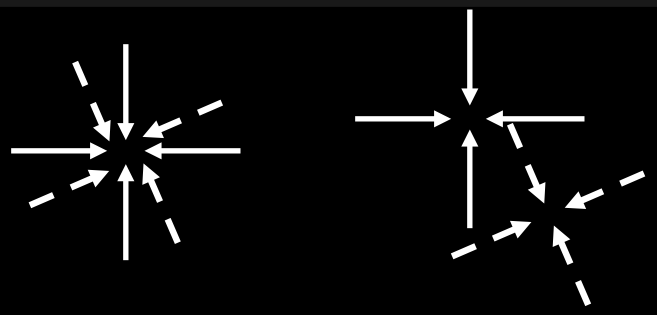
Ecology, Vol. 77, No. 1. (Jan., 1996), pp. 149-156.



hunting homing

Taxis Strategy – following a direct measure of the goal

Acanthopleura gemmata



hunting homing

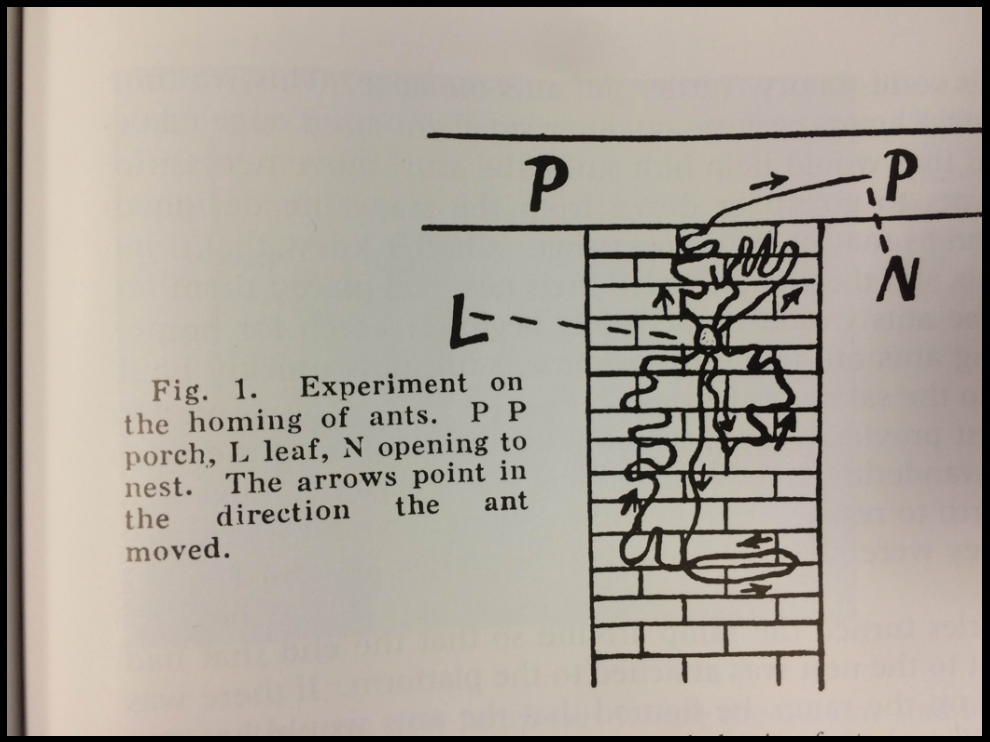
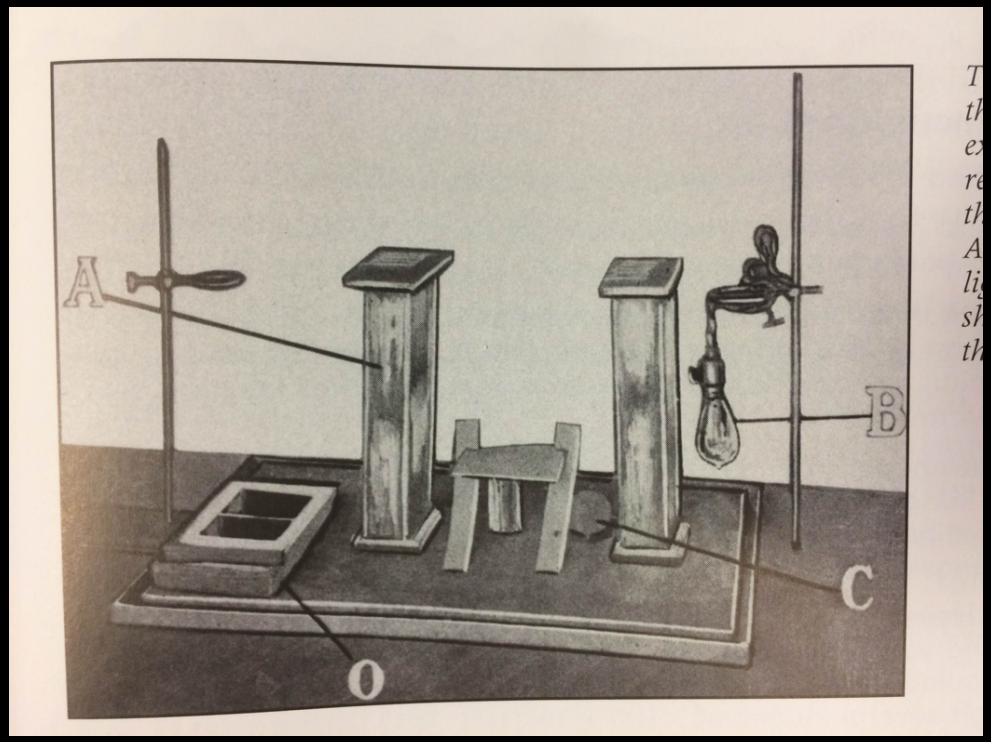


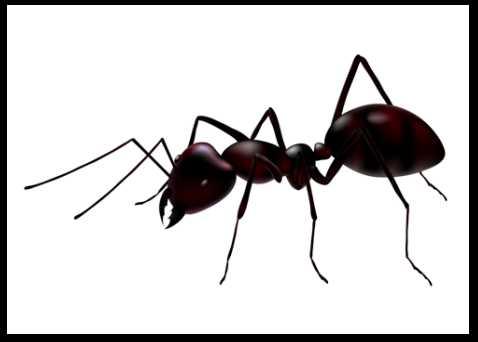
Fig. 1. Experiment on the homing of ants. P P porch, L leaf, N opening to nest. The arrows point in the direction the ant moved.



How do ants Navigate?

Charles Henry Turner (1867-1923)

Turner, CH (1907) The homing of ants: An experimental study of ant behavior. J. Com Neurol & Psych 17:367-434



Dead Reckoning Strategy
= path integration
- requires “logging”

Design an experiment to test whether animals use path integration

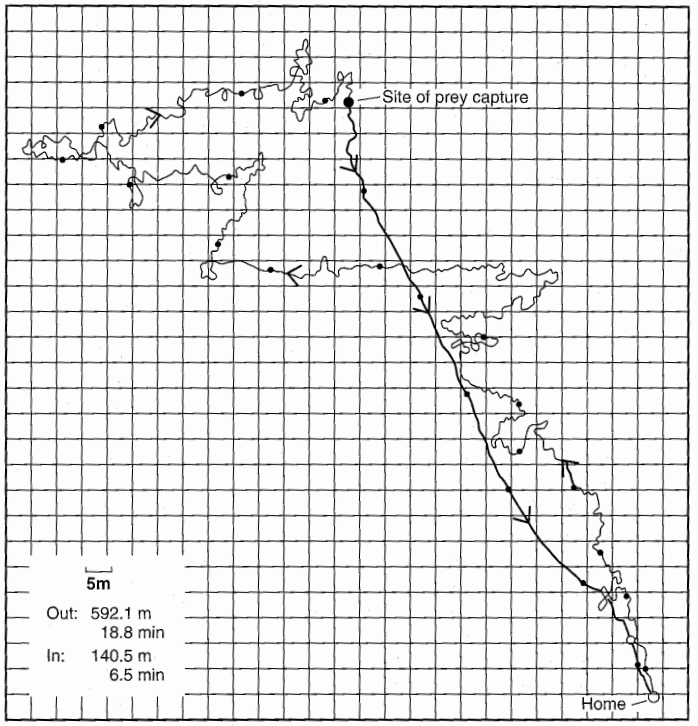
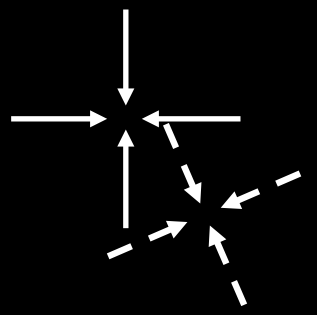


FIGURE 13.10 **Foraging route and return path of a desert ant, *Cataglyphis fortis*.** Note that the outward route is a meandering search, but once a prey item is captured, the ant follows a direct route home.

Source: Redrawn after Wehner, R. 1992. Arthropods. pp. 45–144 in *Animal Homing* (F. Papi, ed.). London: Chapman and Hall.

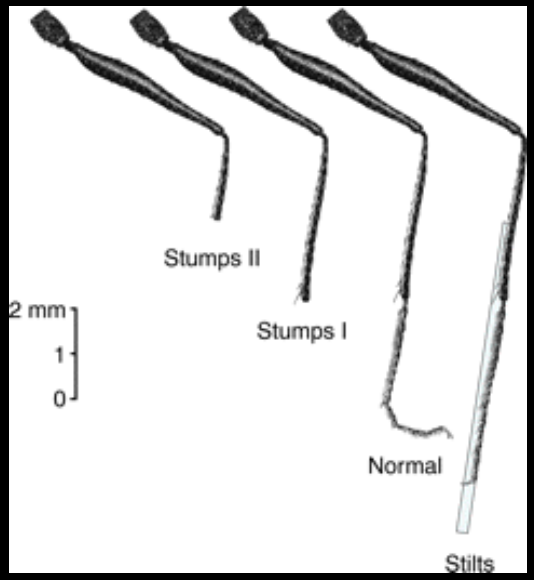
Thomas Collett

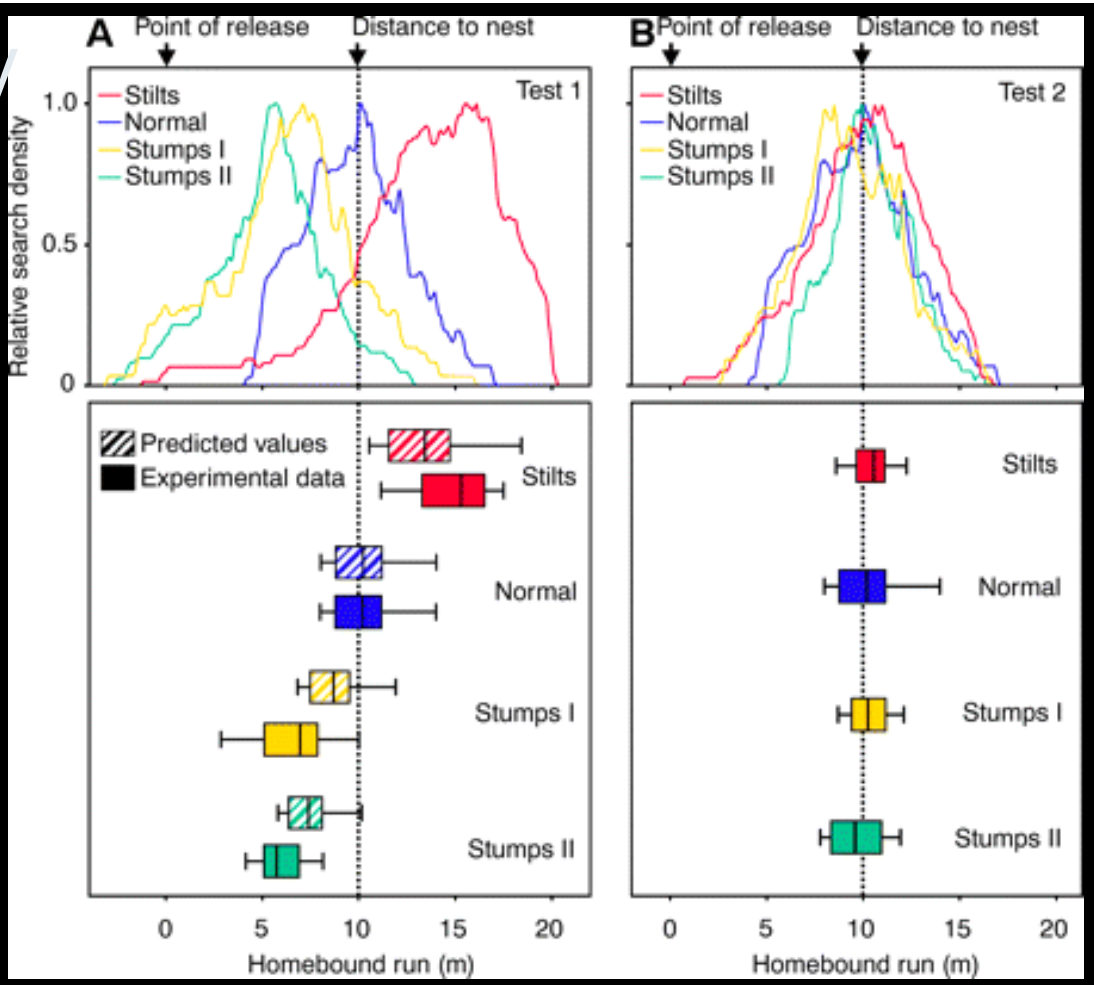
University of Sussex



homing

Dead Reckoning Strategy
= path integration
- requires “logging”





Science 30 June 2006:
Vol. 312. no. 5782, pp. 1965 – 1967
DOI: 10.1126/science.1126912

The desert ant odometer: a stride integrator that accounts for stride length and walking speed

Matthias Wittlinger, Rüdiger Wehner, Harald Wolf

Journal of Experimental Biology 2007 210: 198-207; doi: 10.1242/jeb.02657

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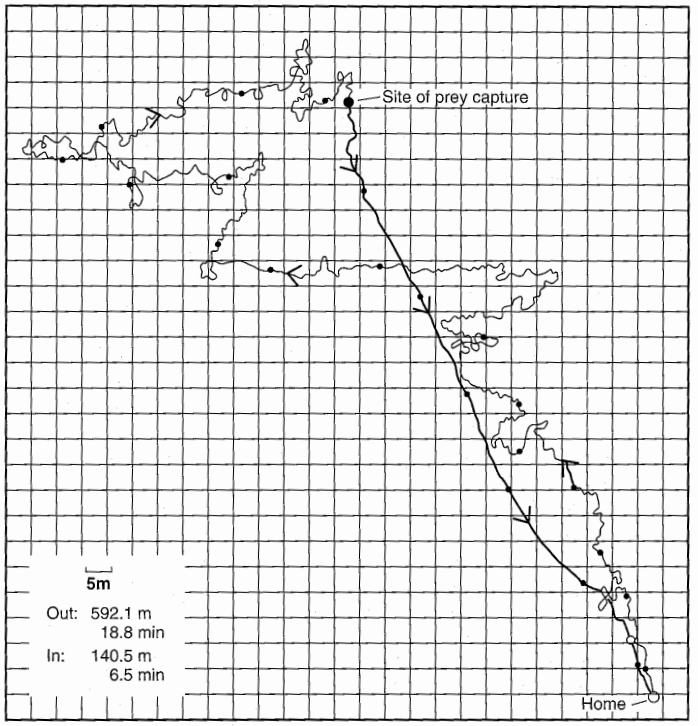

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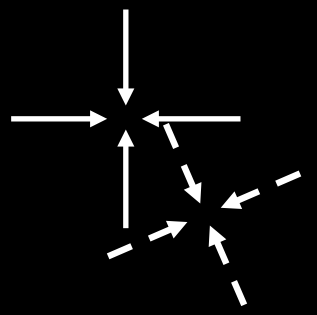

homing

Dead Reckoning Strategy
= path integration
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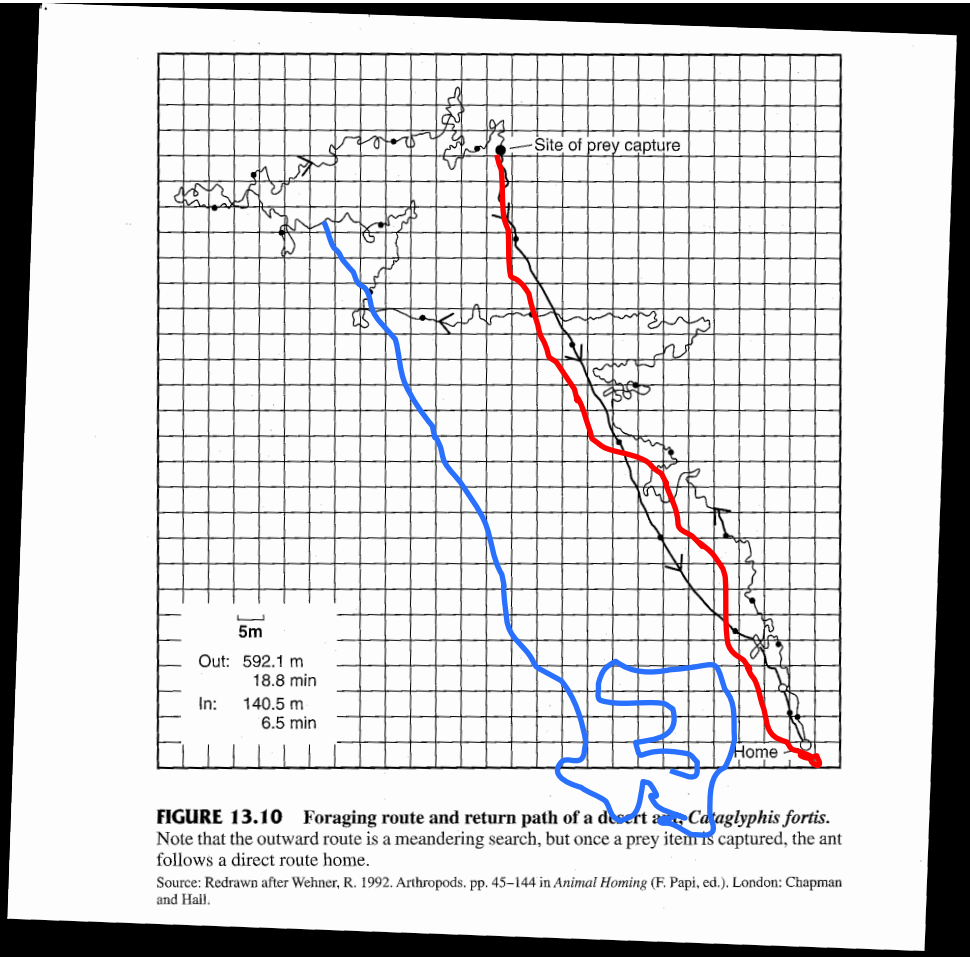

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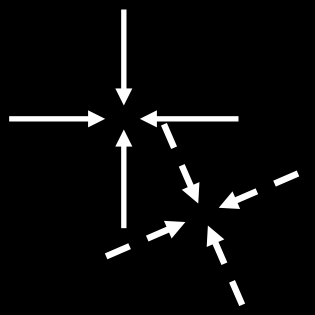
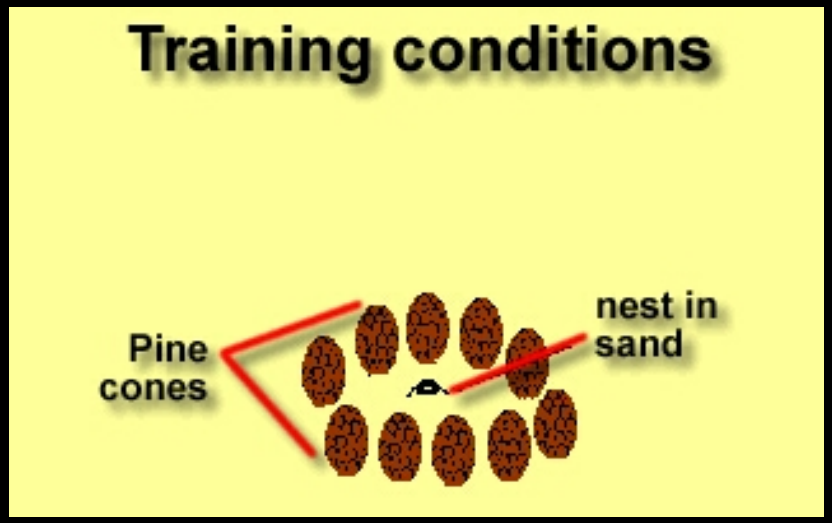
Thomas Collett

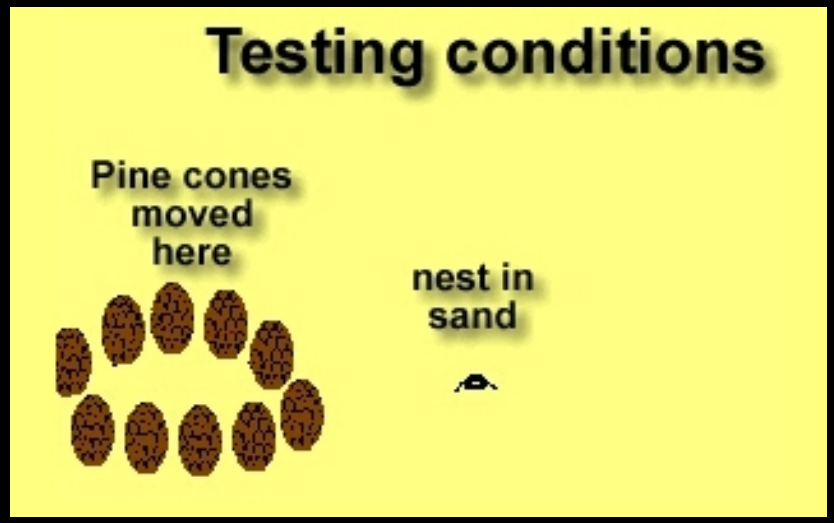
University of Sussex



homing

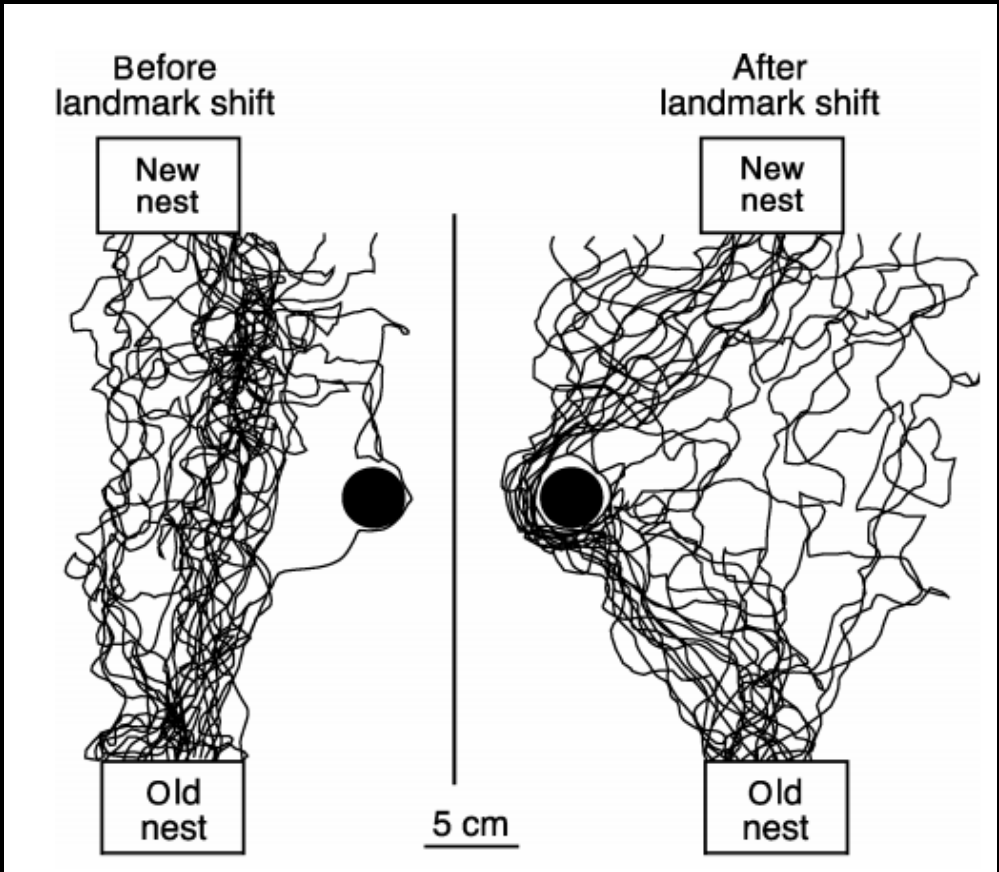
Piloting strategy (landmarks) - Requires a map (familiarity)

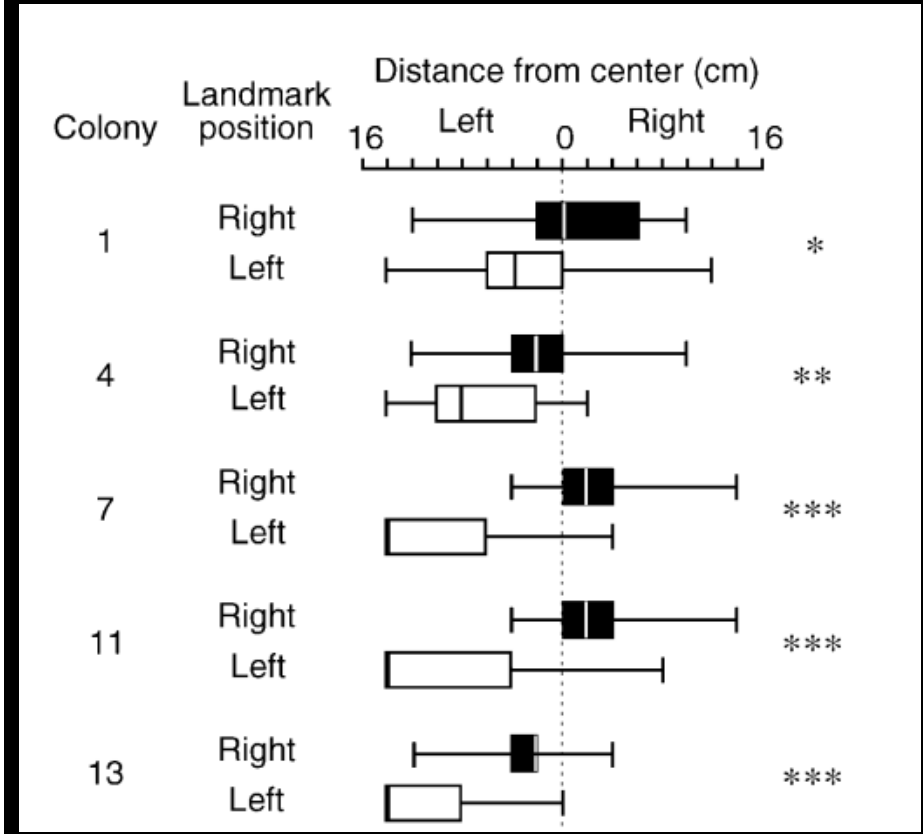




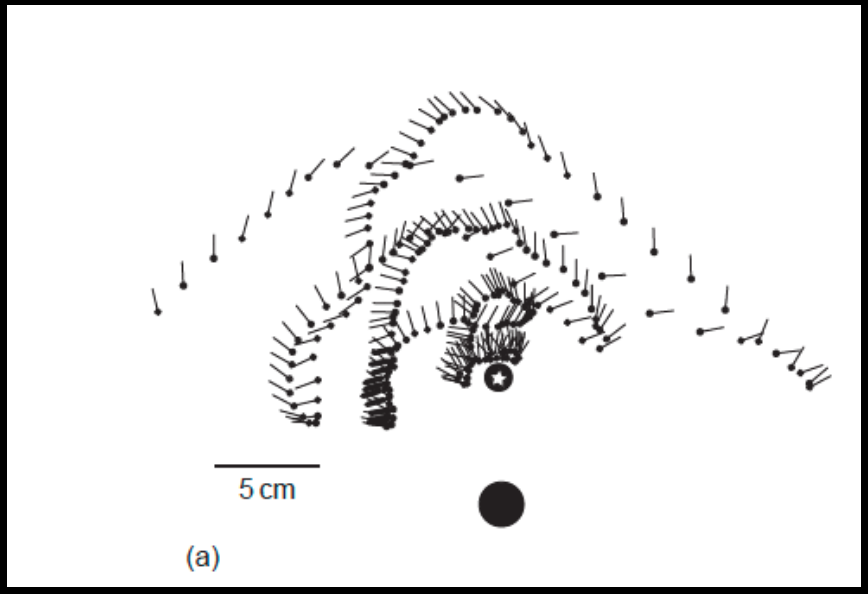
Design an experiment to test whether animal use landmarks

Tinbergen, 1951. The Study of Instinct . Oxford University Press, London.



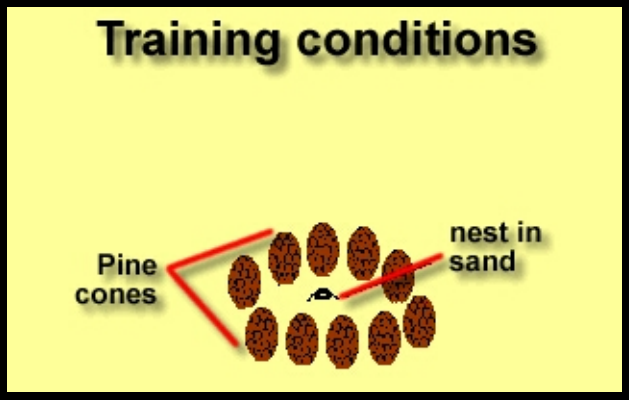


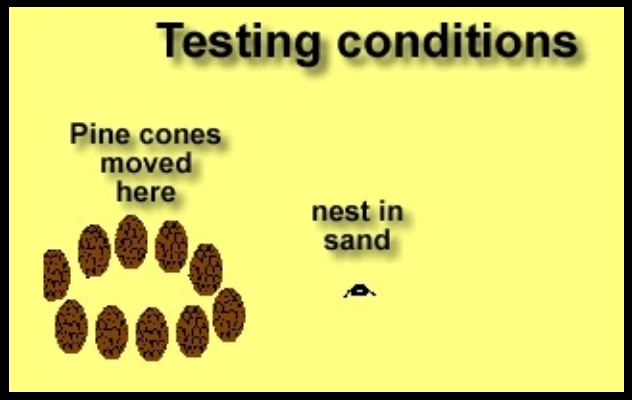
McLeman et al 2002 Insectes soc. 49 (2002) 203–208

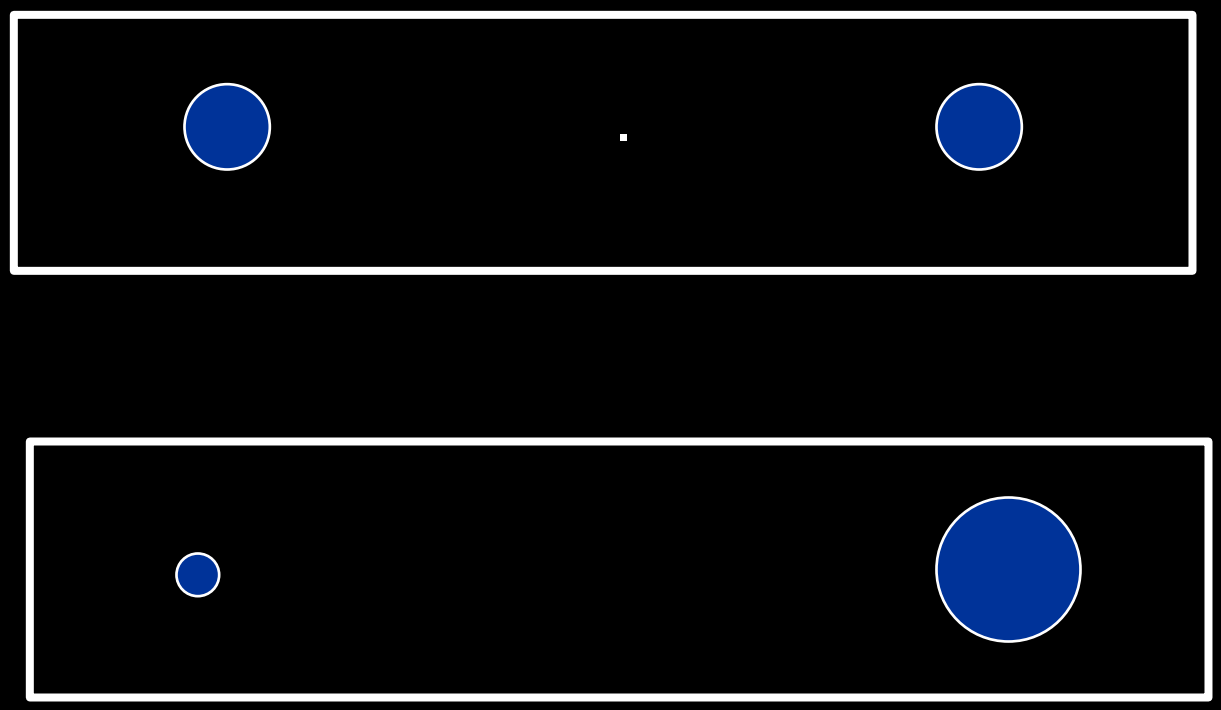


Learning Flight

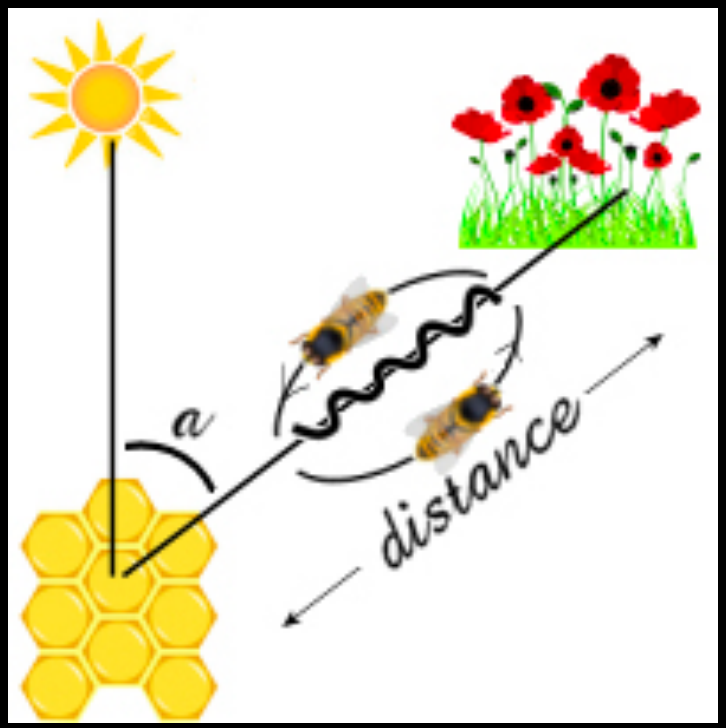
Design an experiment to test what information animals use from landmarks





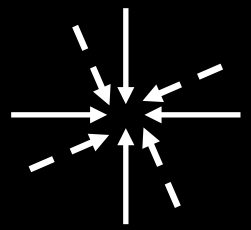


View-based Matching : does not require calculation of distance



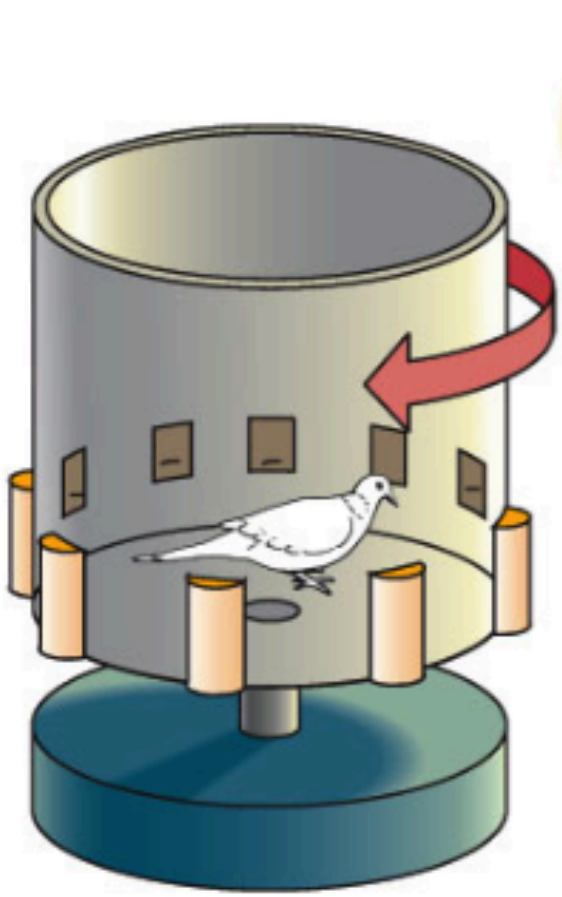
Direction and Distance

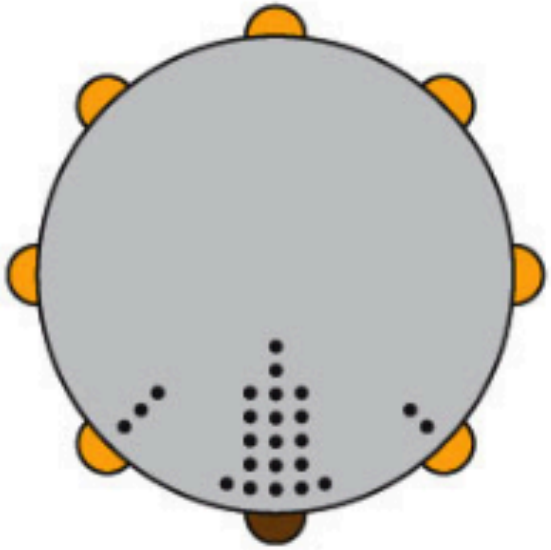
Design an experiment to show that animals use a “time compensated sun compass”.

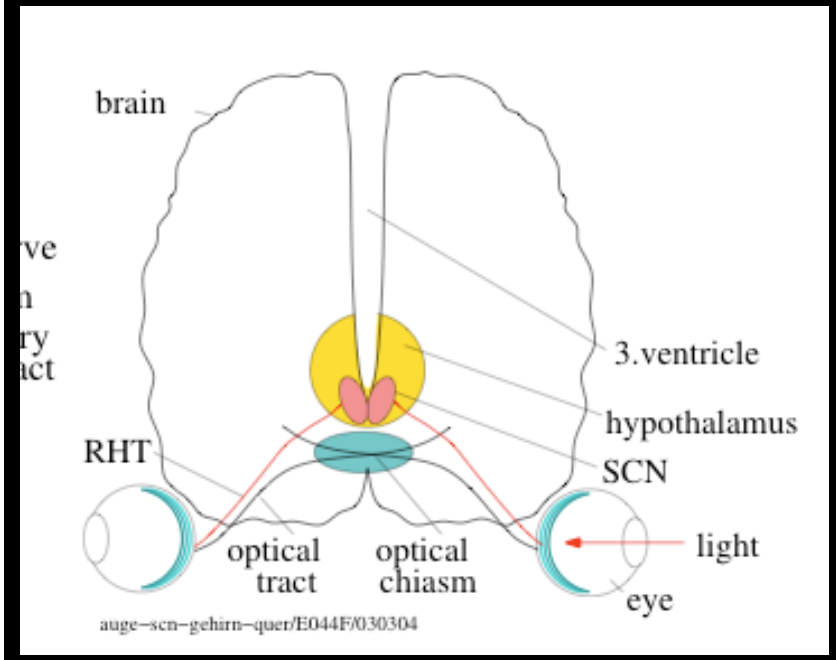


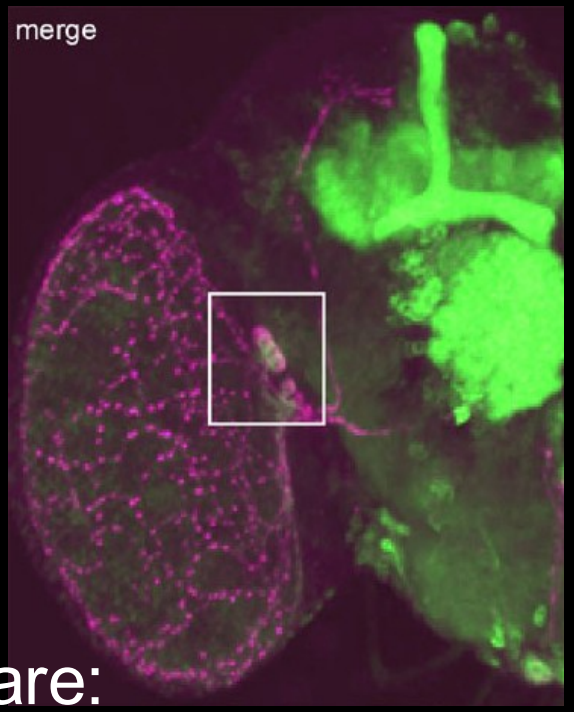
hunting

Phase advance an animal and it will make counter clockwise errors (in the Northern hemisphere)

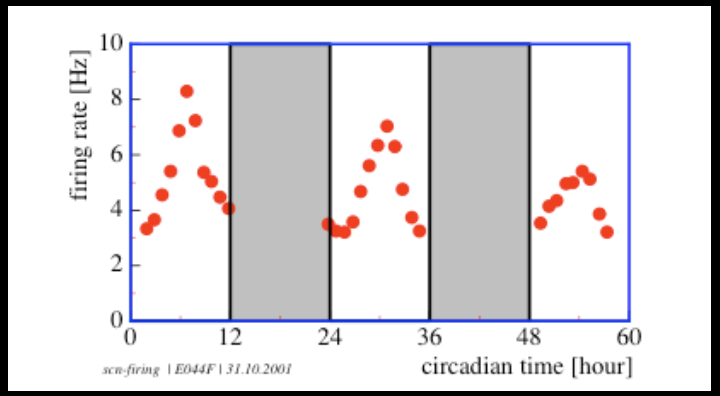




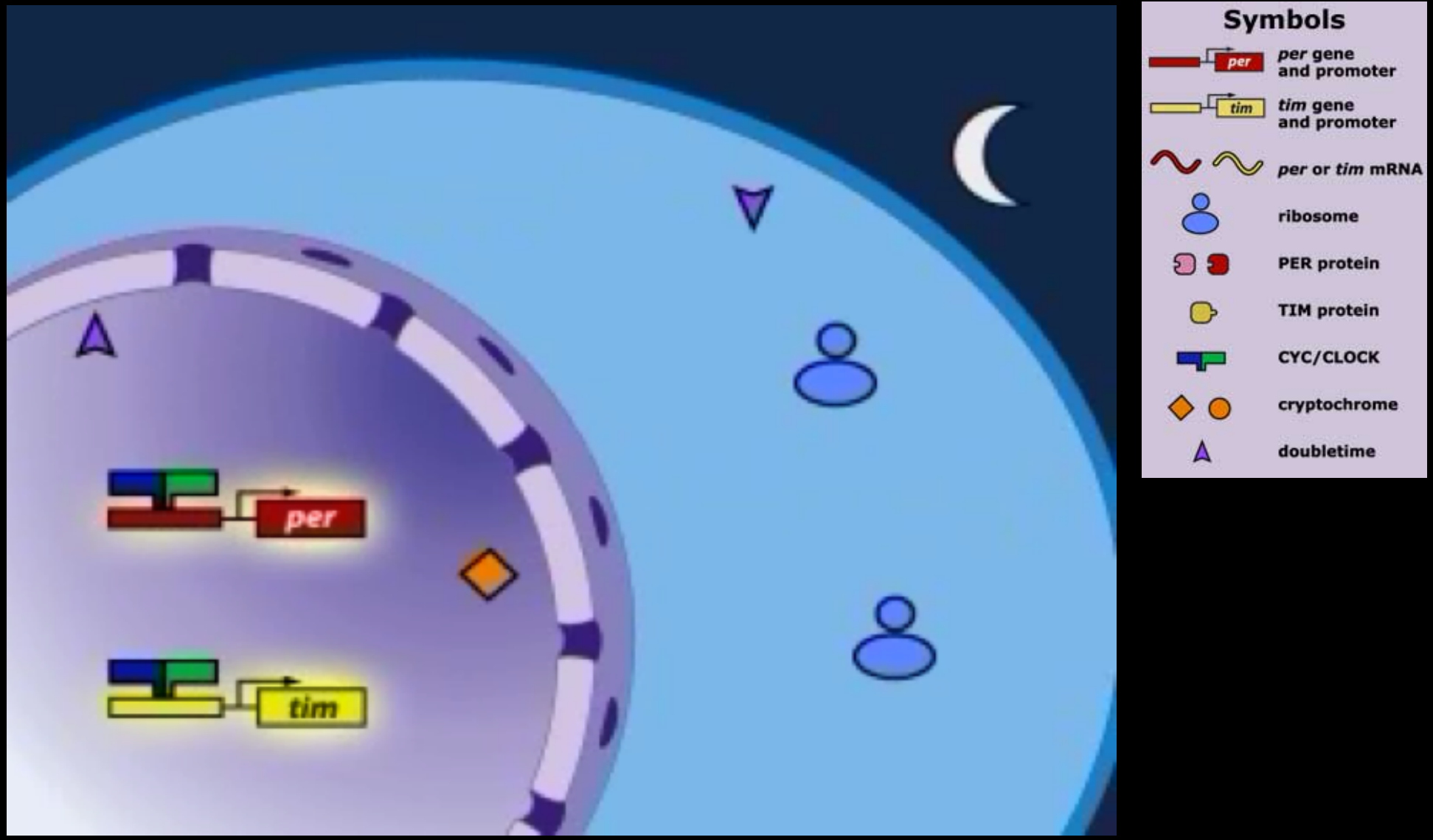




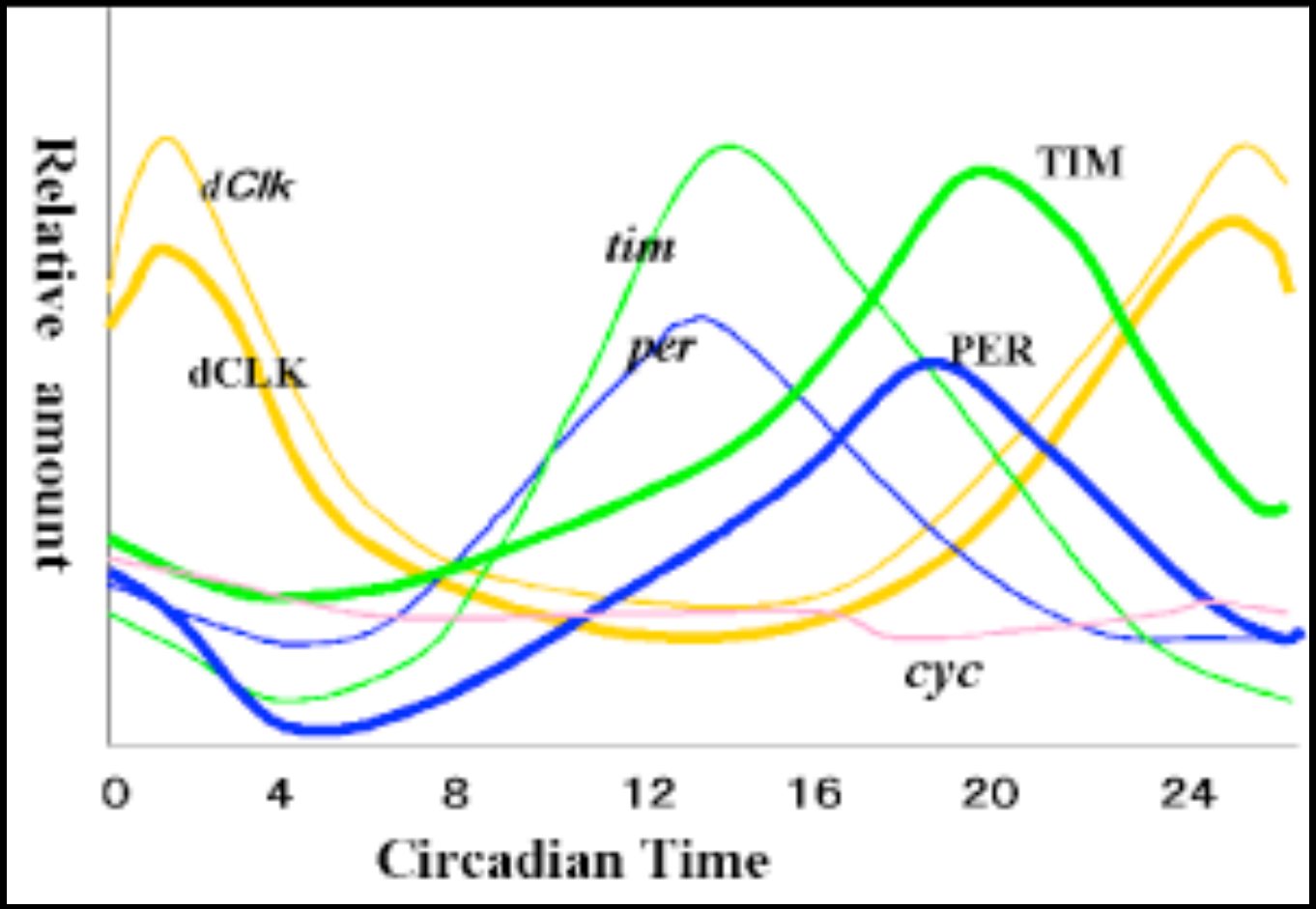
circadian rhythms are:
autonomous
entrainable
have ~24 hr rhythm

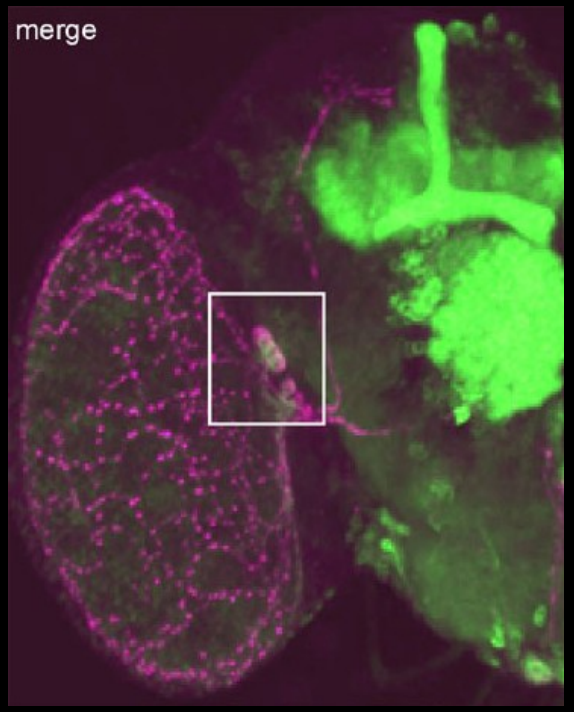


Molecular Clock in *Drosophila*

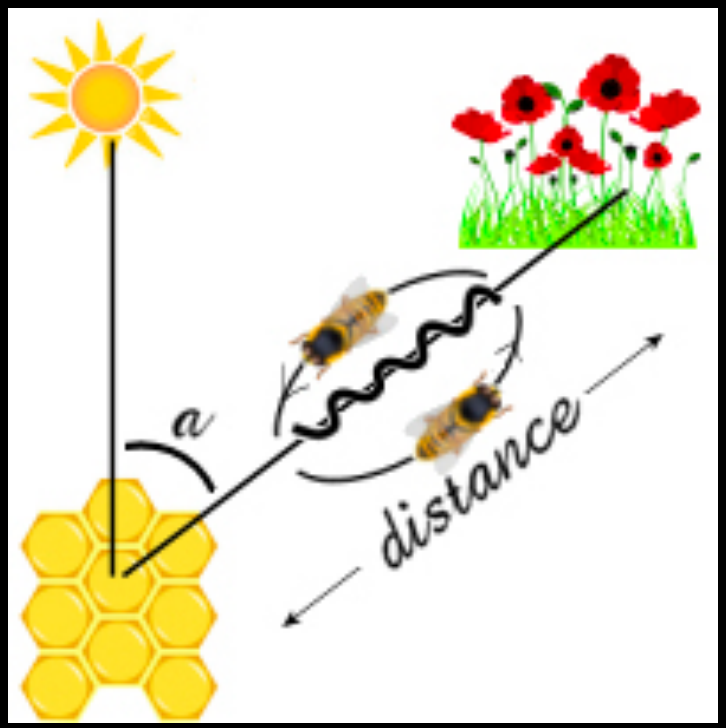


I won’t ask the details of this mechanism



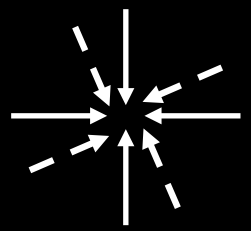


you should know that some of the genes are expressed with a circadian rhythm
and proteins accumulate with a circadian rhythm (some with delay)

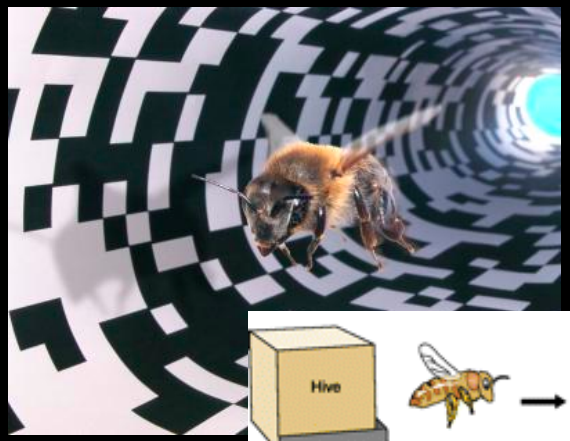


Direction and Distance

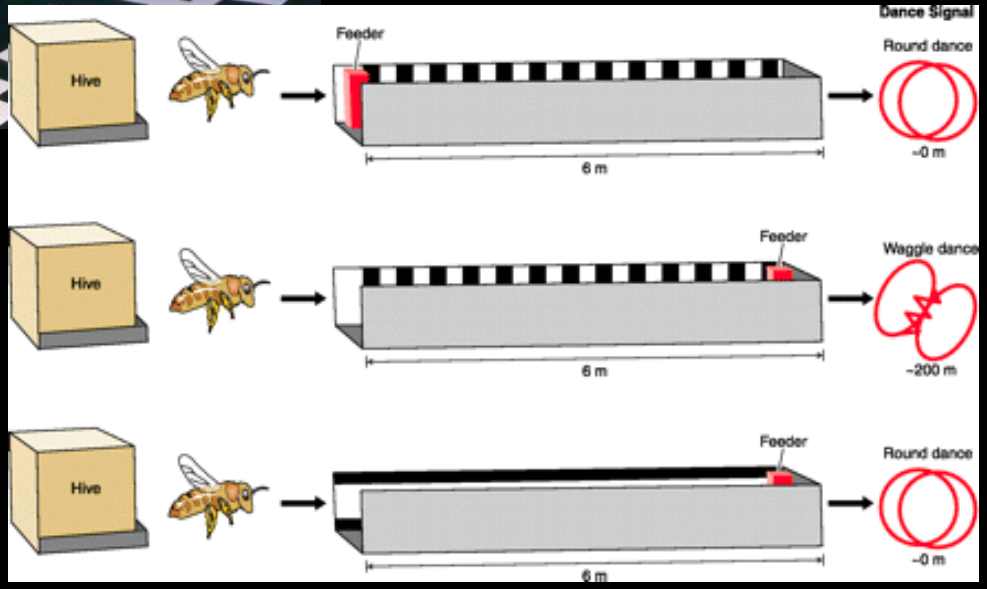
Design an experiment to determine how bees know distance.

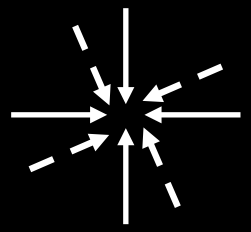


hunting



optic flow is the correct answer





hunting

Hitching Strategy

Taxis Strategy

Dead Reckoning

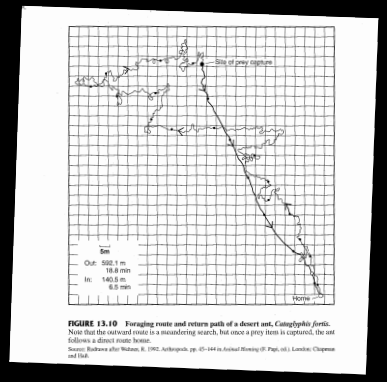
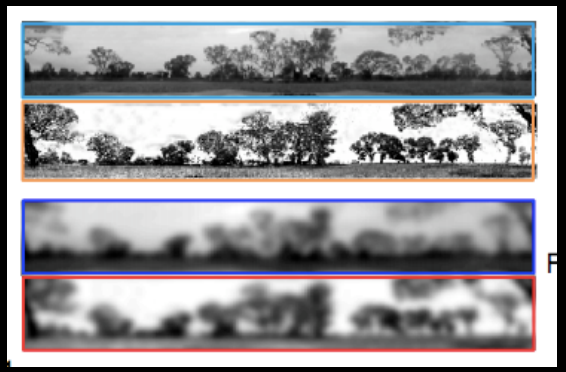


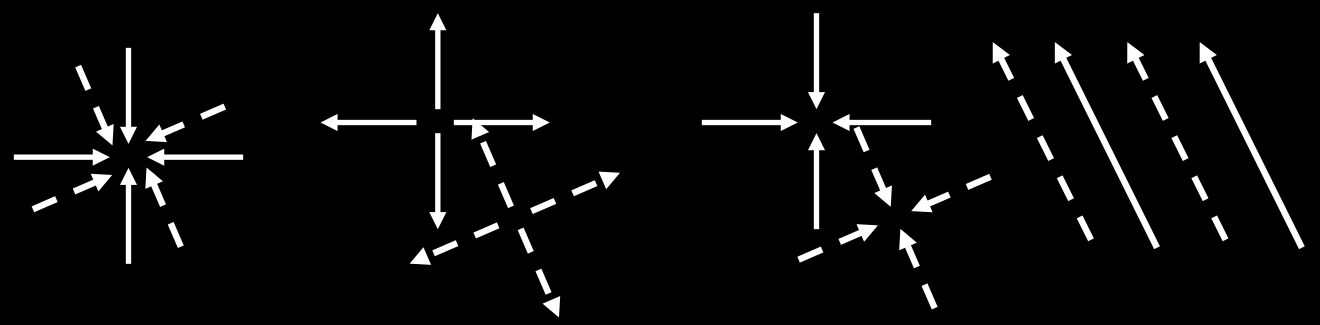
FIGURE 13.10 Foraging route and return path of a desert ant, *Cataglyphis fortis*. Note that the outward route is a meandering search, but once a prey item is captured, the ant follows a direct route home.

Source: Redrawn after Wehner, R. 1982. Arthropods. pp. 45–144 in *Animal Homing* (P. Papi, ed.). London: Chapman and Hall.

Piloting strategy

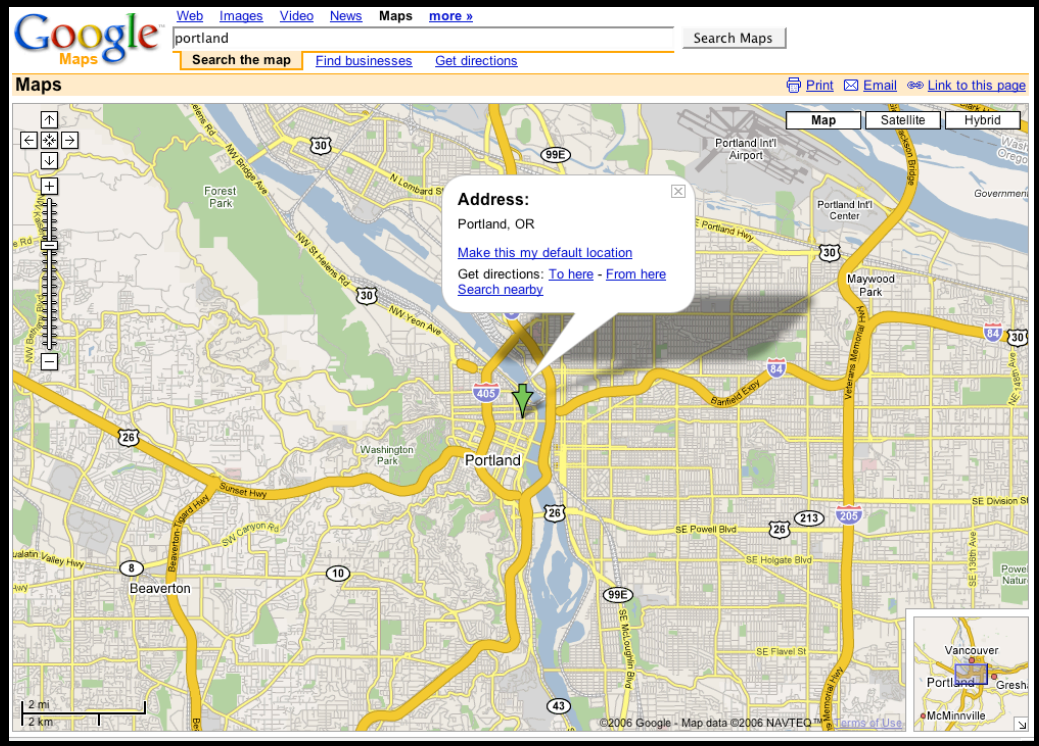


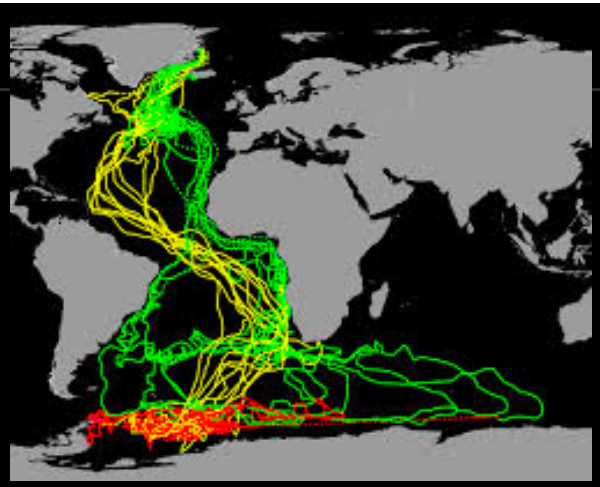
Hitching – undirected movement
Taxis – following a direct measure of goal
Ded Reckoning = path integration – requires logging
Piloting - requires a map (familiarity)
Navigation – (targeting distant goal) requires a map and a compass

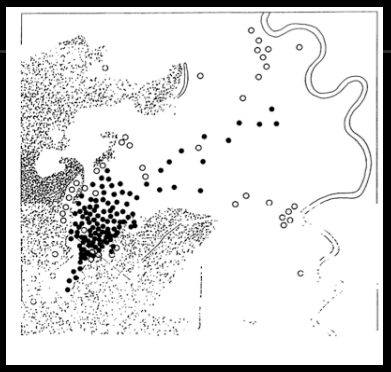


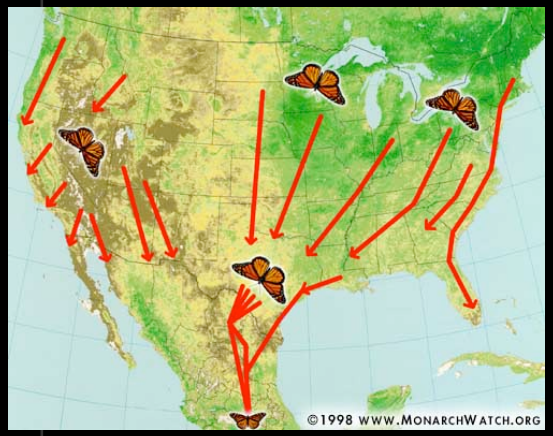
hunting dispersal homing migration

Navigation requires a map

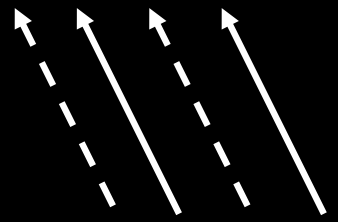






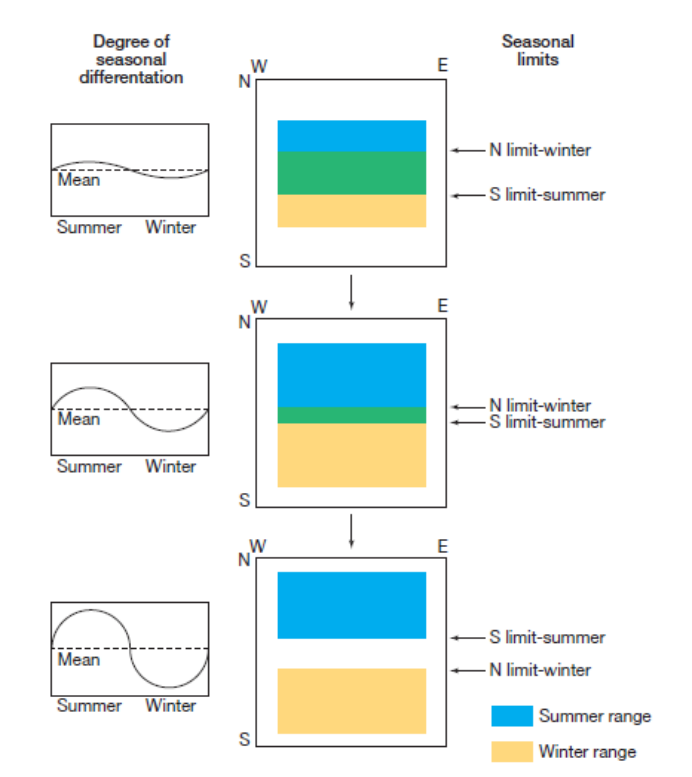


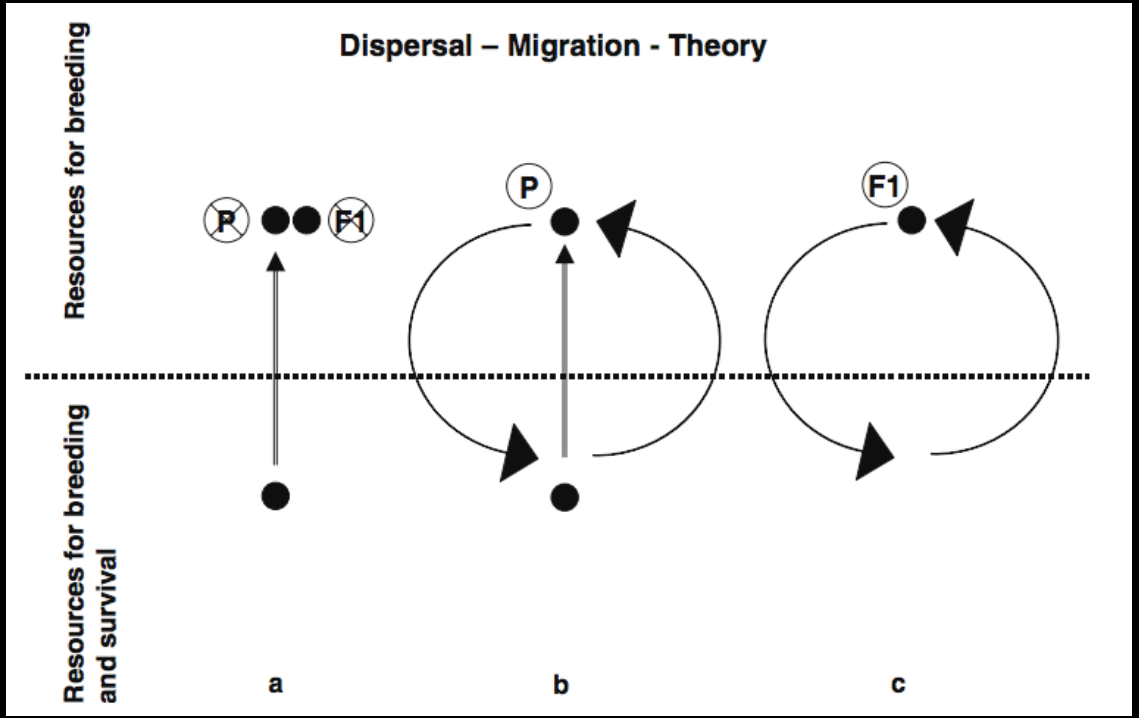
When and Where



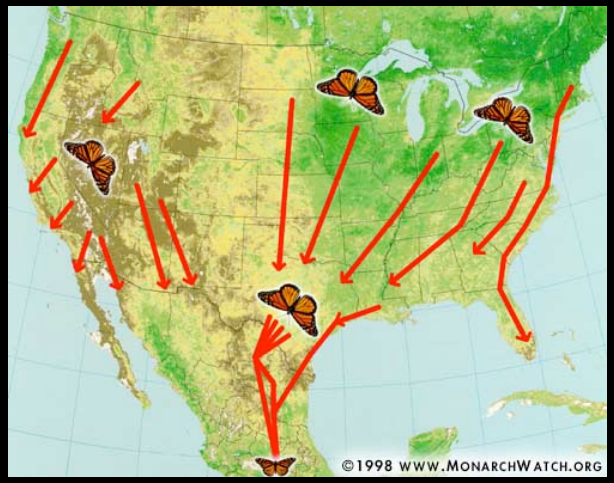
migration

How did Migration Evolve?

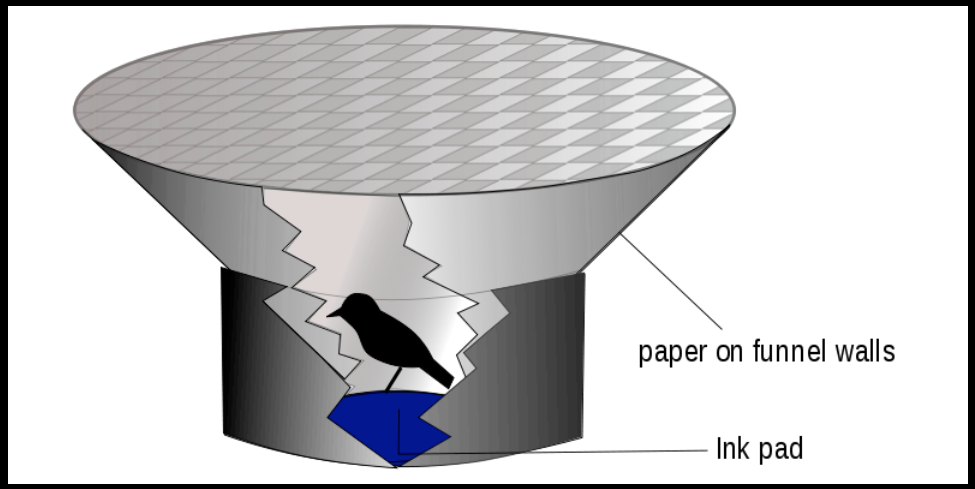




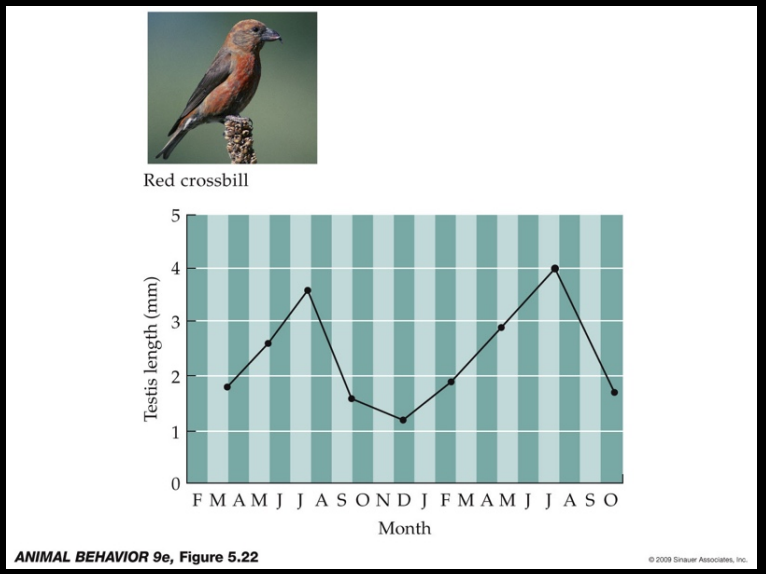
In a simple model, George Cox (1968) showed how an increase in seasonal variation within a species habitat can lead from partial to full migration



Time compensated sun compass

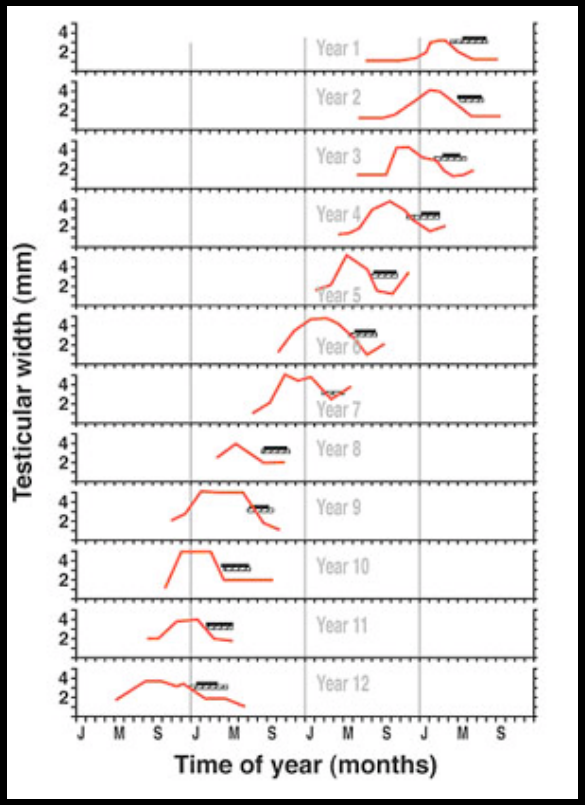


Zugunruhe

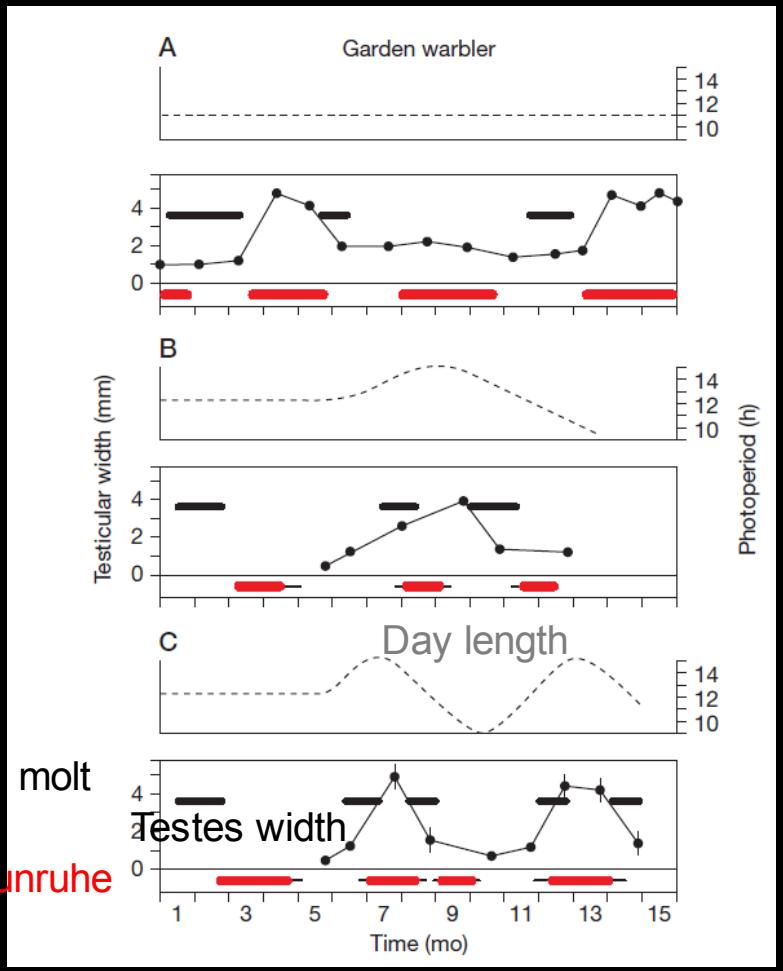


Circannual rhythms

European Stonechat Circaannual rhythm



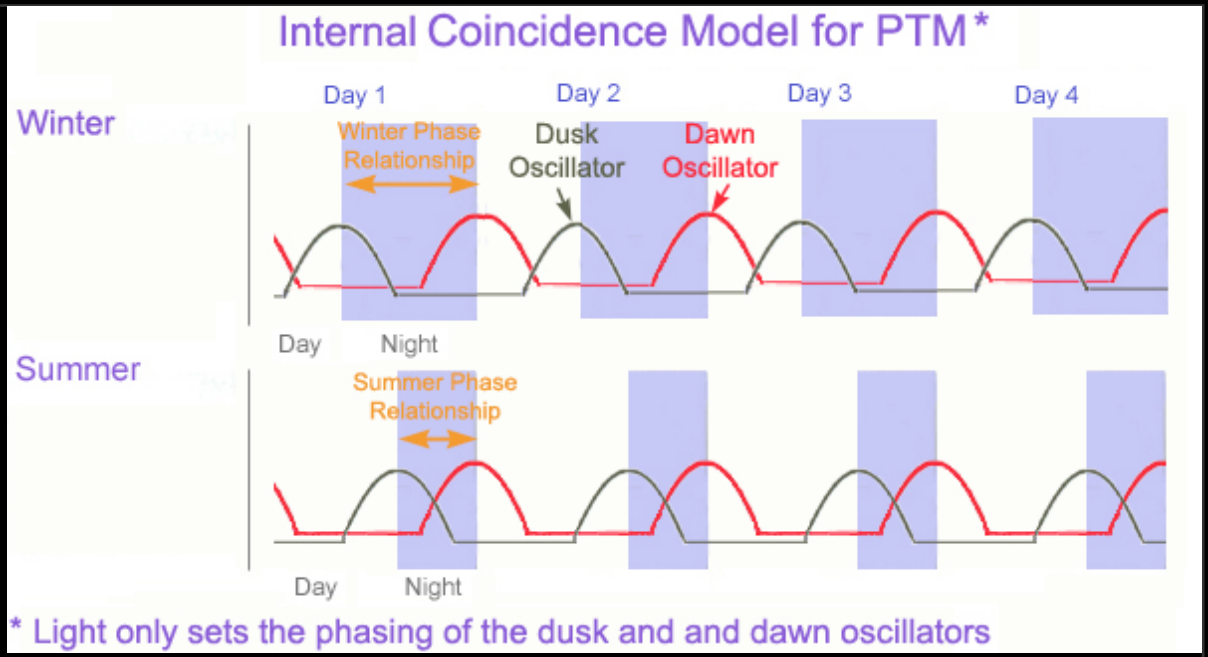
Circaannual rhythm is also entrained by the Photoperiod



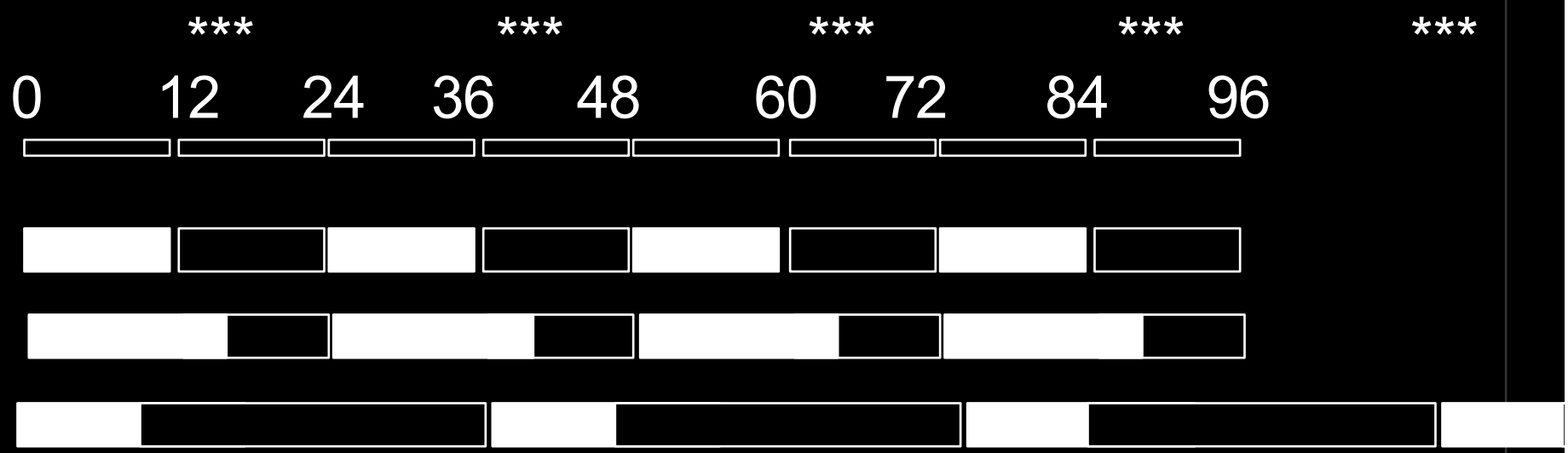
Circaannual rhythm is also entrained by the Photoperiod

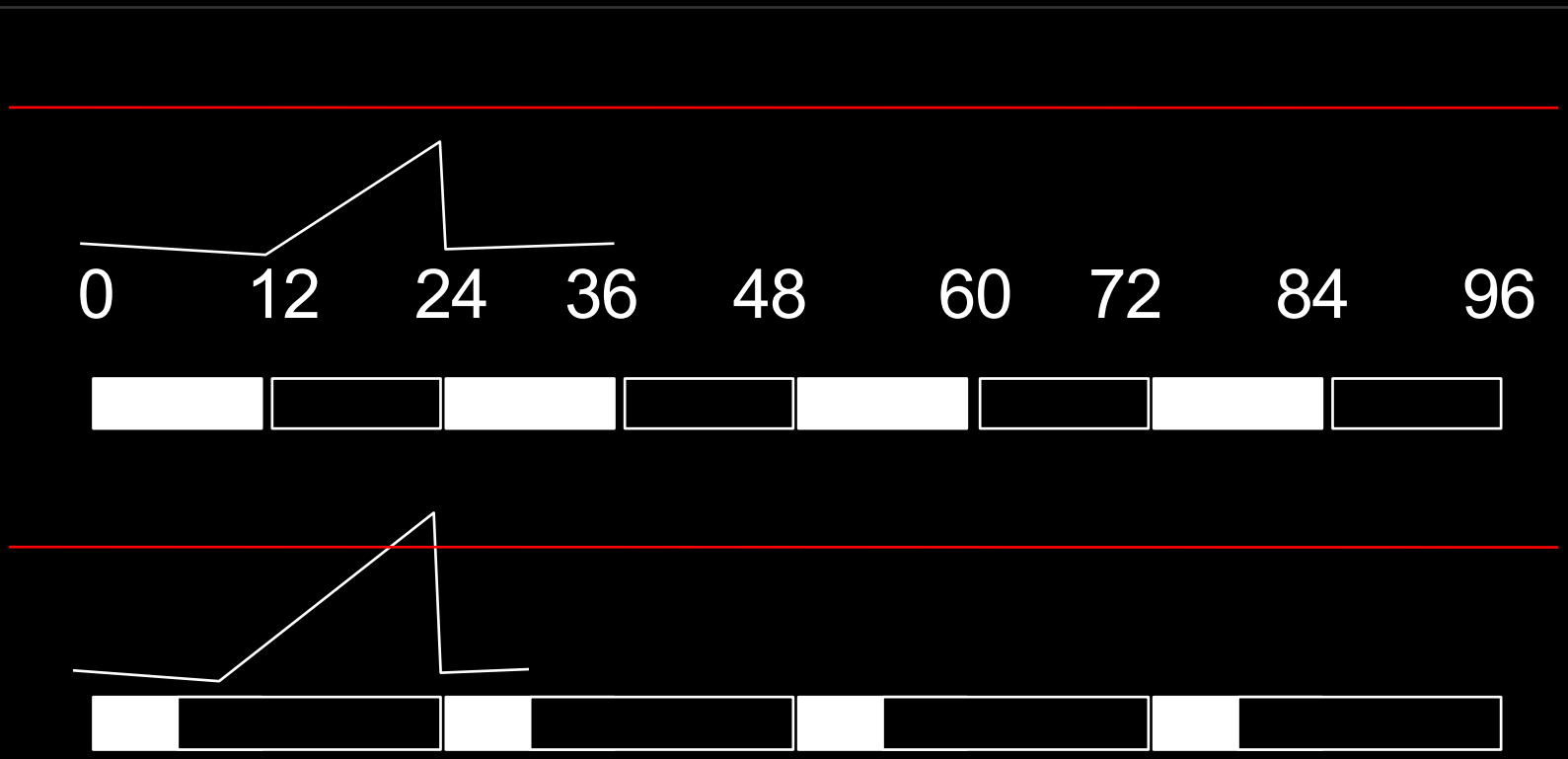
HOW ?????

Two Theories
1)Internal coincidence detection
2)External coincidence detection

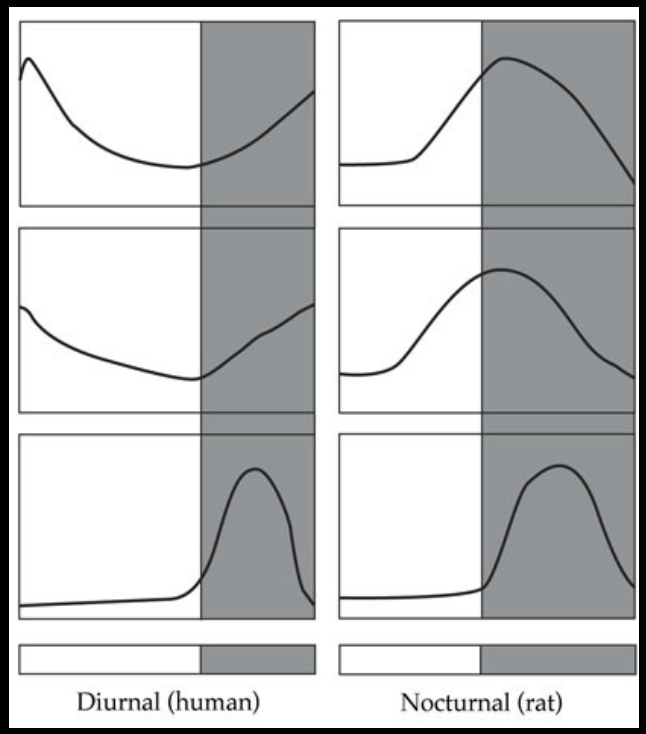

Internal Coincidence Model for PTM*
Day 1
Day 2
Day 3
Day 4
Winter
Winter Phase Relationship
Dusk Oscillator
Dawn Oscillator
Day
Night
Summer
Summer Phase Relationship
Day
Night
* Light only sets the phasing of the dusk and and dawn oscillators

External coincidence detector.




0
12
24
36
48
60
72
84
96

Melatonin Testosterone Cortisol

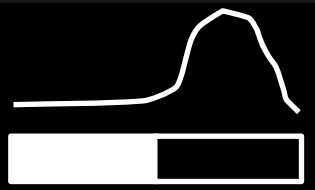


Reversed phase in nocturnal

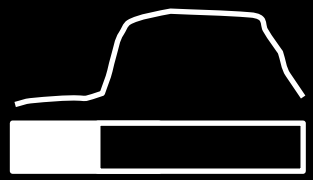
Reversed phase in nocturnal

Same phase in nocturnal

Melatonin level and duration in blood stream seems to measure the length of the night.

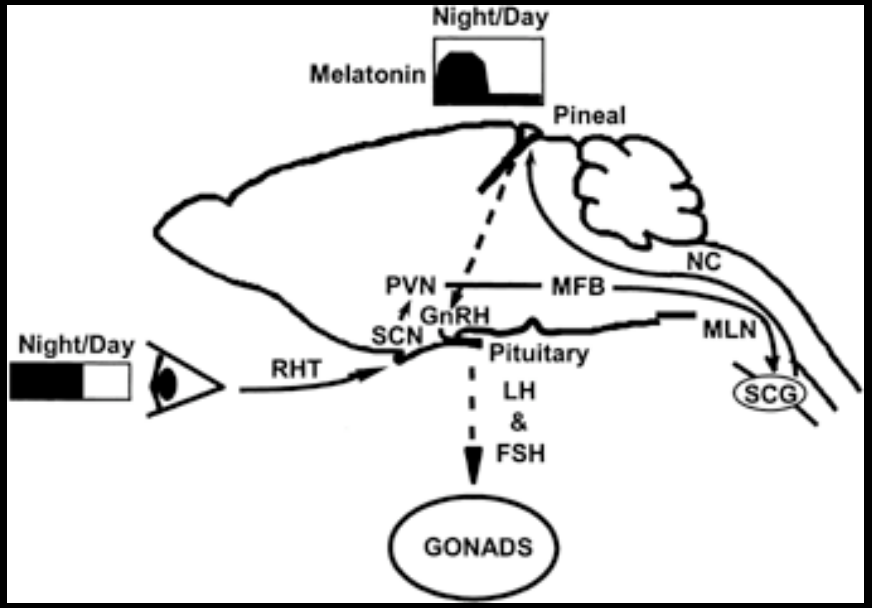


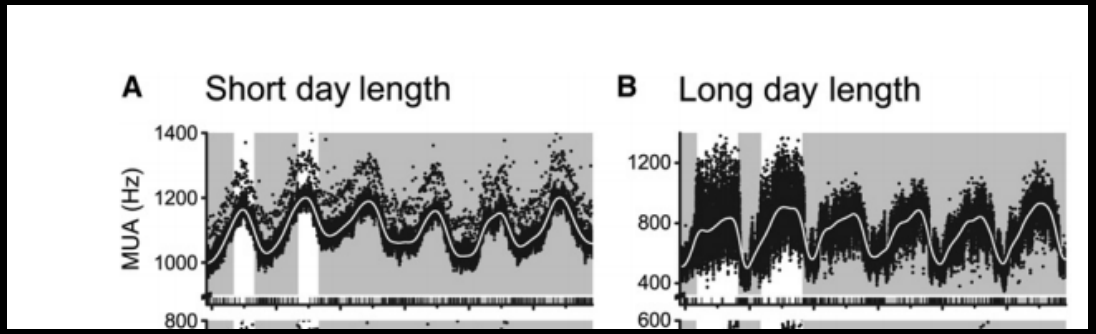
Equinox

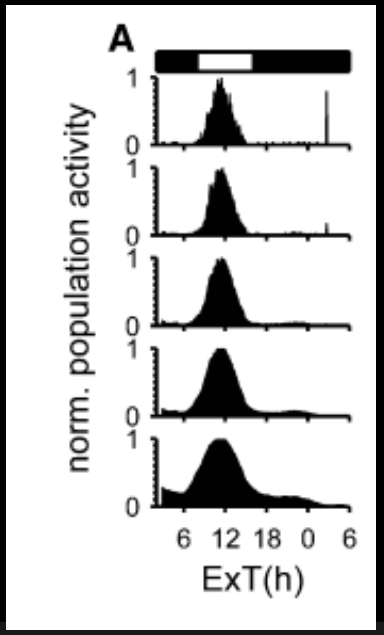


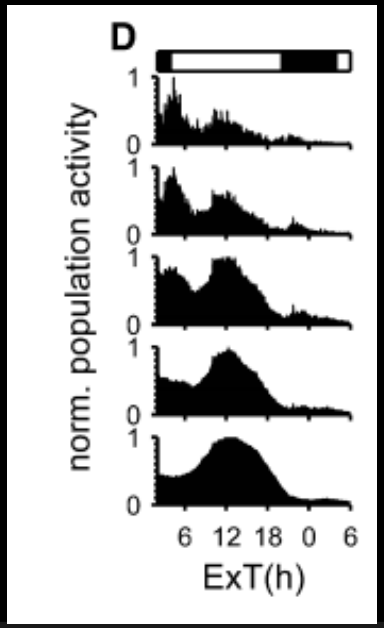
Winter

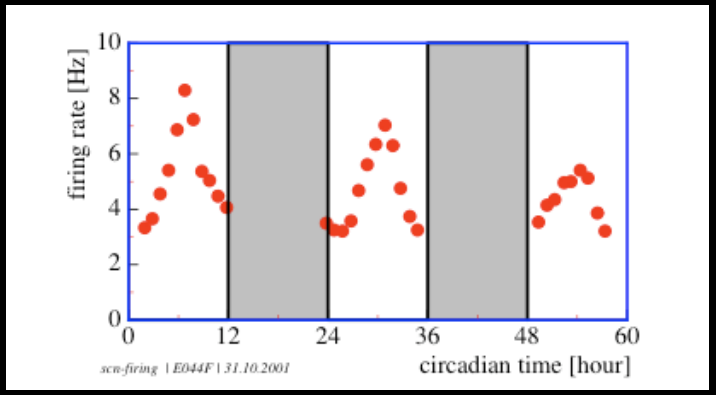
Summer



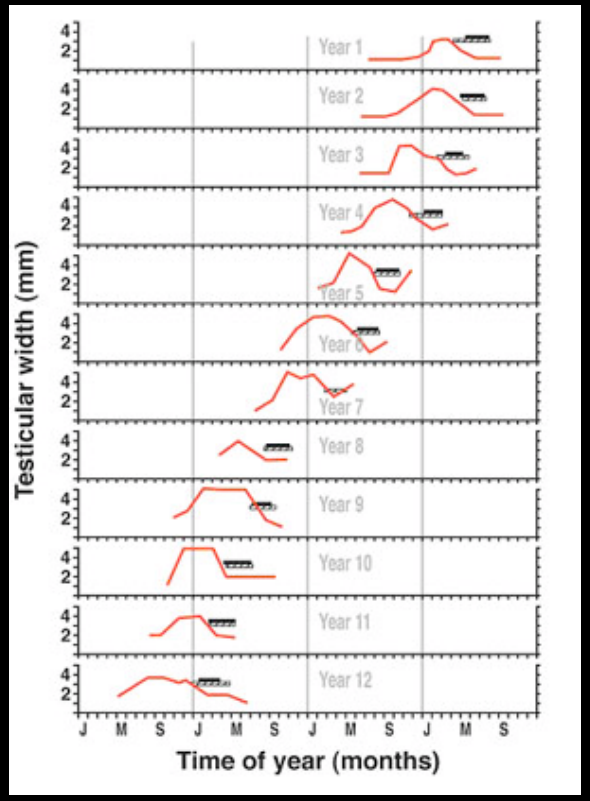


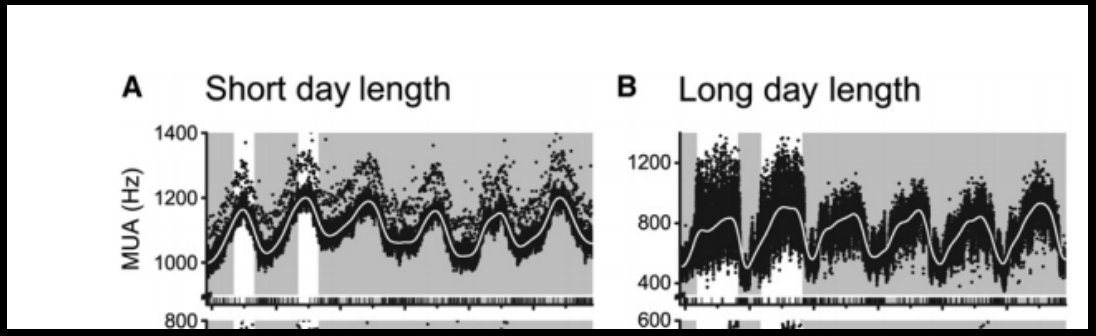


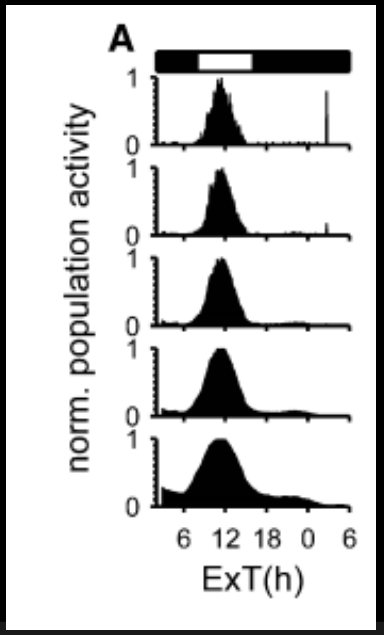


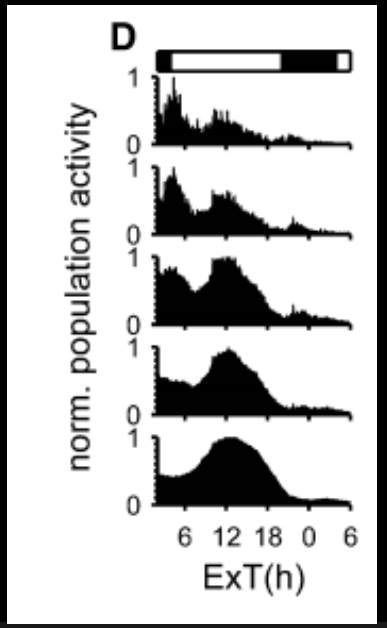


Still, none of this tells us what maintains the circa-annual rhythm ….







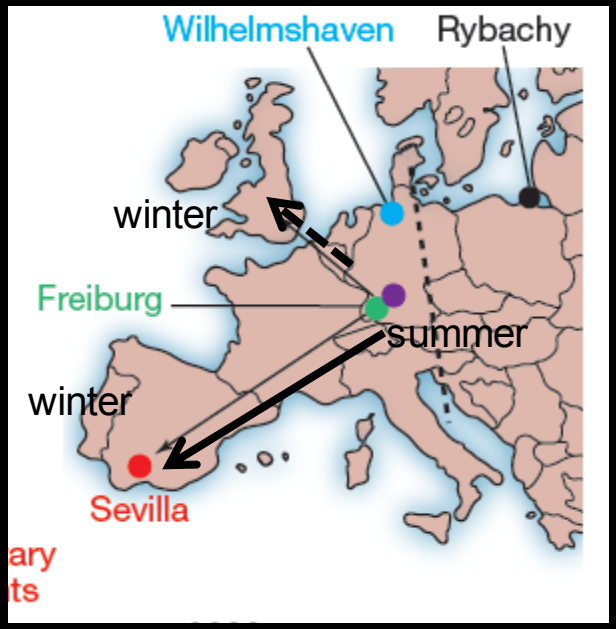


Still, none of this tells us what maintains the circa-annual rhythm ….

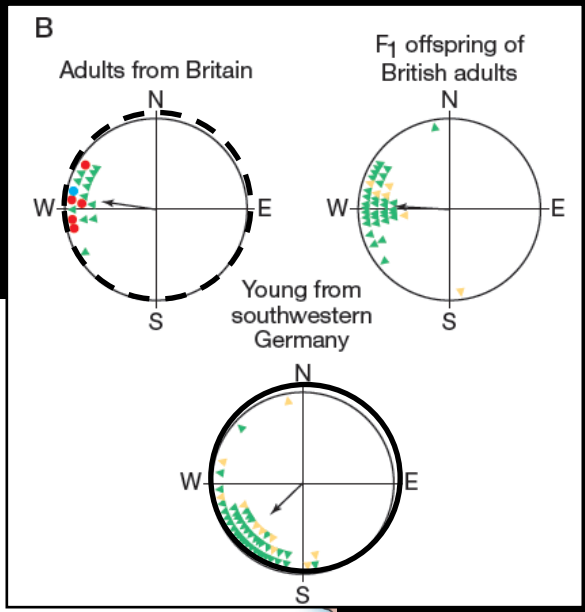
Design an experiment to determine whether migratory behavior heritable?

Is migratory behavior heritable?

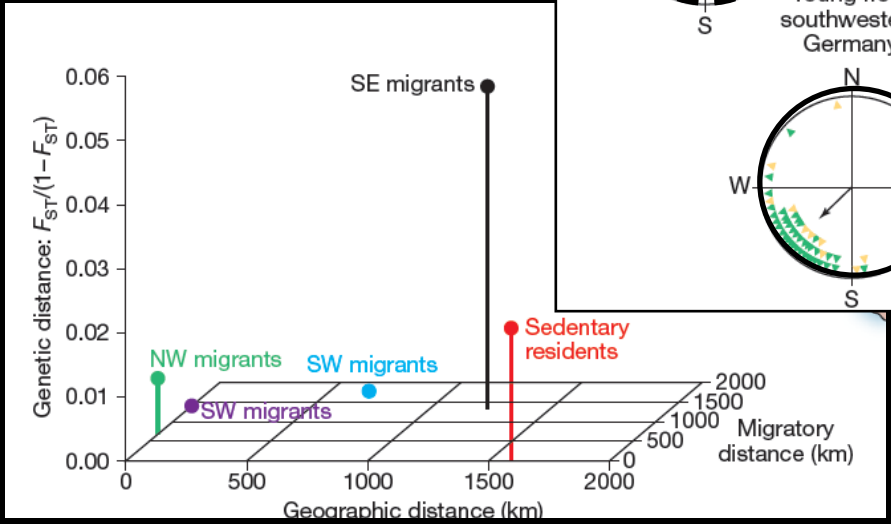
Is migratory behavior heritable?



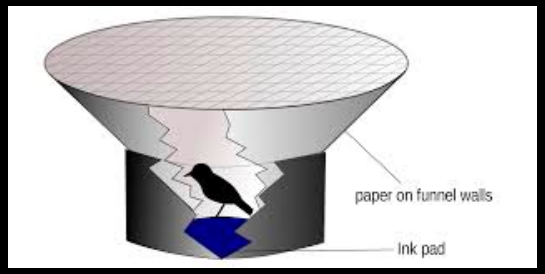
Birds that winter in Britain, tested in September

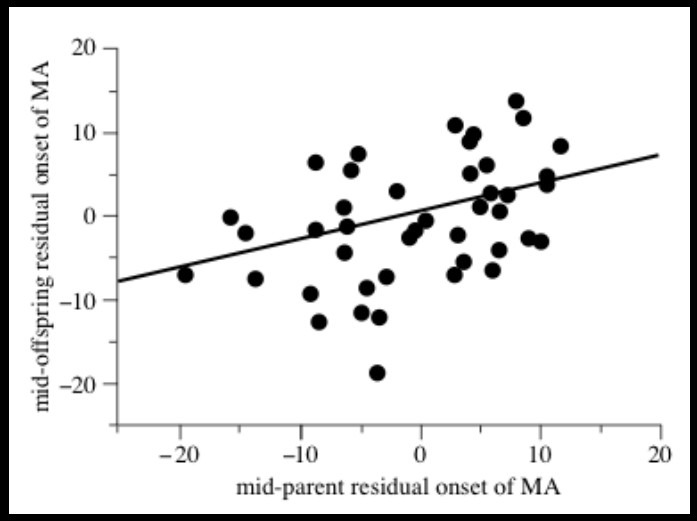


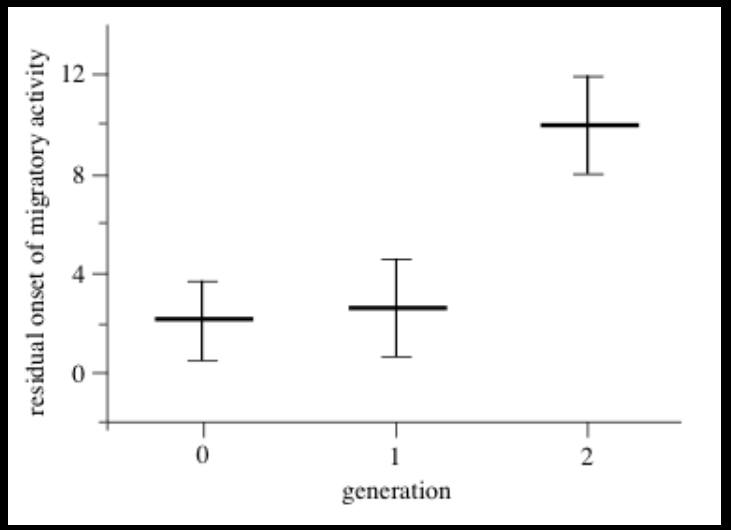
colors here do not correspond to locations



Birds that winter in Germany, tested in September

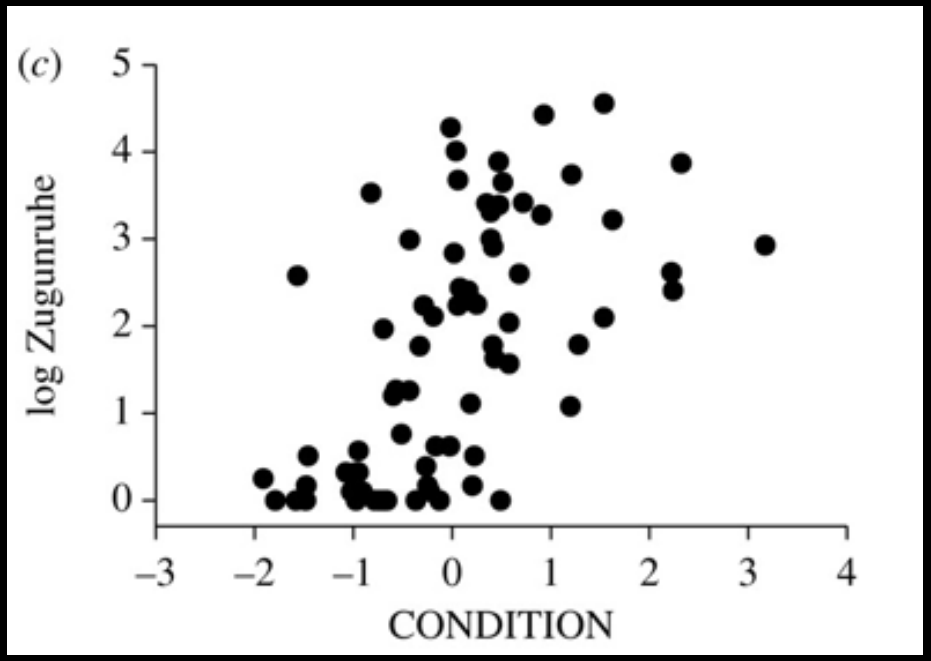






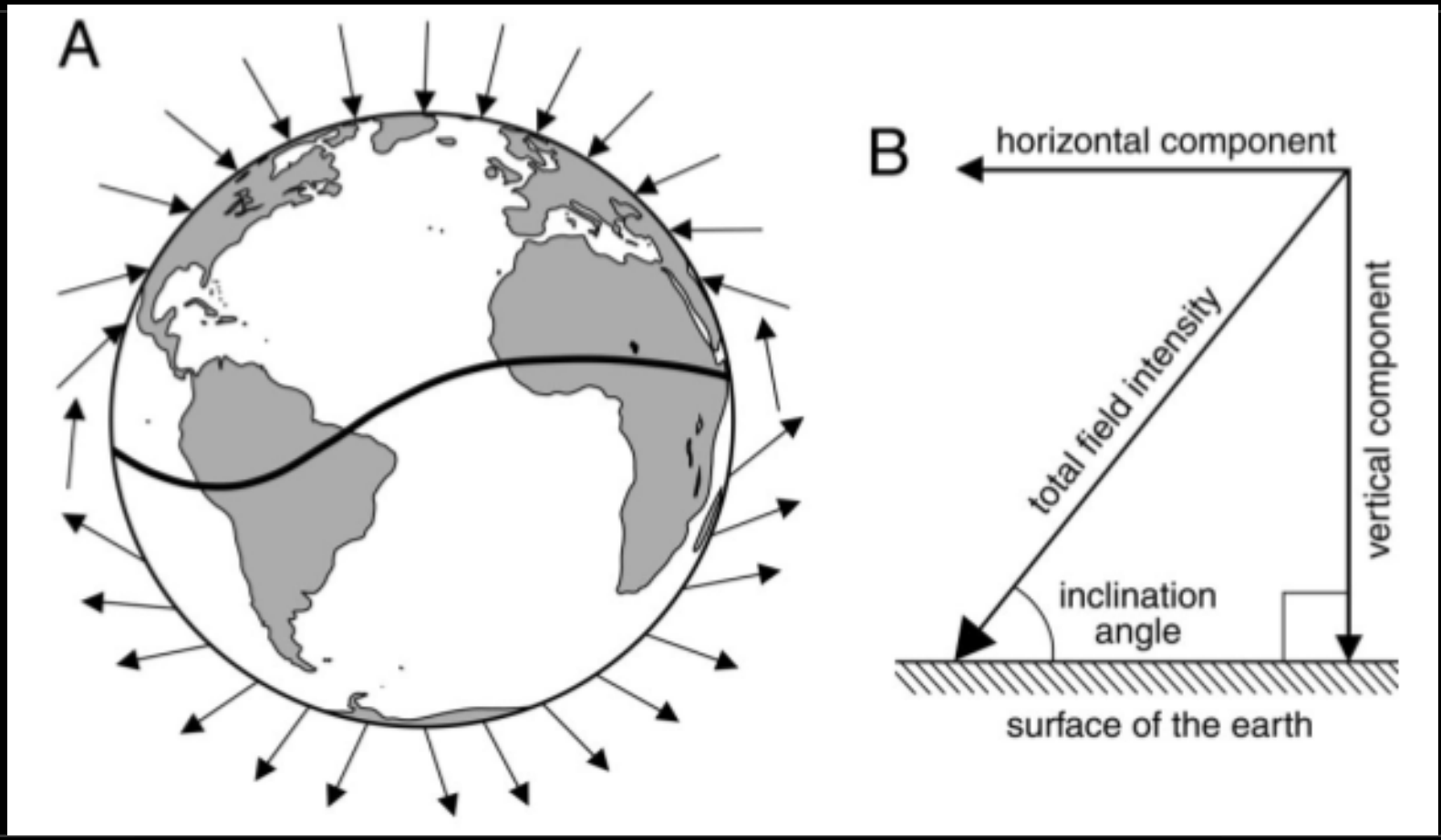
So migration direction and timing is heritable

Pulido et al (2001) PRS 268:953-959.

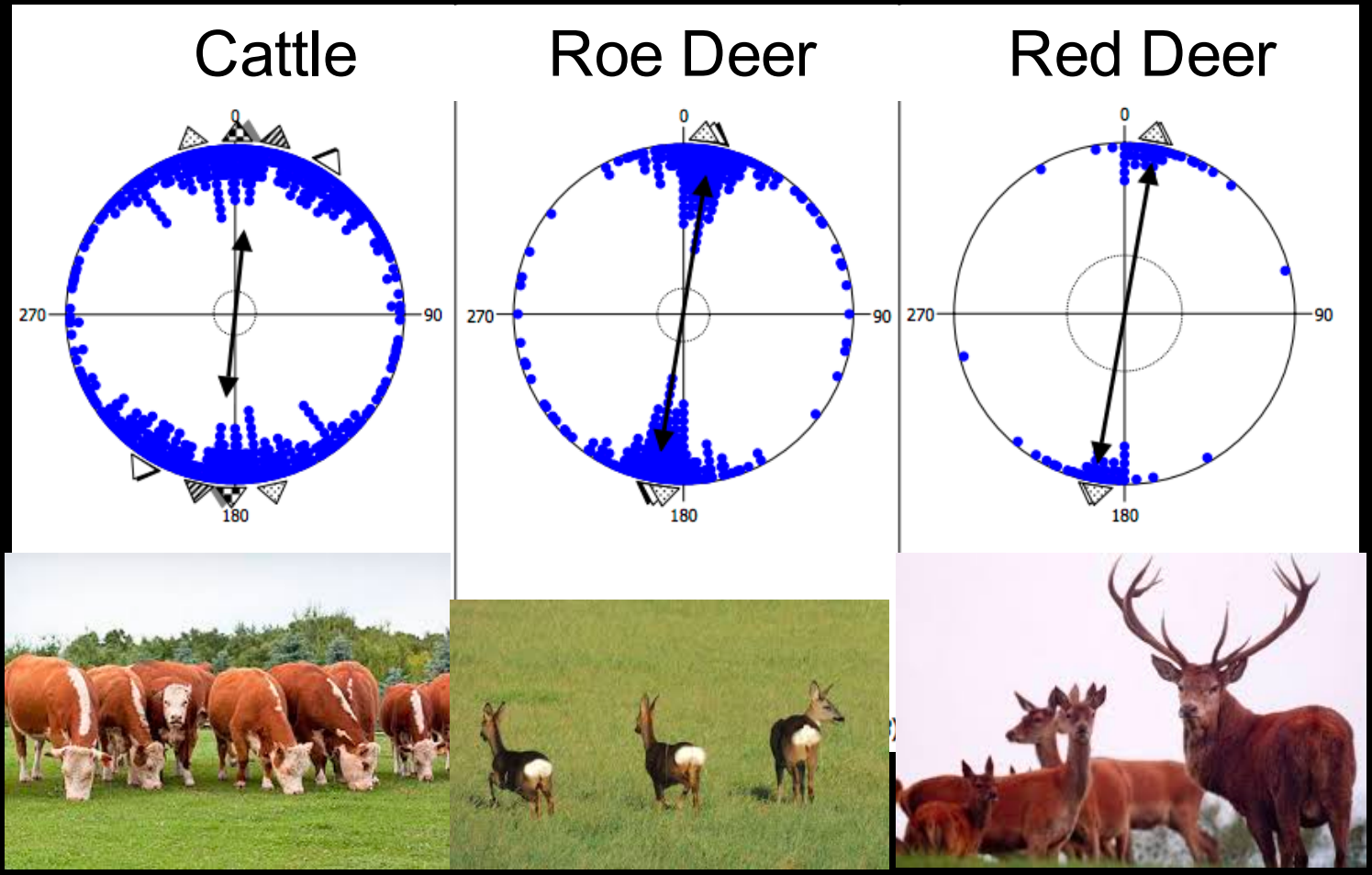


Condition dependent migration

Design an experiment to demonstrate whether dung beetles navigate by the stars



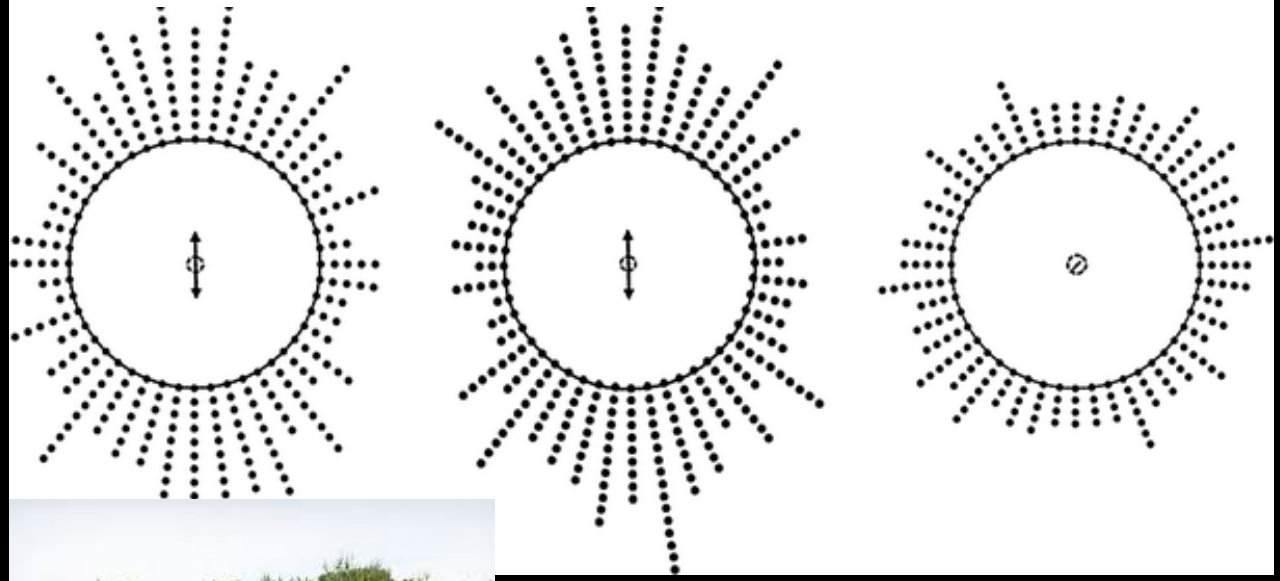
Who can detect the earth's magnetic field?



Analysis of Body Position of Cattle Using Google Earth. We determined the axial directions of 8,510 cattle of 308 randomly selected localities (pastures) from six continents: Africa (Morocco, South Africa), Asia (India), Australia, Europe (Belgium, Denmark, France, Germany, Ireland, Netherlands, Russia, United Kingdom), North America (Connecticut, Kansas, Massachusetts, Montana, New York, Oregon, Texas), and South America (Argentina) by **using satellite images freely available at Google Earth** mapping services.

Begal et al 2008 PNAS

Individual Medium High



Journal of Comparative Physiology A
August 2013, Volume 199, Issue 8, pp 695–701 | Cite as

Cattle on pastures do align along the North–South axis, but the alignment depends on herd density

Authors Authors and affiliations

P. Slaby, K. Tomanova, M. Vacha