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Senior Biology Seminar Series 2010

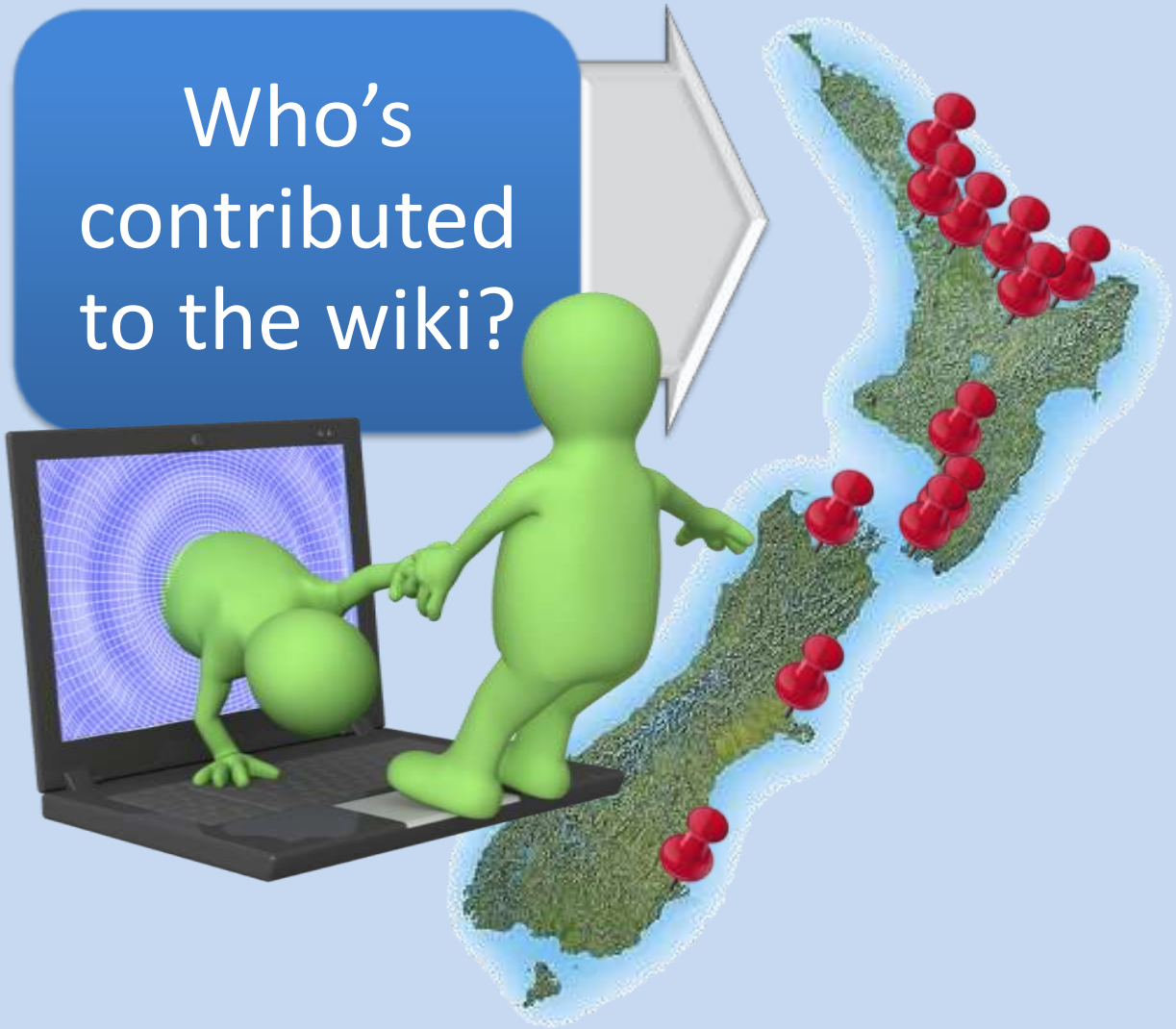
Circadian Rhythms: Keeping Time

Michal Denny, Guy Warman

10th June, 2010

THE UNIVERSITY OF AUCKLAND
FACULTY OF MEDICAL AND HEALTH SCIENCES

SCHOOL OF BIOLOGICAL SCIENCES
FACULTY OF SCIENCE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BEST WIKI DISCUSSION
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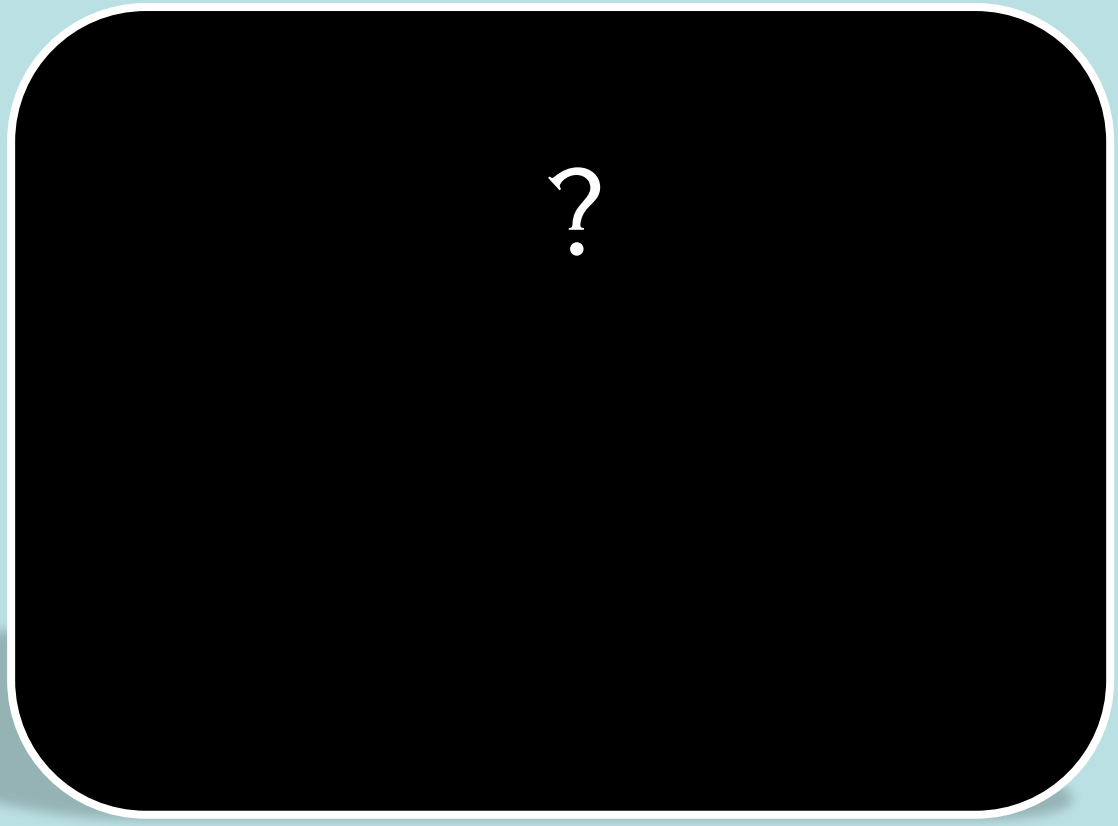



Sleepy teens pose safety risk
Later School Start Times May Cut Teen Car Crashes
LATE
Schools Waking Up to Teens' Unique Sleep Needs

Circadian Rhythms
Keeping Time

- Geophysical Rhythms
- Biological Rhythms
- Biological Clock
- Applications of Biotechnological Techniques
- Nature of Science

New Zealand Scholarship

To use biological knowledge and thinking skills to analyse the biological situation presented and integrate ideas into a coherent response

NCEA Level 3 AS's:

3.1 – Ecological Niche

3.2 –Contemporary Biological Issue

3.3 – DNA and Gene Expression

3.4 – Animal Behaviour & Plant Responses

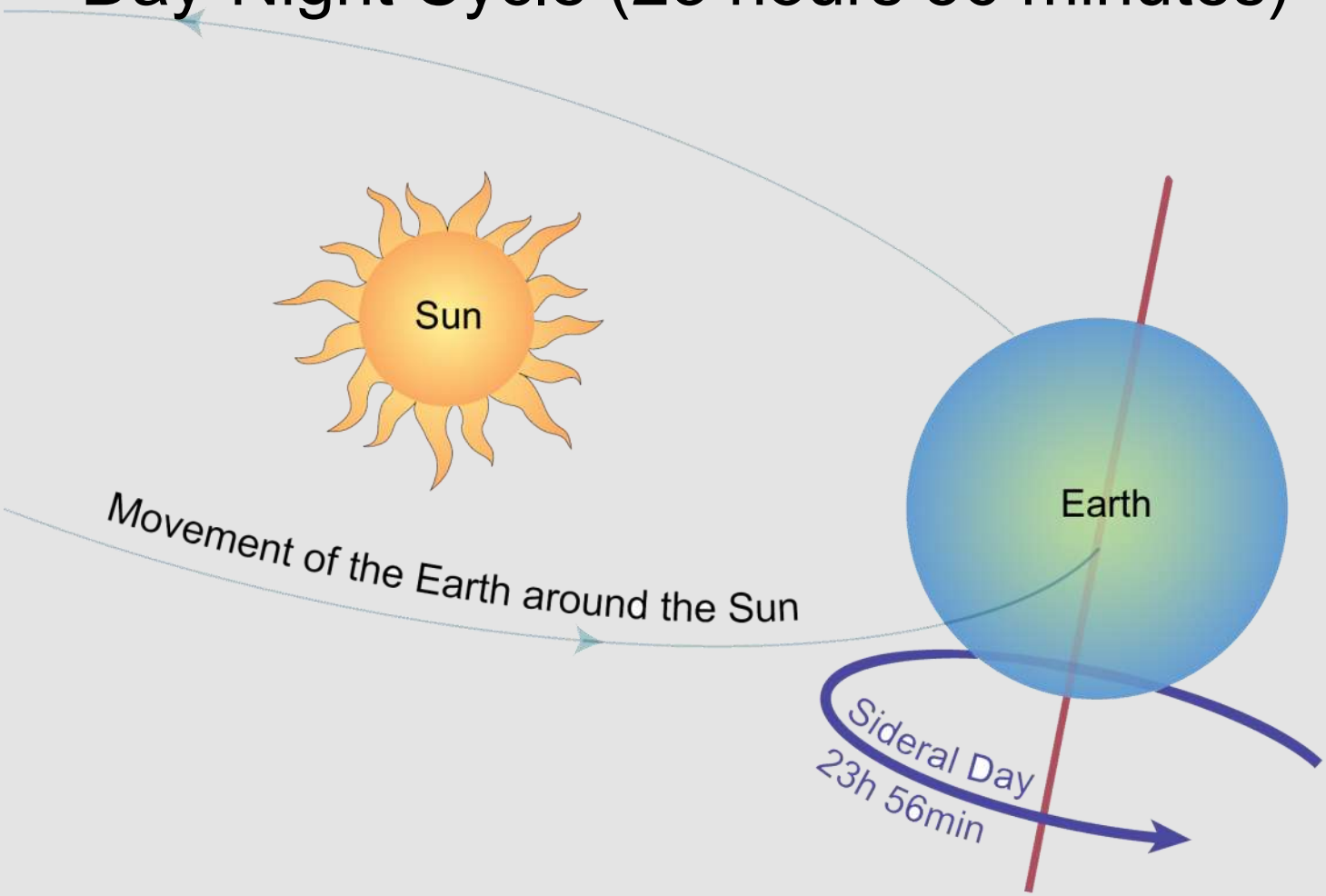
3.5 – Processes & Patterns of Evolution

3.6 – Applications of biotechnological techniques

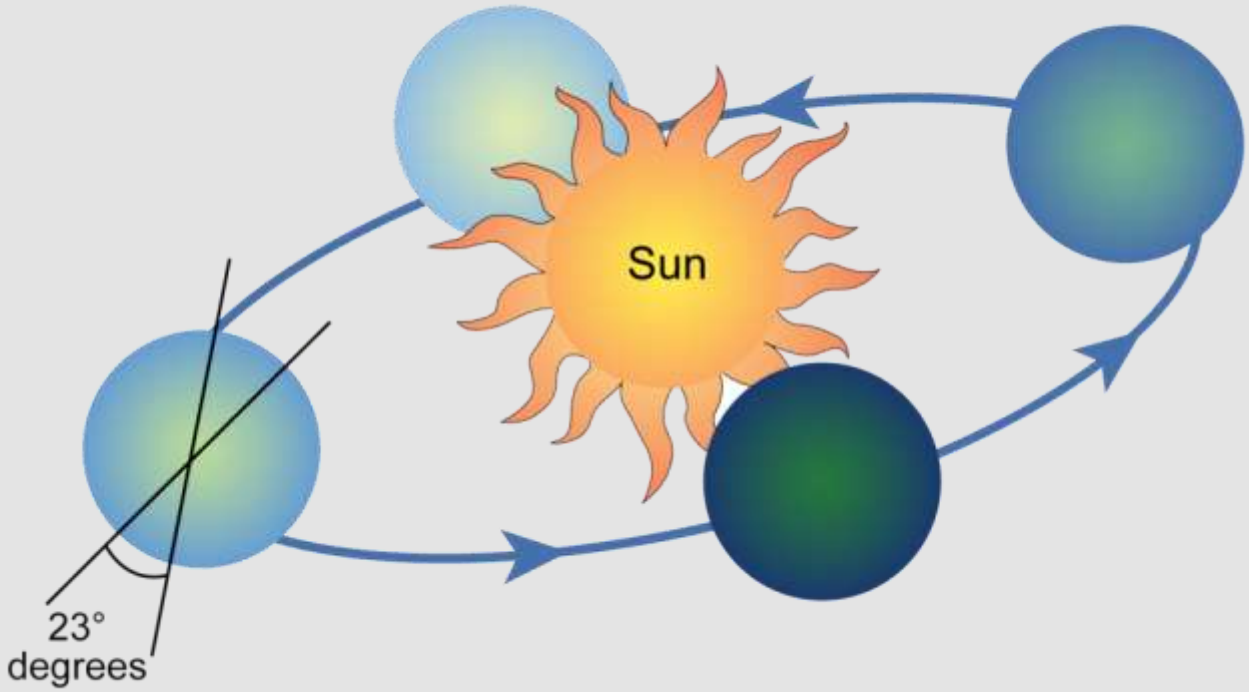
3.7 – Trends in Human Evolution

Geophysical Cycles

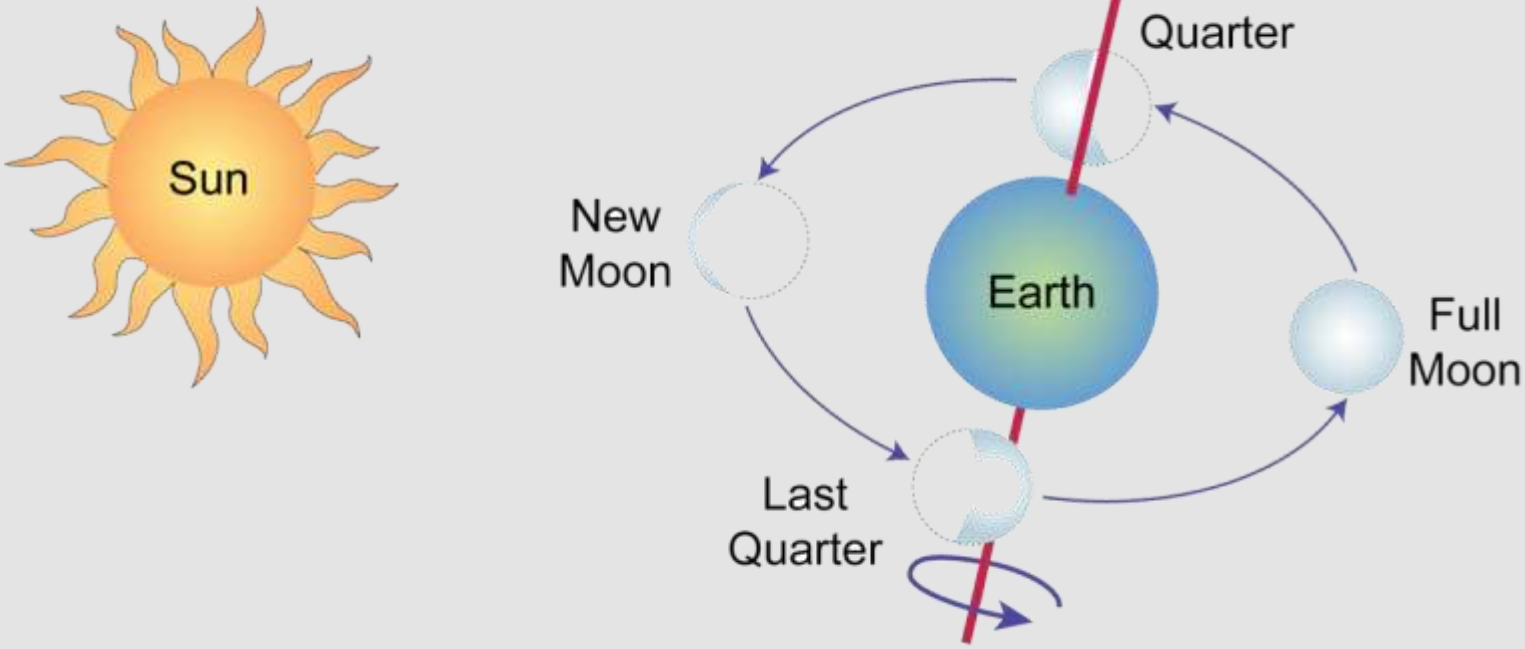
Day-Night Cycle (23 hours 56 minutes)



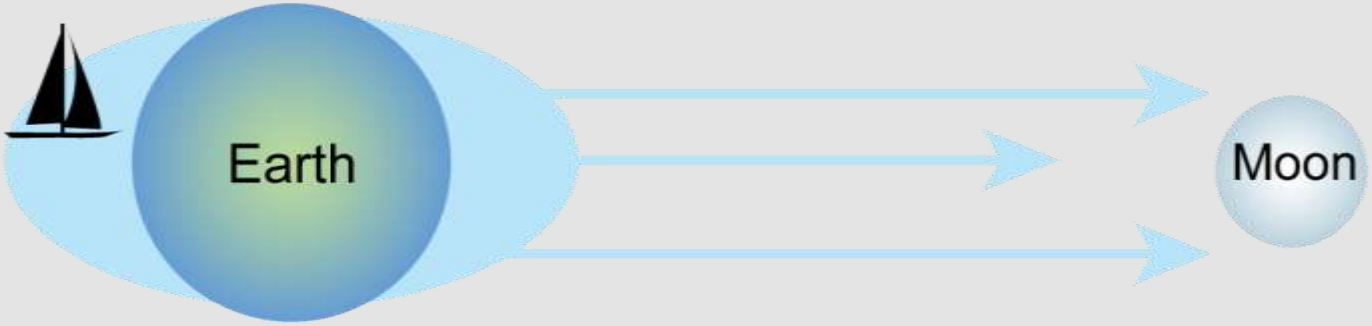
Seasonal Cycle (365.35 Days)



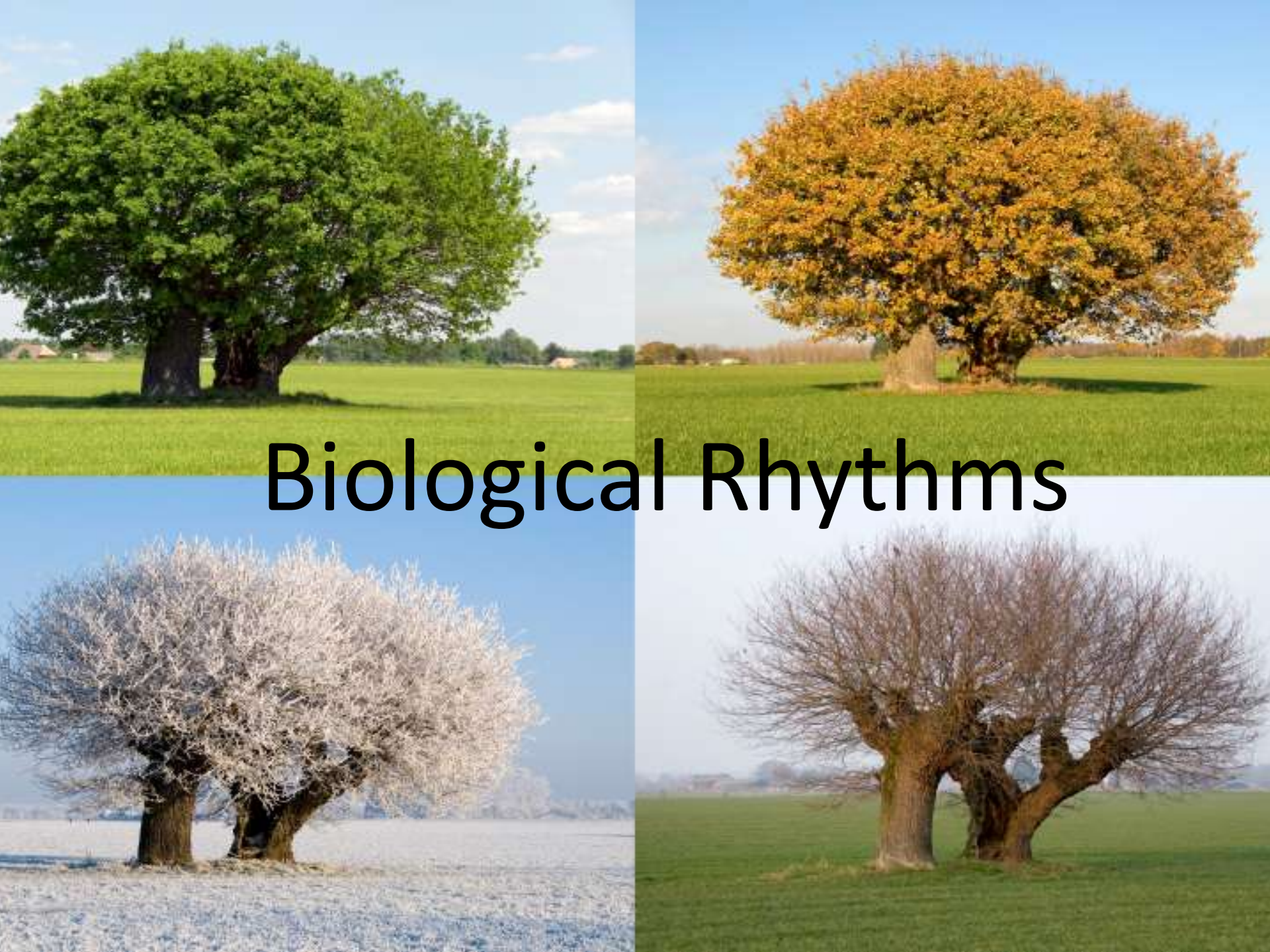
Lunar Cycle (29 Days)



Tidal Cycle (12.4 Hours)



Depends on currents/land masses



Biological Rhythms

Day-Night Rhythm

Diurnal

Day-Night Rhythm

Nocturnal

Day-Night Rhythm

Crepuscular

Day-Night Rhythm

Circadian

Seasonal Rhythm

Seasonal Rhythm

Circannual

Lunar Rhythm

Lunar Rhythm

Circalunar

Tidal Rhythm

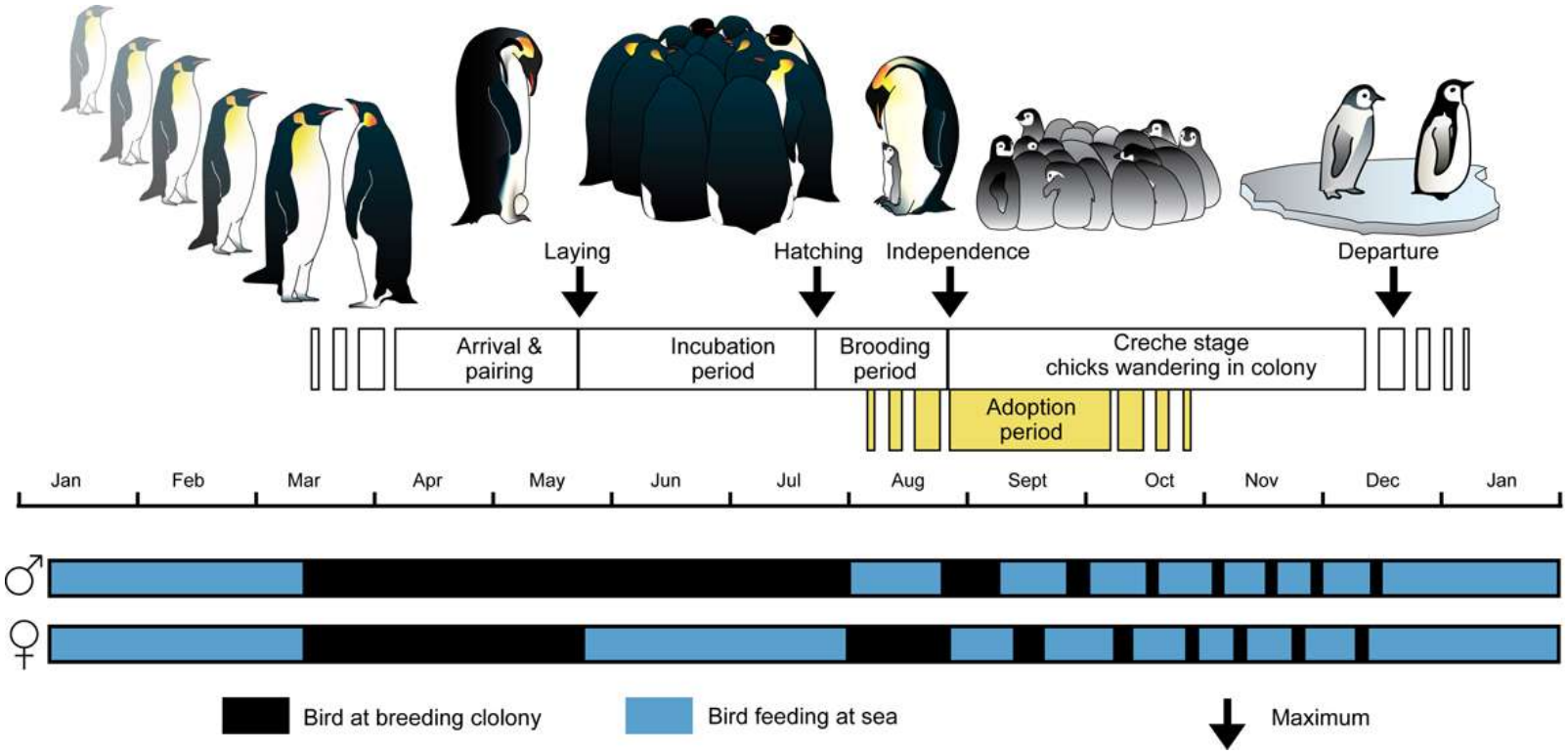
Tidal Rhythm

Circatidal

What controls these rhythms?

How do we know there is a biological clock?

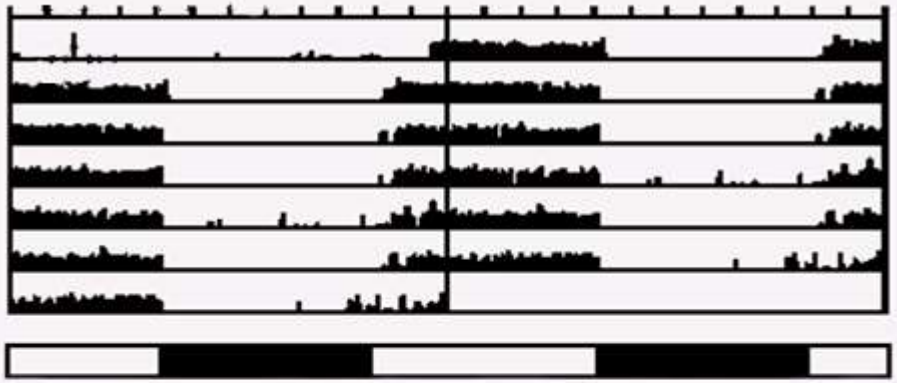
Absence of rhythmic environments?



Recording Animal Activity

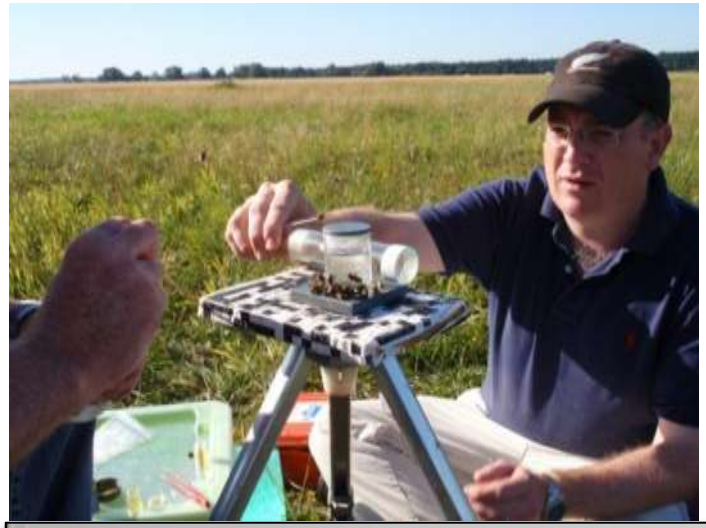
Interpreting Actograms

Equal periods of light and dark



Constant darkness

Free running

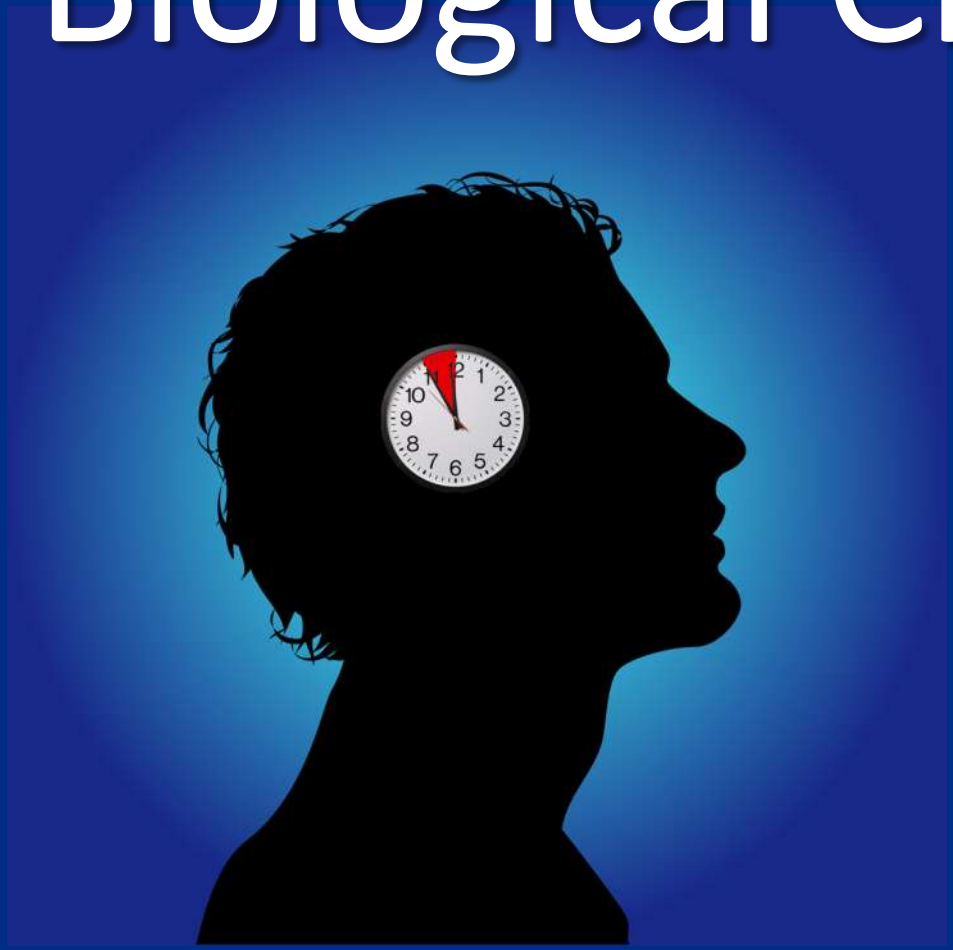


Researching Circadian Rhythms

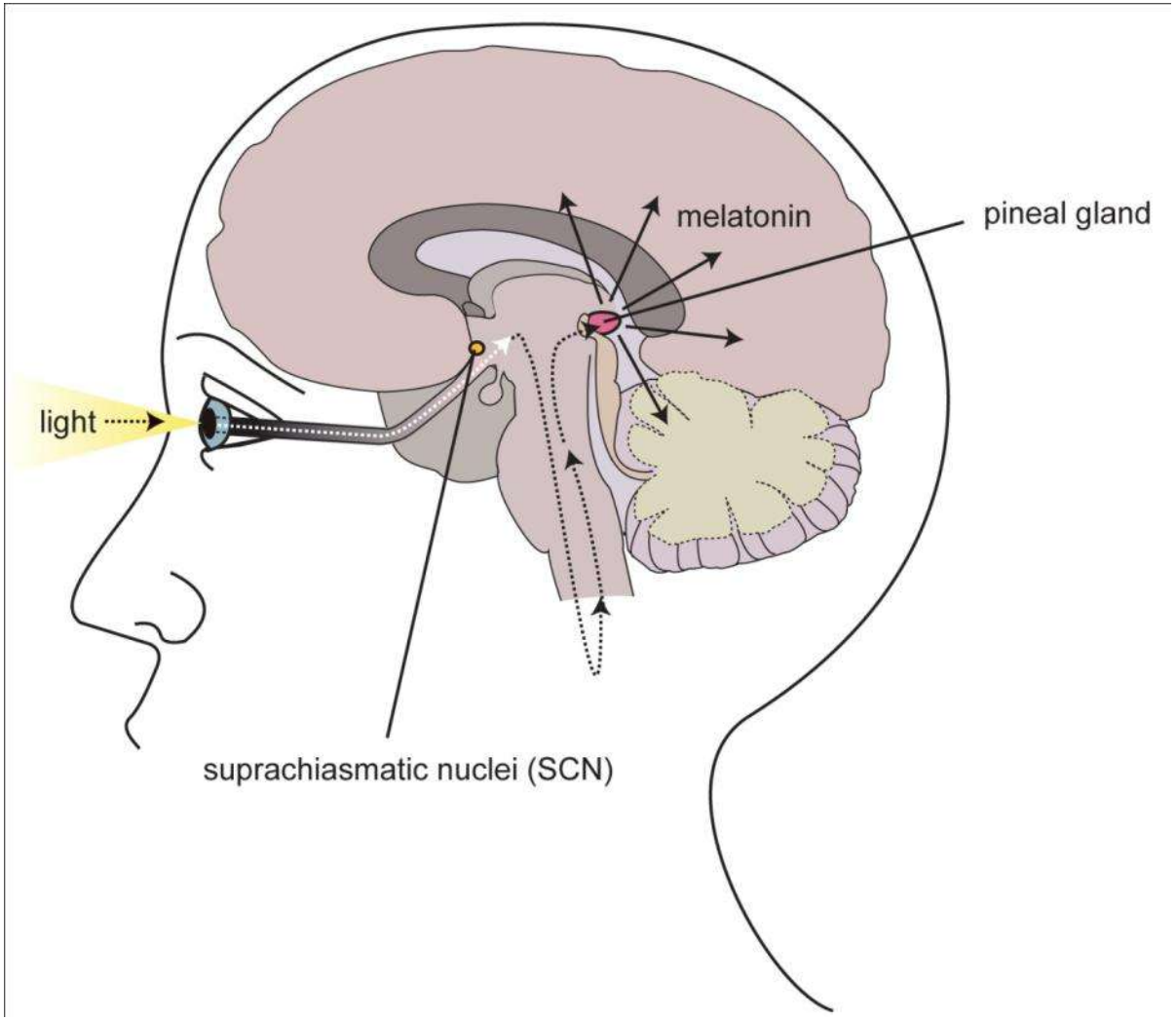
Guy Warman

University of Auckland
Chronobiology

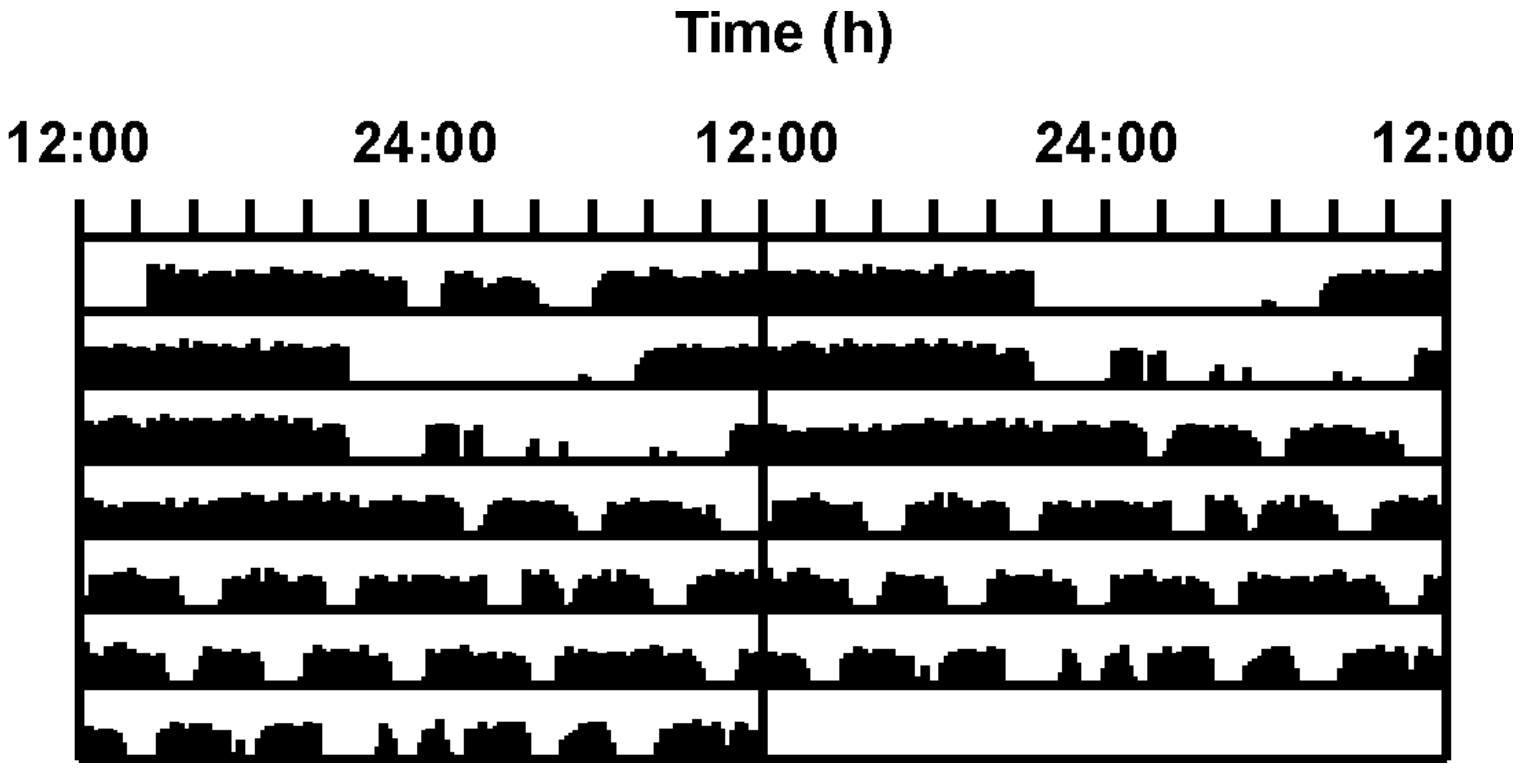
The Biological Clock



Location of the Clock



Ablation Experiments



Transplantation Experiments

A

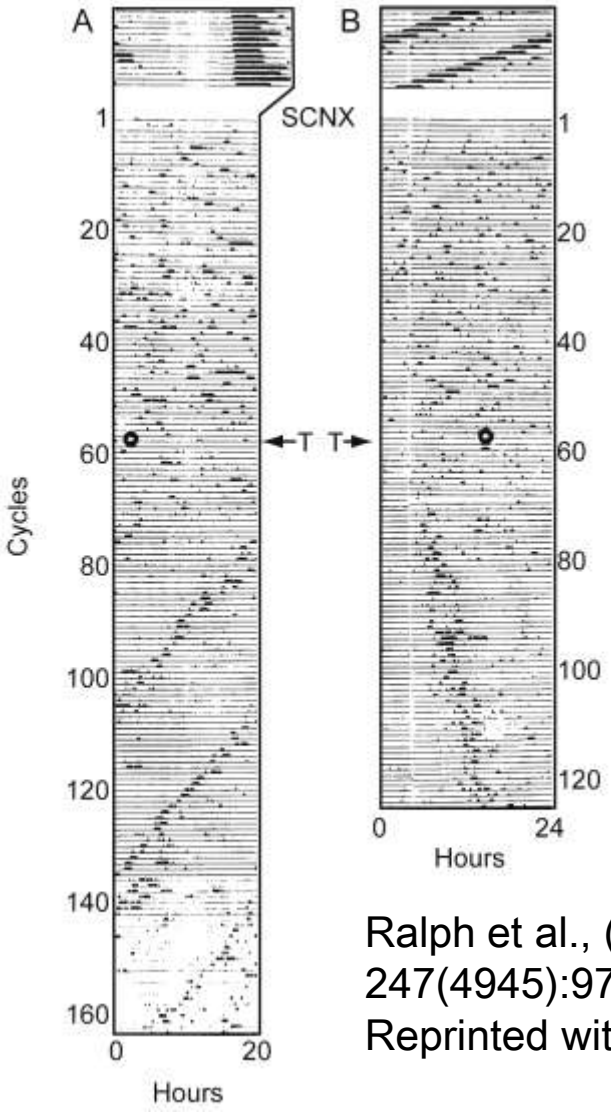
SCN removed

SCN removed

B

Wild type
Free running
period: 24 hours

Tau mutant
Free running
period: 22 hours



Ralph et al., (1990) Science 247(4945):975-8
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Molecular Basis for the Clock

Konopka and Benzer, 1971

(from Takahashi, 2004, JBR19(5) 339-347).

Molecular Basis for the Clock

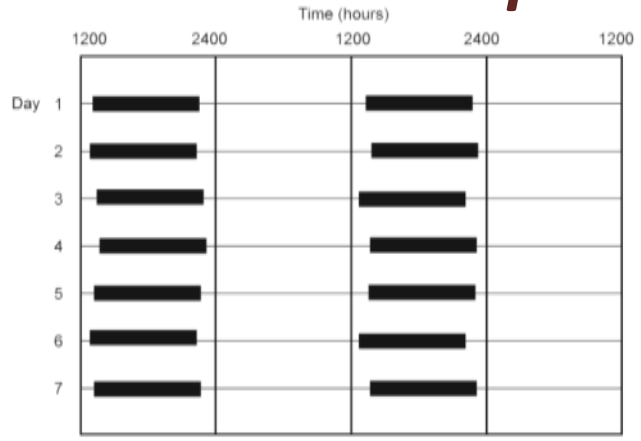
Wild Type flies — 24 hour clock

Slow Clock (*period* – long) — 27 hour clock

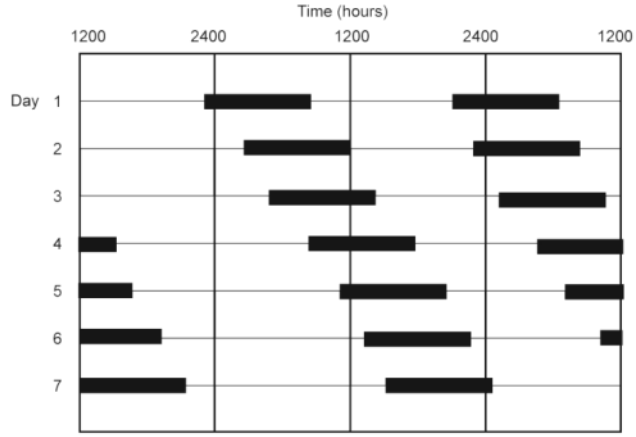
Fast Clock (*period* – short) — 19 hour clock

No Clock (*period* – zero) — Arrhythmic

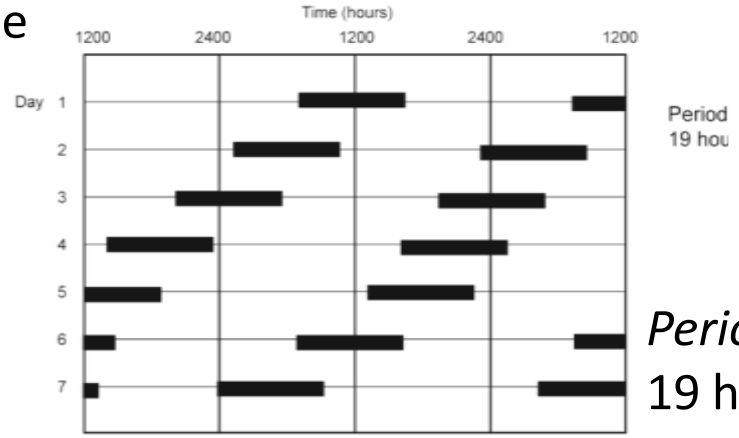
The *period* Mutants



Wild Type



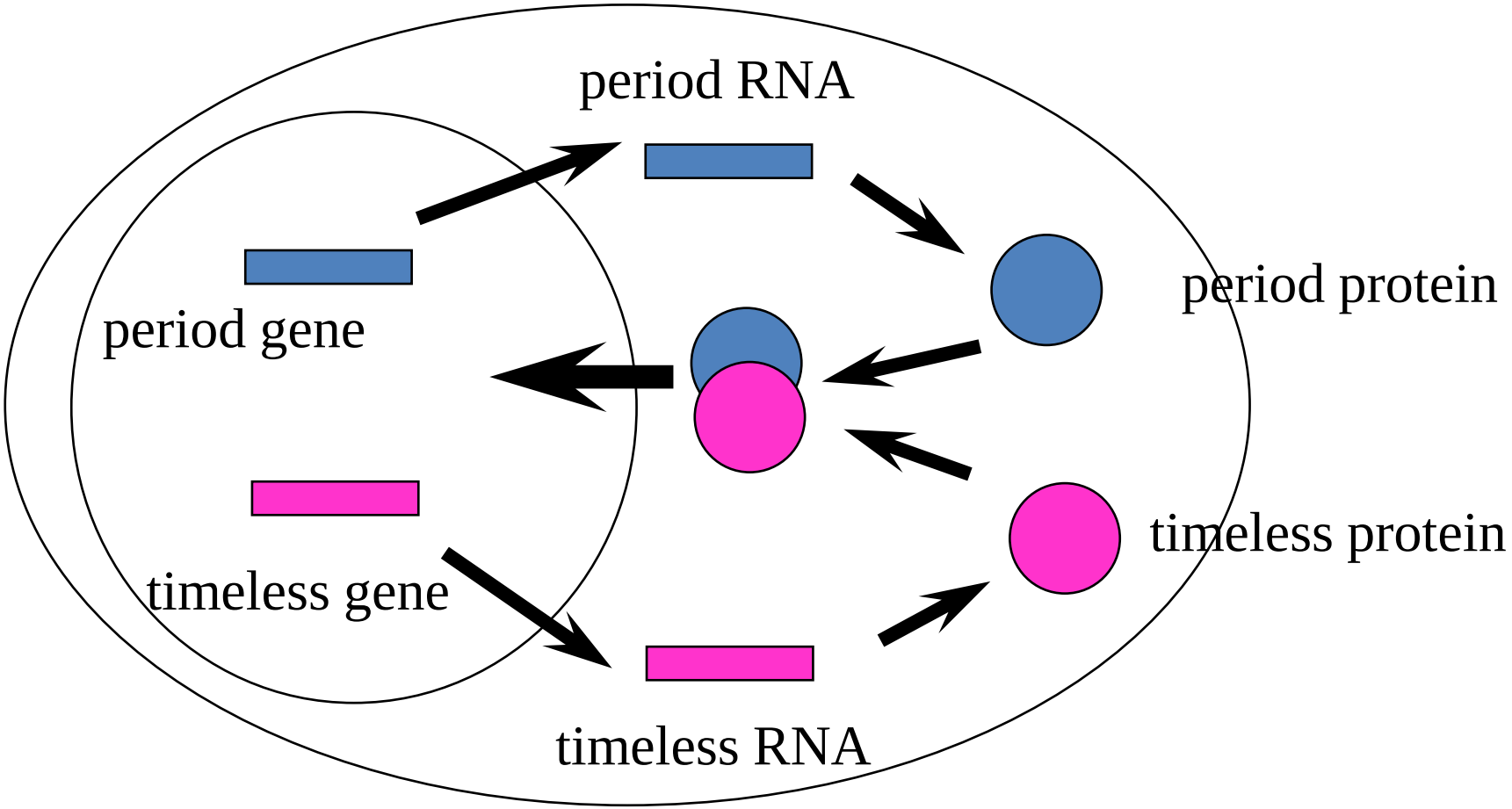
Period-long
27 hour cycle



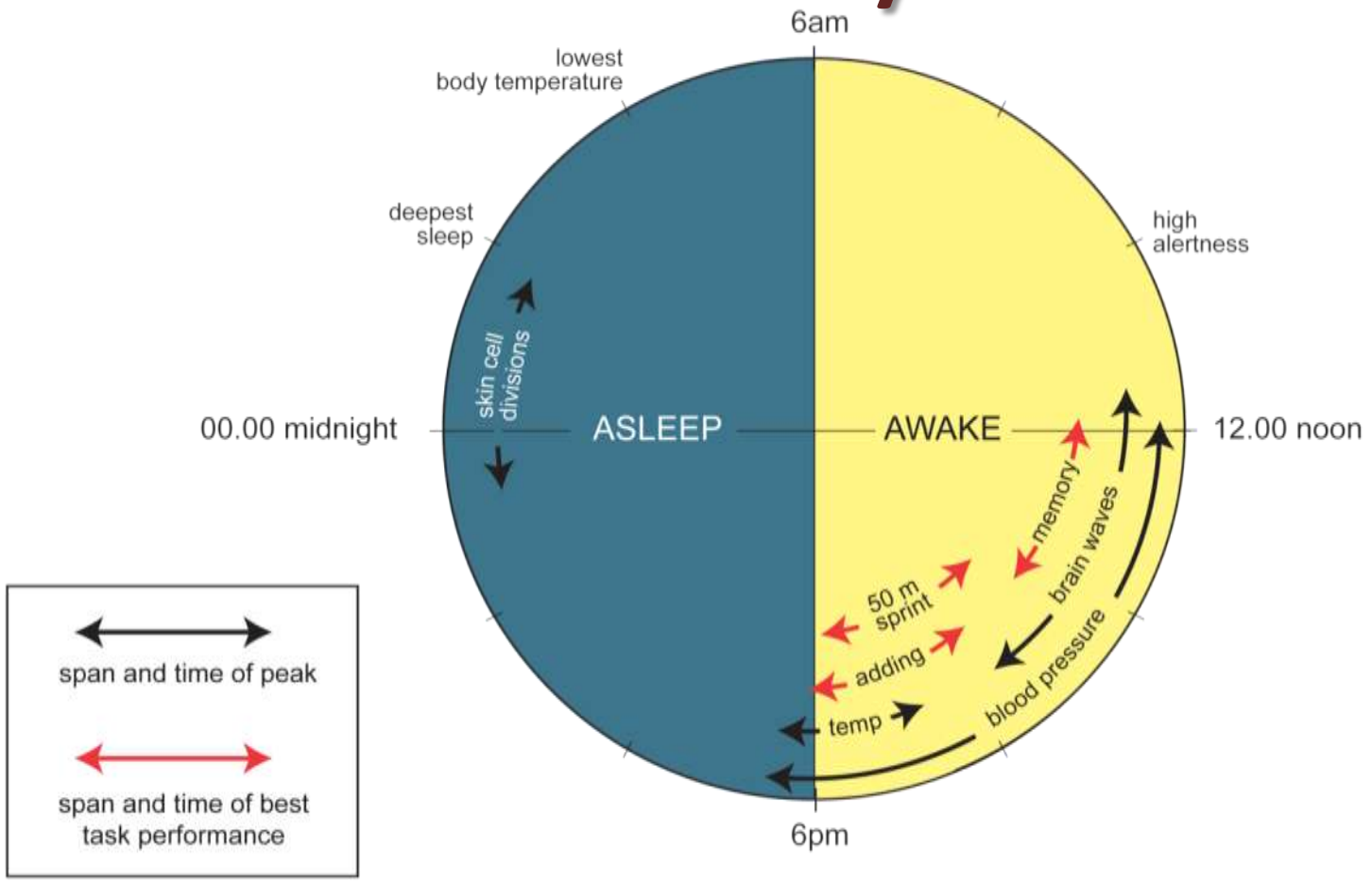
Period-short
19 hour cycle

Redrawn from Konopka, R.J. and Benzer, S. (1971). PNAS 68: 2112-2116.

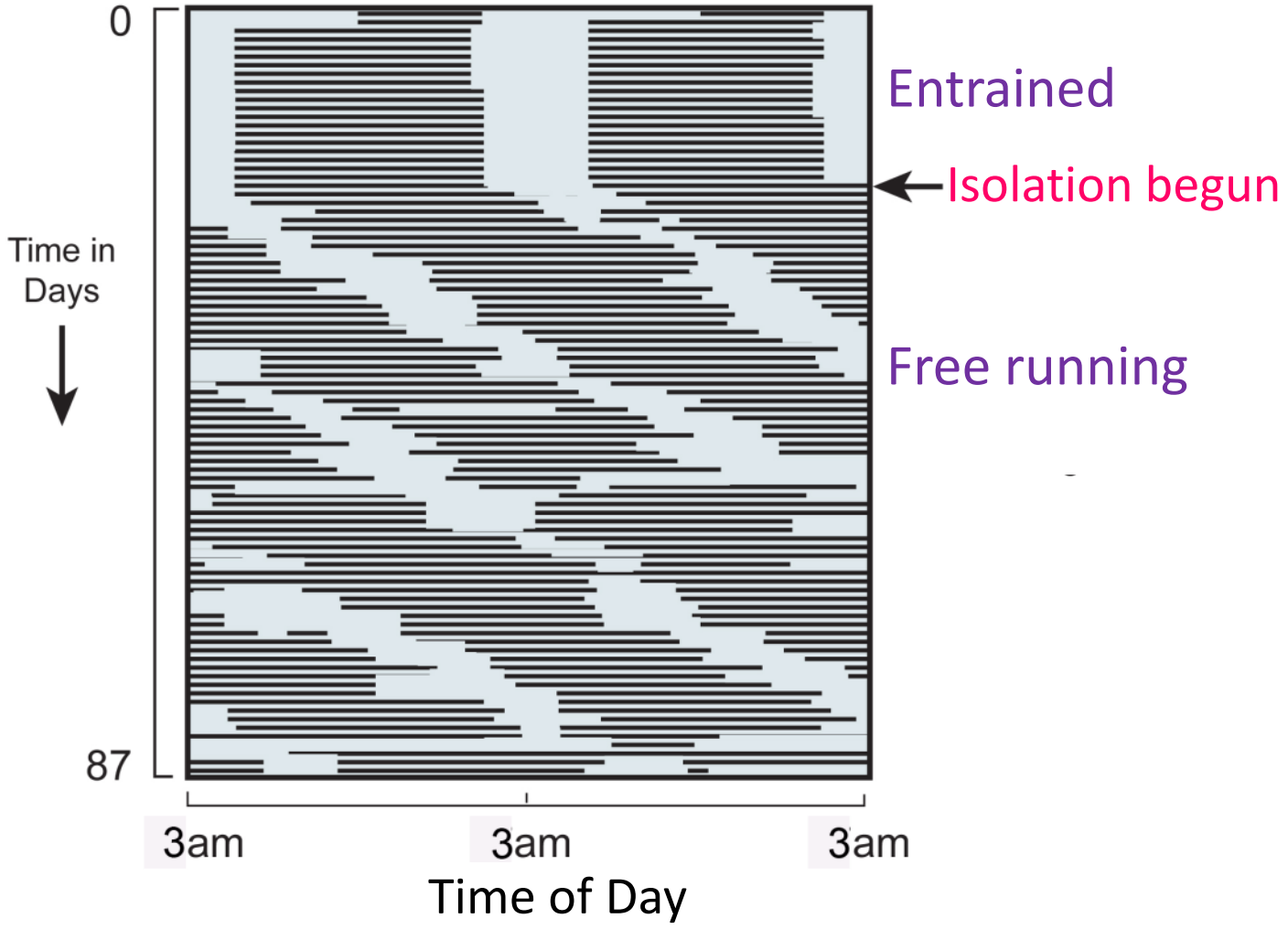
Genetic Basis for the Clock



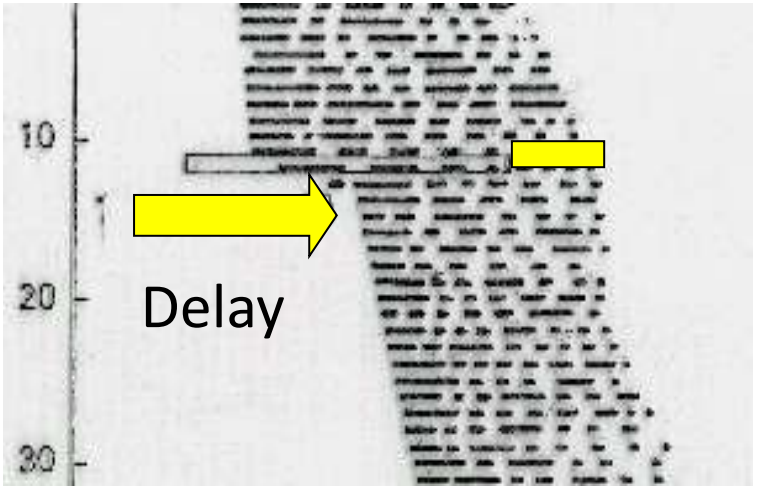
Human Biorhythms



Human circadian clock

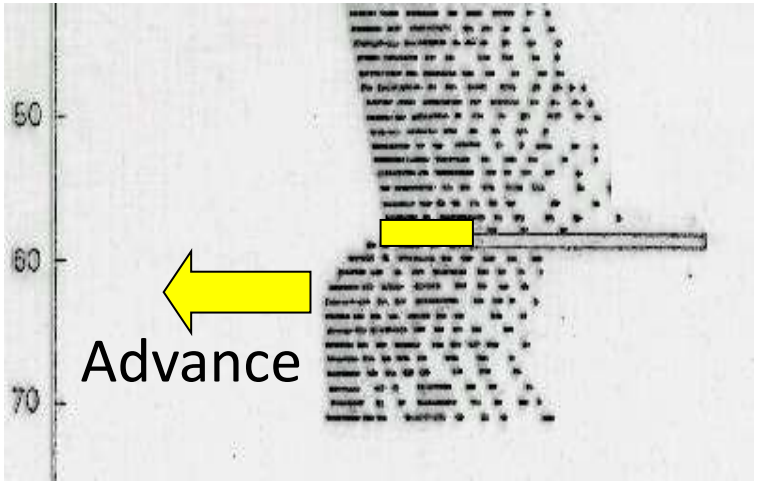


How light affects the clock in humans



Light in evening delays you to a later ‘time zone’

Sleep later



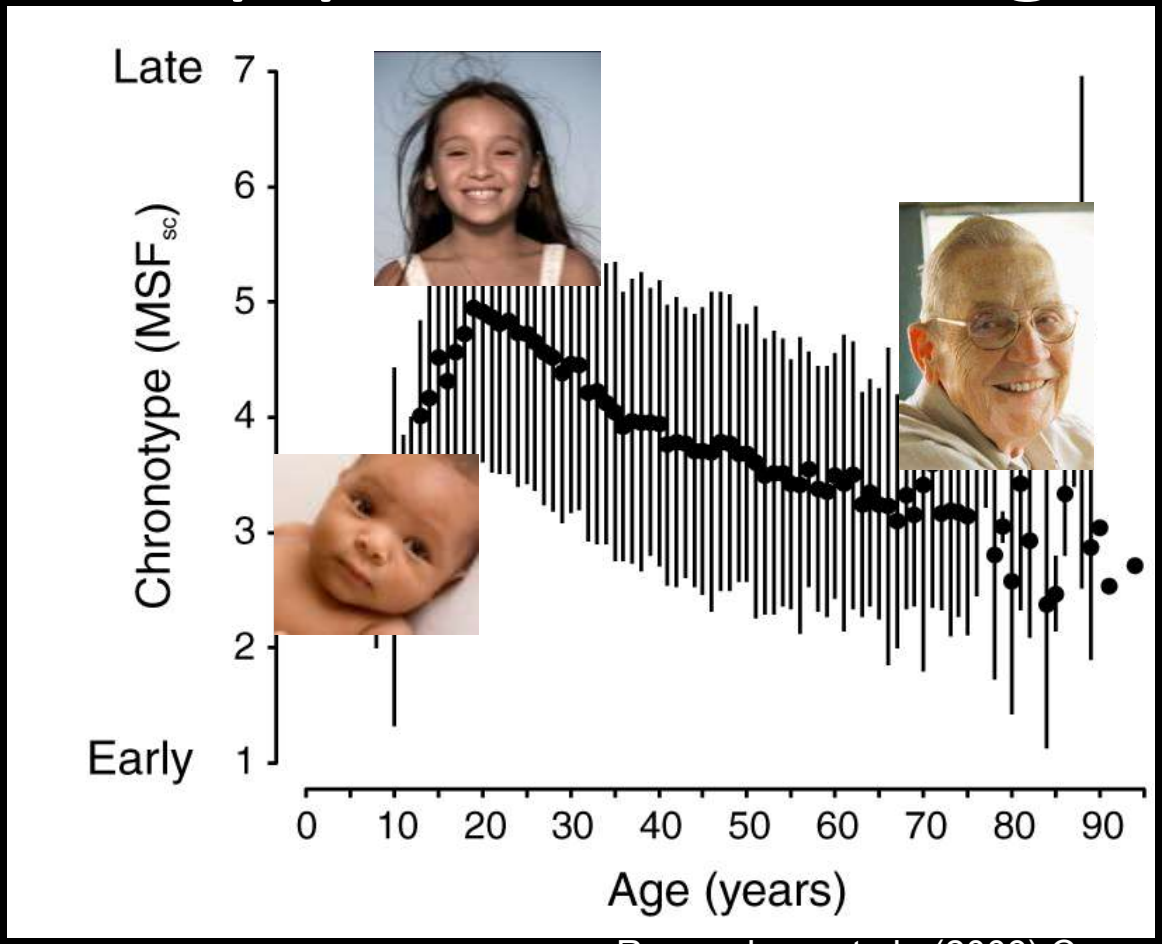
Light in morning advances to an earlier ‘time zone’

Sleep earlier

Hard to get up on a Monday morning? Easier by Thursday?

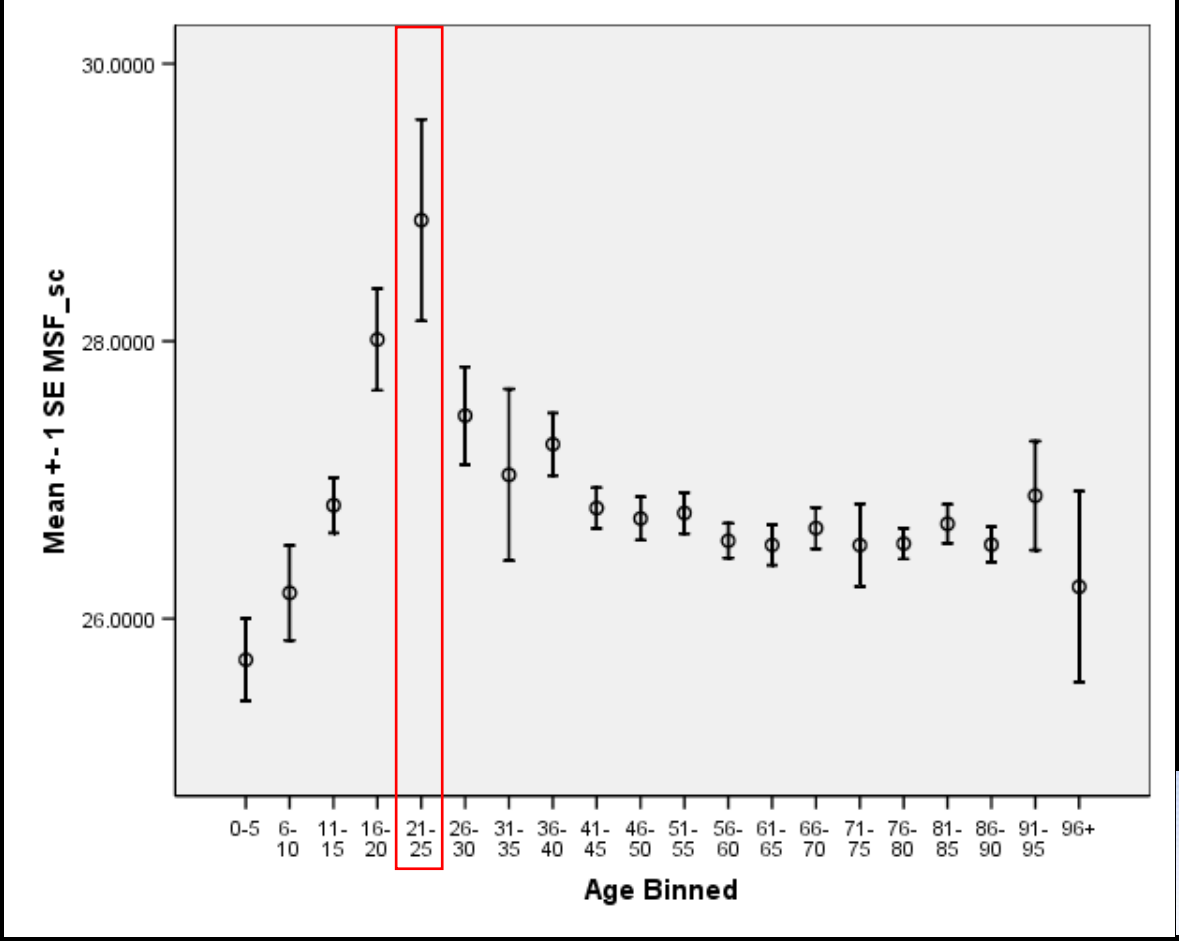
- Light in evening on Friday
- No light Saturday morning
- Light in evening on Saturday
- No light in morning Sunday --- wake up Australia time
- Monday morning hard to get up
- Light on Monday morning
- Light on Tuesday morning
- Light on Wed morning...

Sleep patterns and age

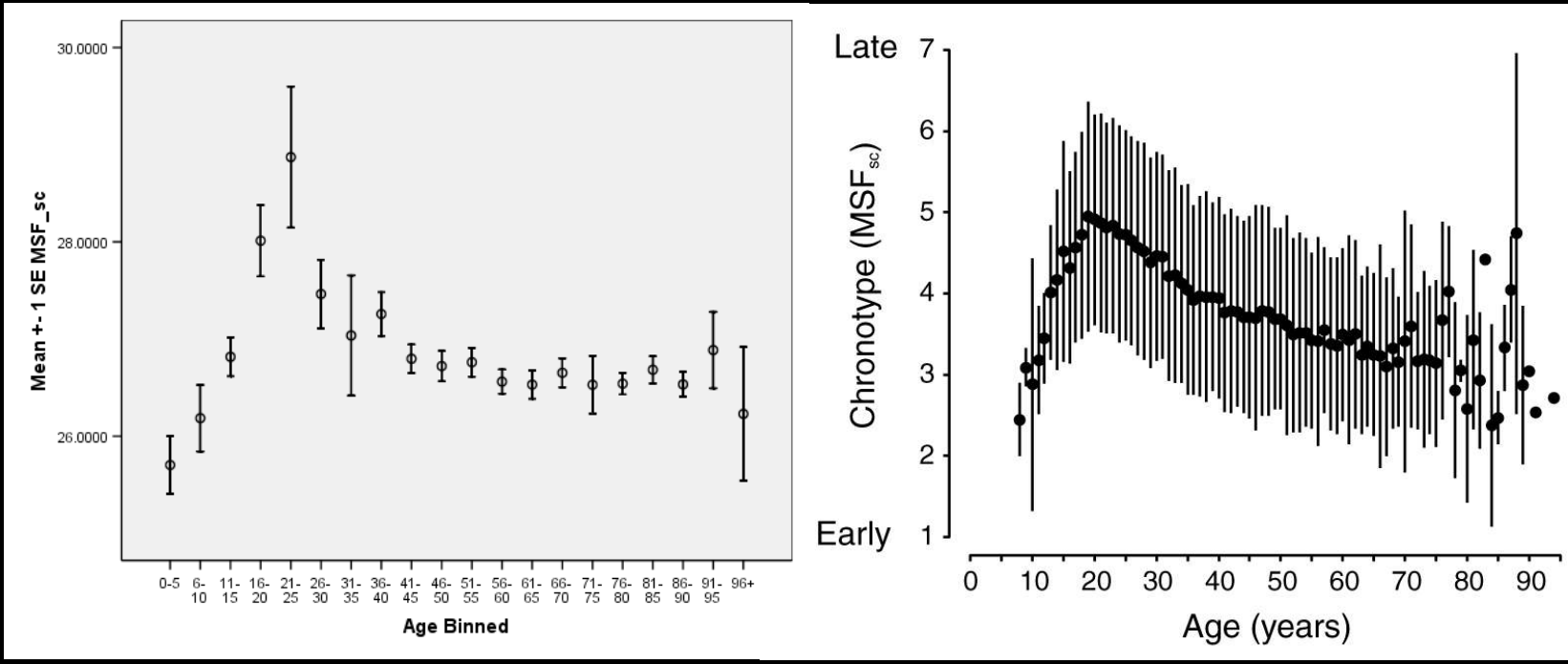


Roenneberg et al., (2003) Current Biology 14: 1038-39. Reprinted with permission from Elesvier

Sleep timing in blind people



Sleep patterns and age



Size of the problem in the blind

Up to 25% blind people suffer from a sleep timing problem

Does anaesthesia steal time?

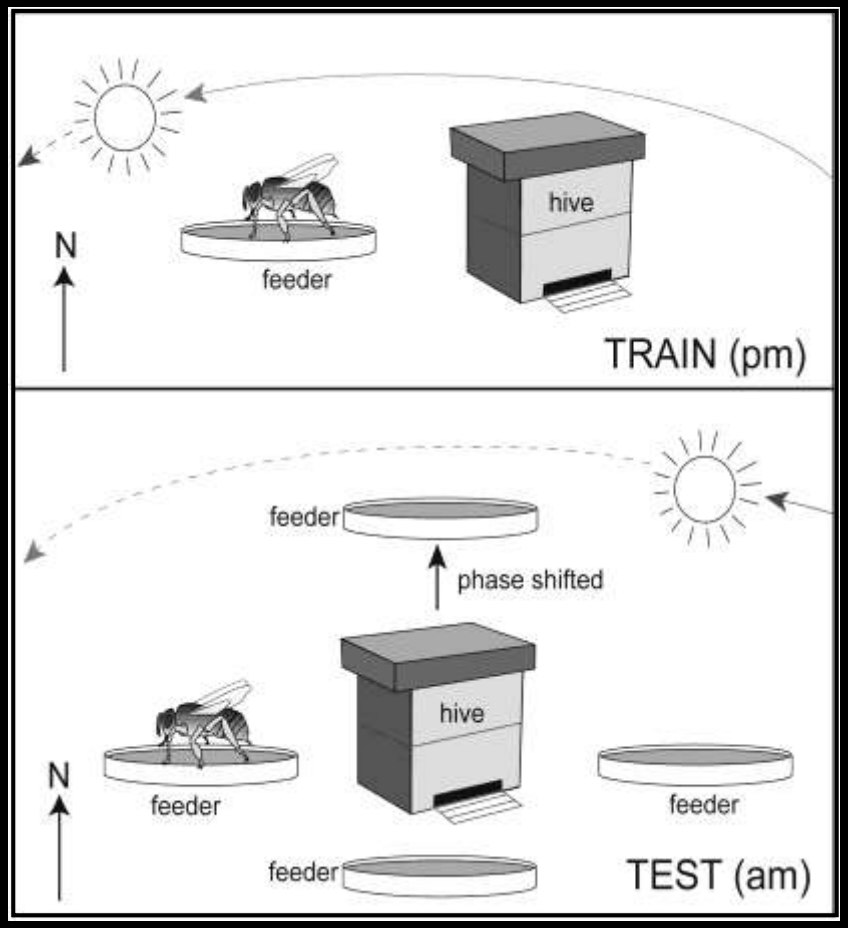
MARSDEN FUND
TE PŪTEA RANGAHAU A MARSDEN

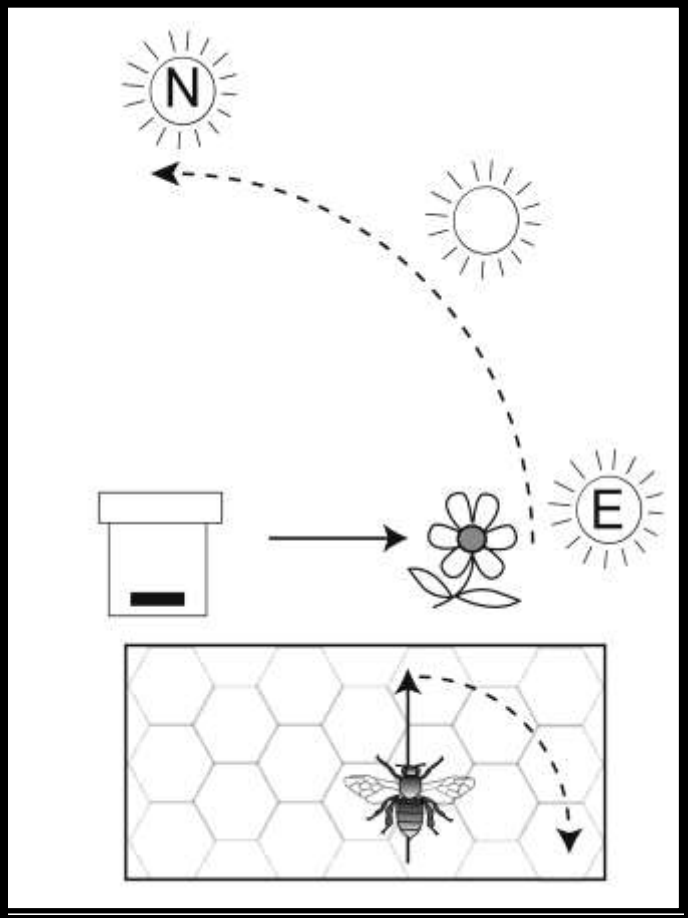
Animal Model: Honey Bees

Waggle Dance

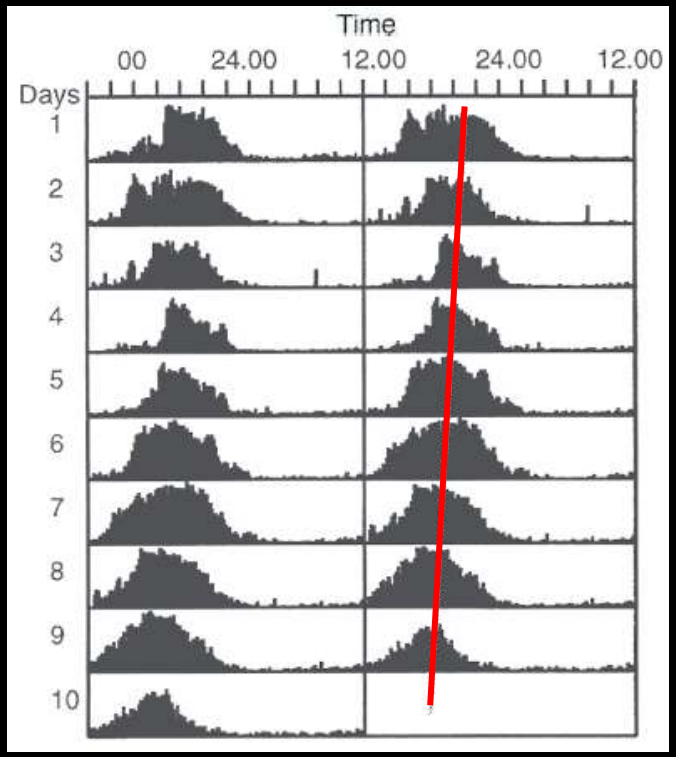
A reason NOT to use bees

Time sense in bees

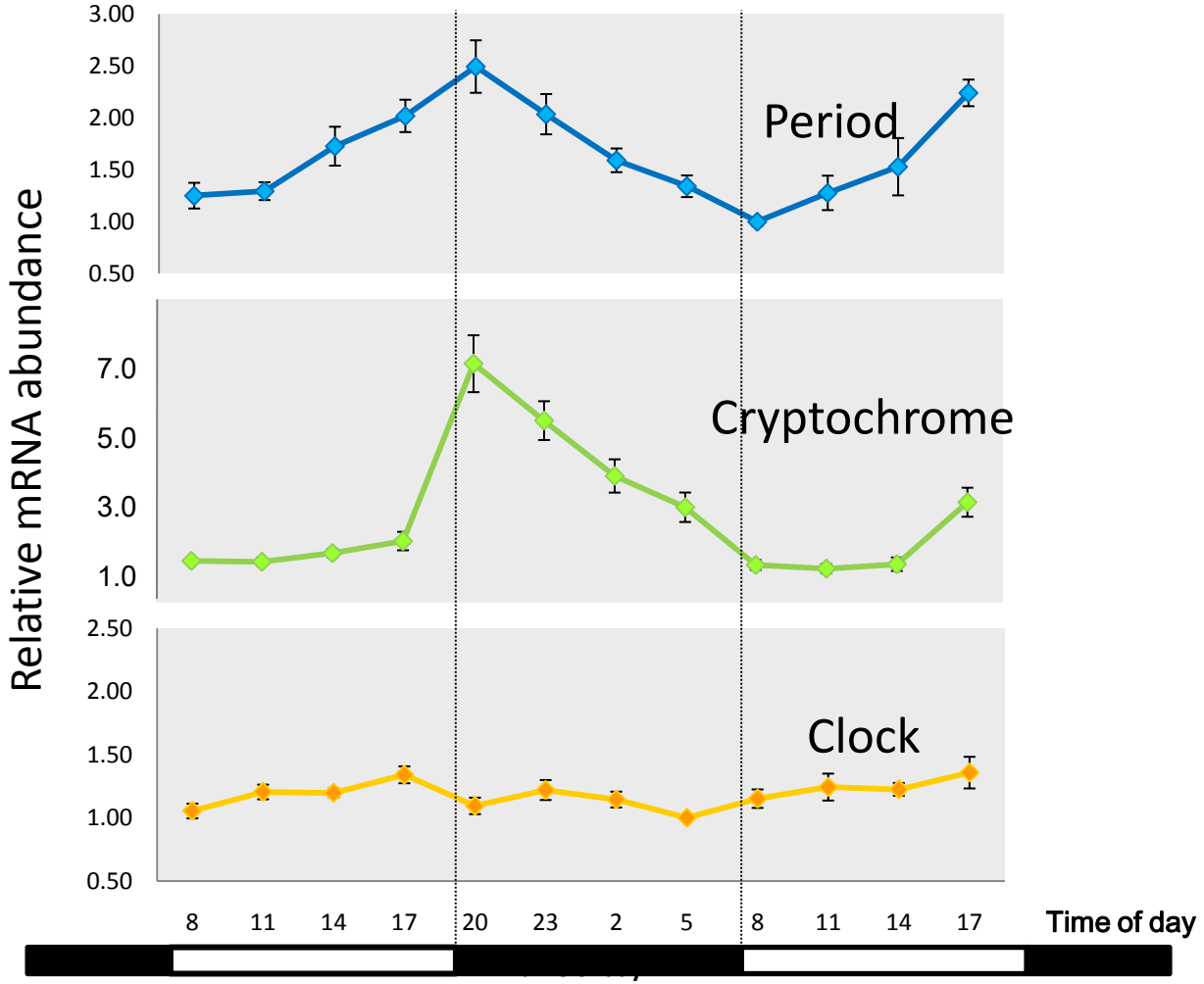




Circadian rhythms in behaviour



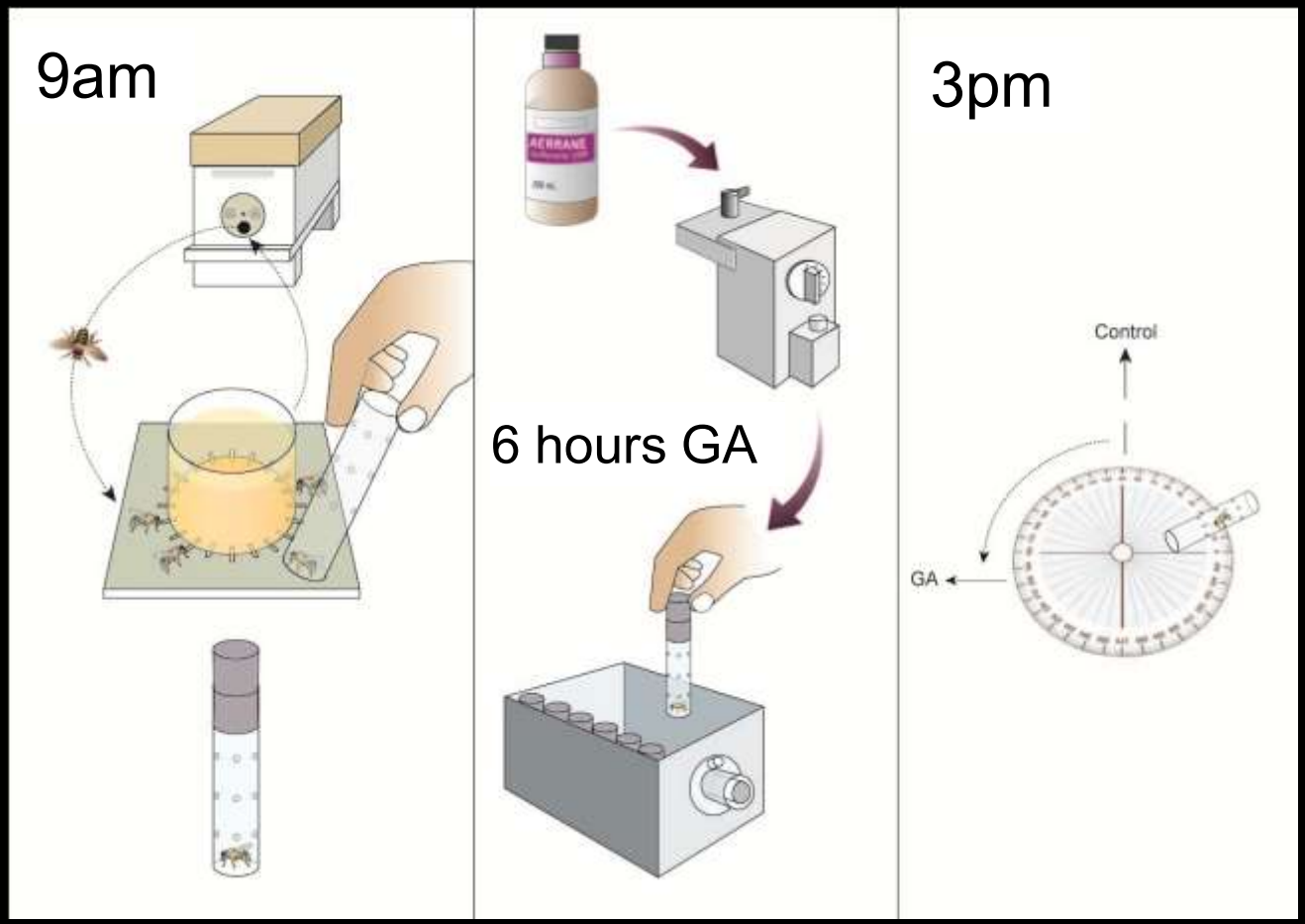
Clock Gene Expression in Bees



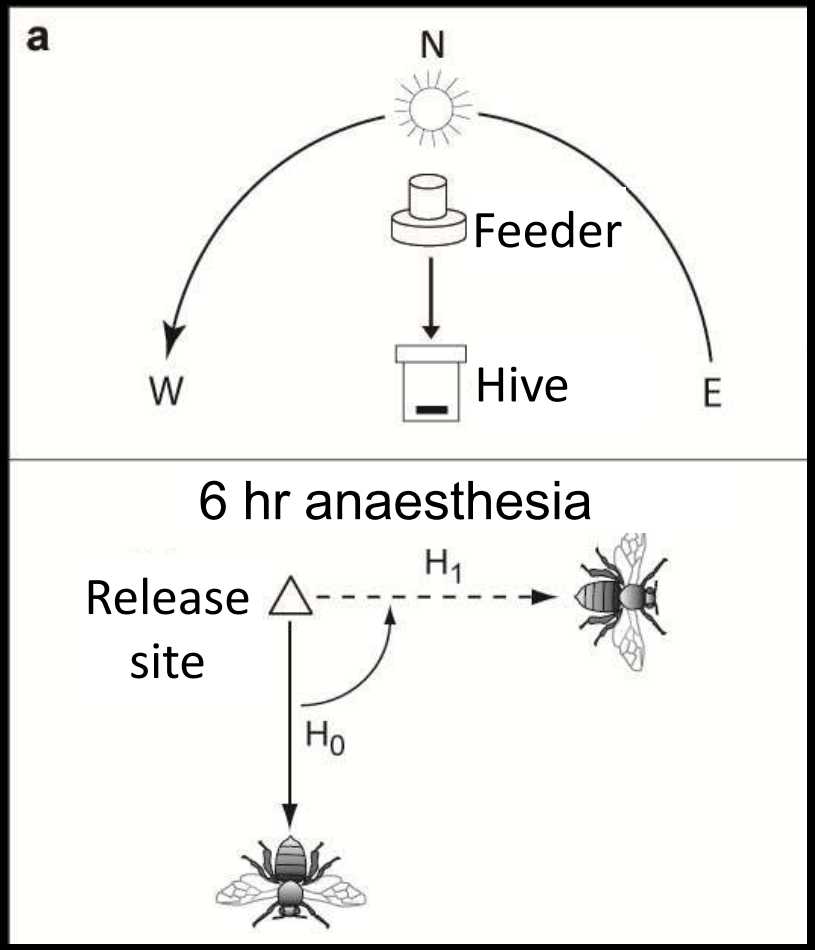
How to anaesthetise bees


Results

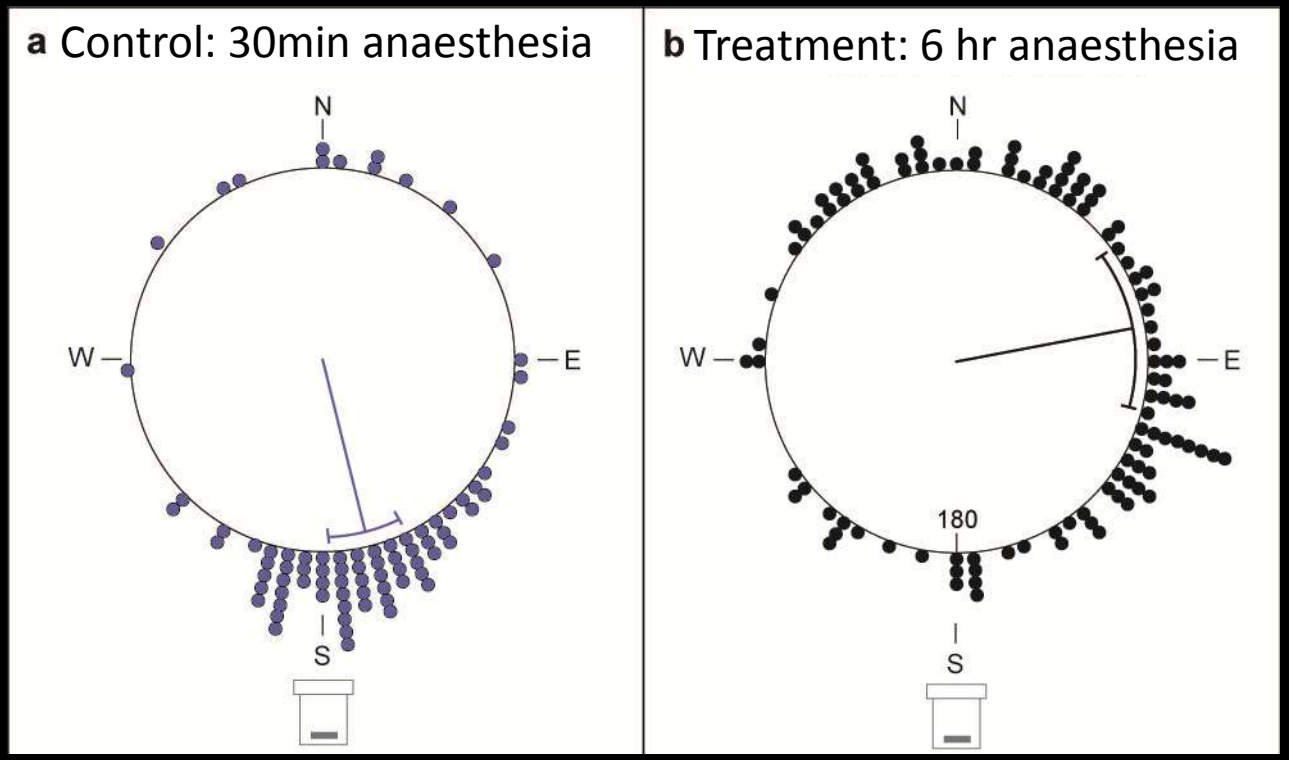
1. Effect of anaesthesia on the perception of time



Expected results



A. Vanishing Bearings



B. Harmonic Radar


1


2


3

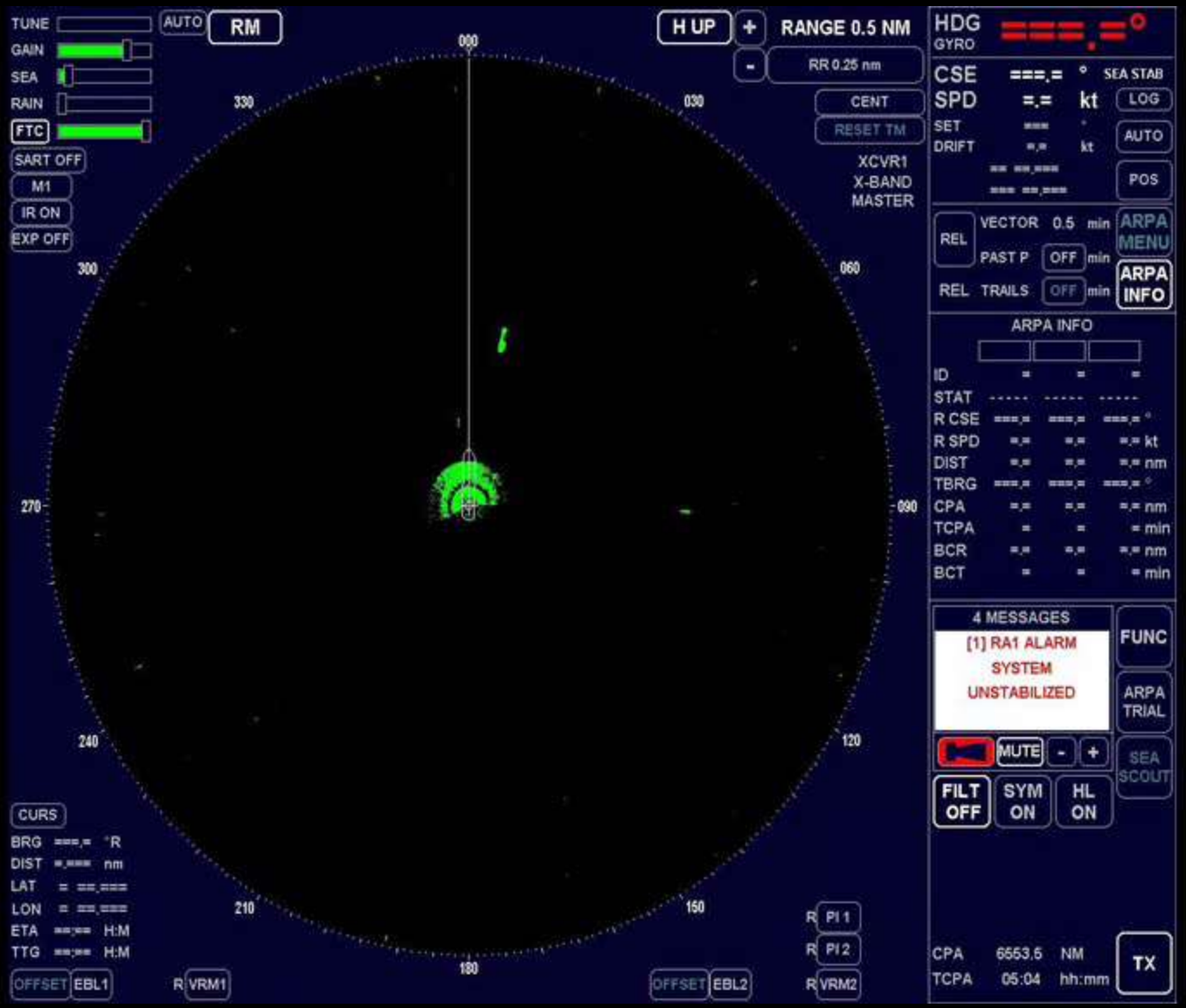

4

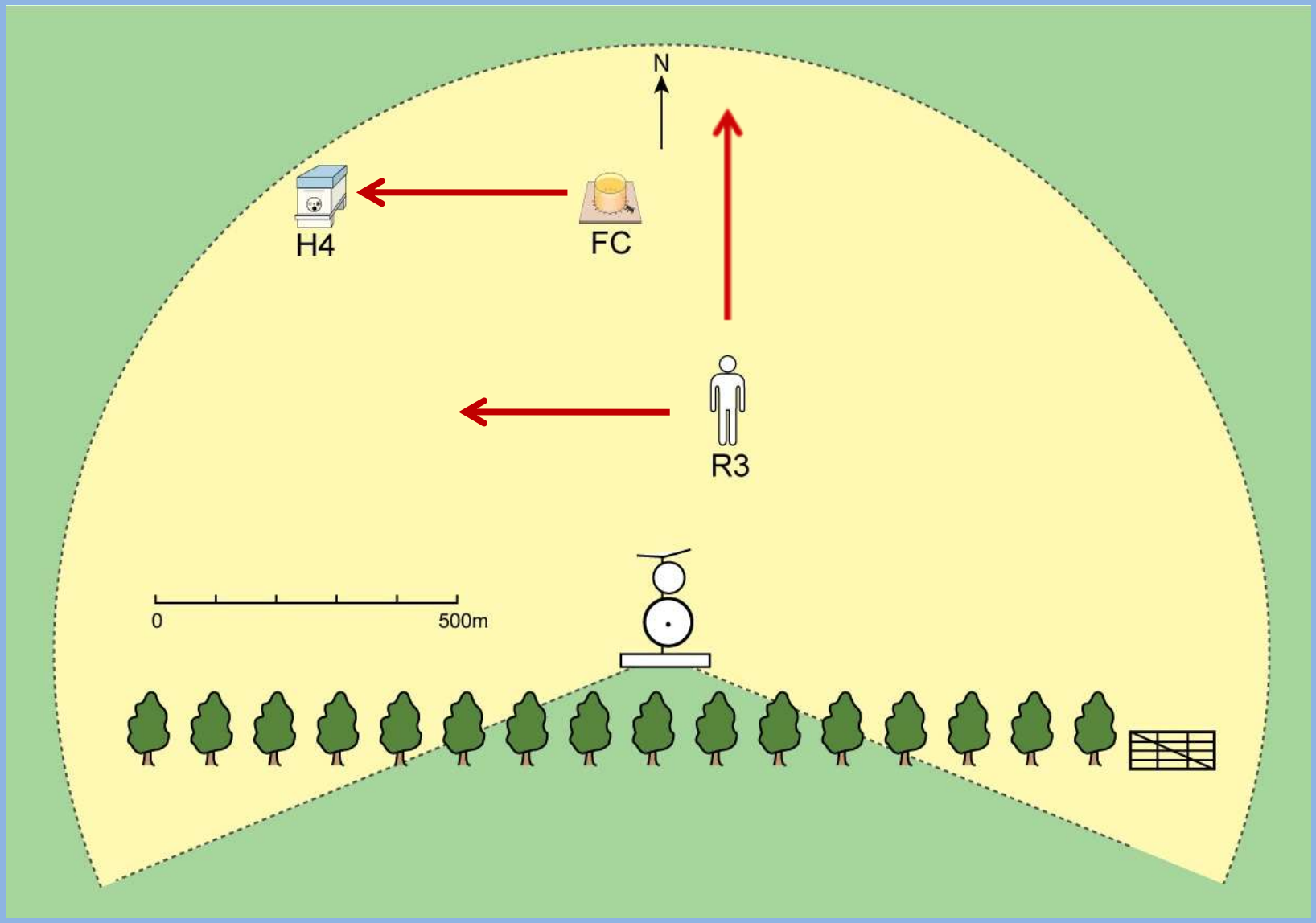

5


6

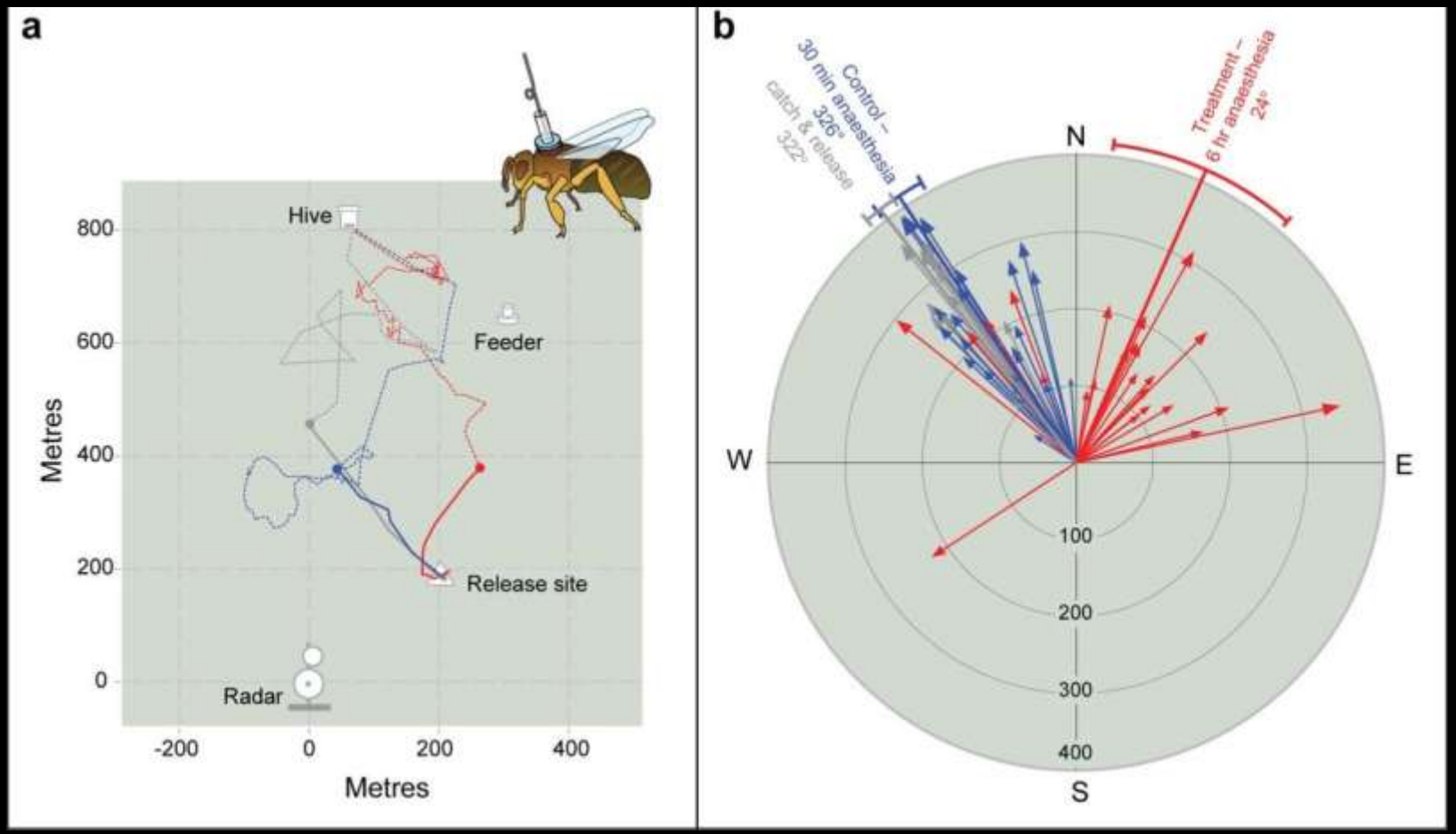

7


8

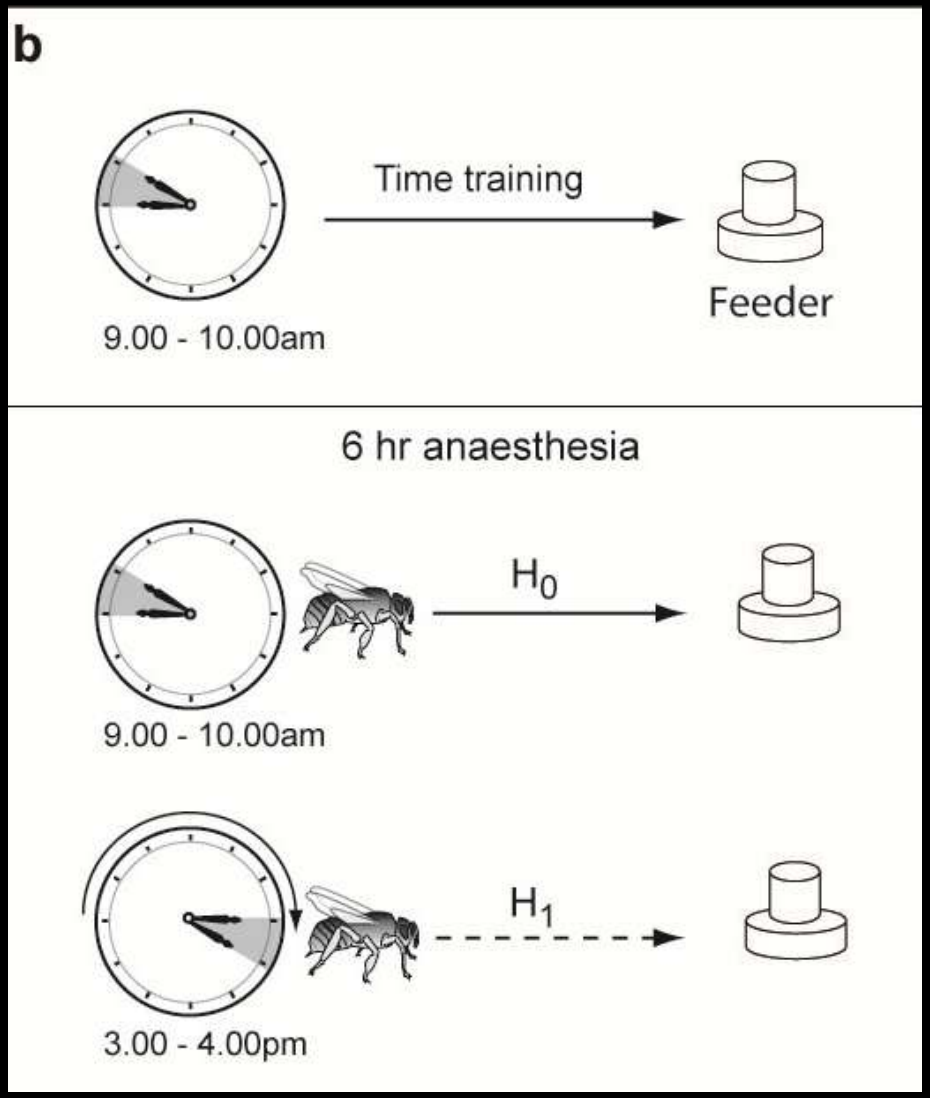

TUNE
AUTO
RM
GAIN
SEA
RAIN
FTC
SART OFF
M1
IR ON
EXP OFF
H UP
+
-
RANGE 0.5 NM
RR 0.25 nm
CENT
RESET TM
XCVR1
X-BAND
MASTER
000
030
060
090
120
150
180
210
240
270
300
330
CURS
BRG ===.= °R
DIST =.=== nm
LAT = ==.===
LON = ==.===
ETA ==:== H:M
TTG ==:== H:M
OFFSET
EBL1
R VRM1
OFFSET
EBL2
R VRM2
R PI 1
R PI 2
HDG
GYRO
CSE ===.= ° SEA STAB
SPD =.= kt
LOG
SET ===
DRIFT =.= kt
AUTO
POS
REL
VECTOR 0.5 min
PAST P OFF min
REL TRAILS OFF min
ARPA MENU
ARPA INFO
ARPA INFO
ID = = =
STAT ----- ----- -----
R CSE ===.= ===.= ===.= °
R SPD =.= =.= =.= kt
DIST =.= =.= =.= nm
TBRG ===.= ===.= ===.= °
CPA =.= =.= =.= nm
TCPA = = = min
BCR =.= =.= =.= nm
BCT = = = min
4 MESSAGES
[1] RA1 ALARM
SYSTEM
UNSTABILIZED
FUNC
ARPA TRIAL
MUTE
-
+
SEA SCOUT
FILT OFF
SYM ON
HL ON
CPA 6553.5 NM
TCPA 05:04 hh:mm
TX


N
H4
FC
R3
0
500m

A. Vanishing Bearings

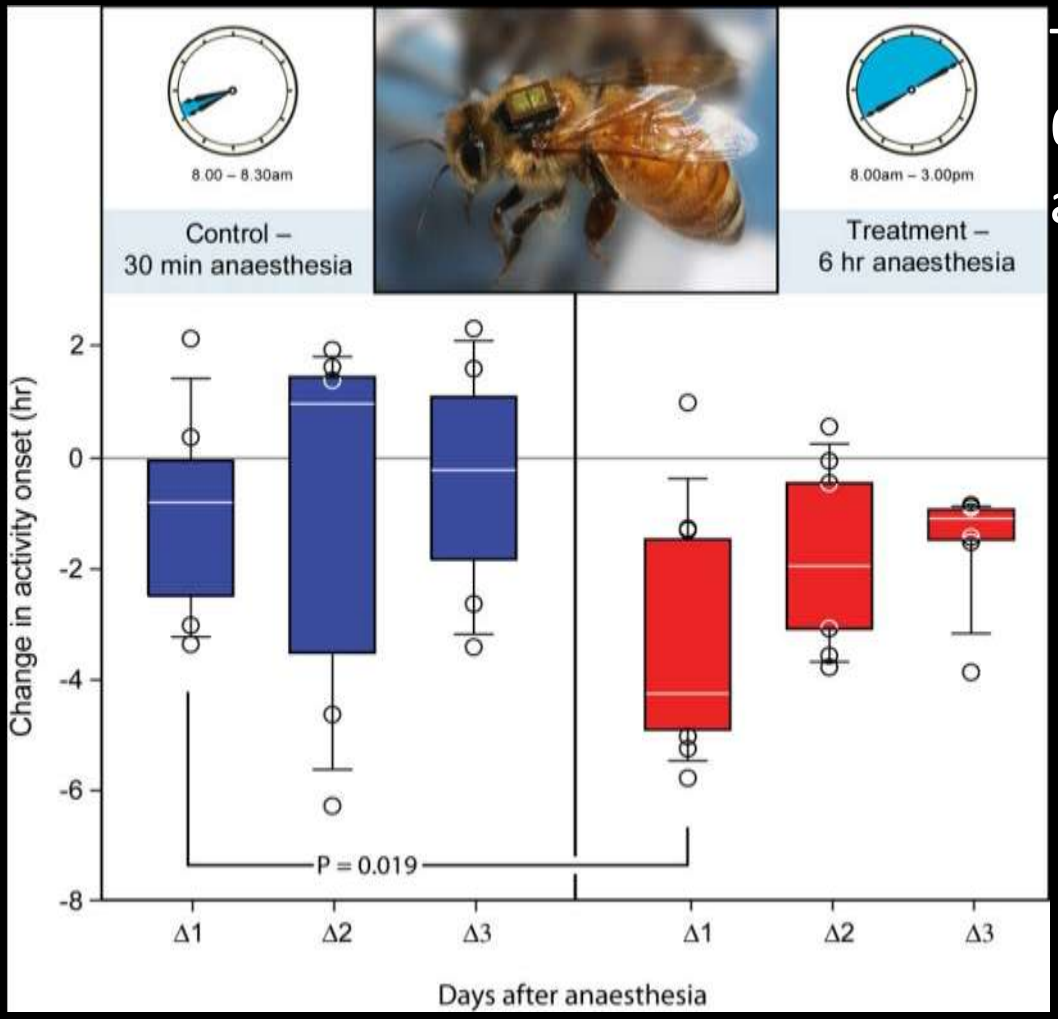


Effect of anaesthesia on food anticipatory behaviour


b
Time training
Feeder
9.00 - 10.00am
6 hr anaesthesia
H0
9.00 - 10.00am
H1
3.00 - 4.00pm

Timing to feeder

Control: 30min anaesthesia



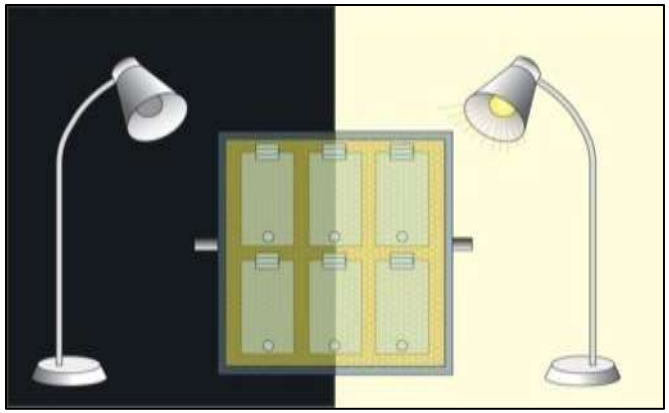
Treatment: 6 hr anaesthesia

Anaesthesia is a thief of time.

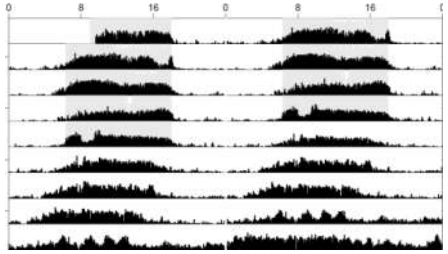
The effect persists for several days post-anaesthetic.

Is this because it stops the clock?

1. Effect of anaesthesia on the clock



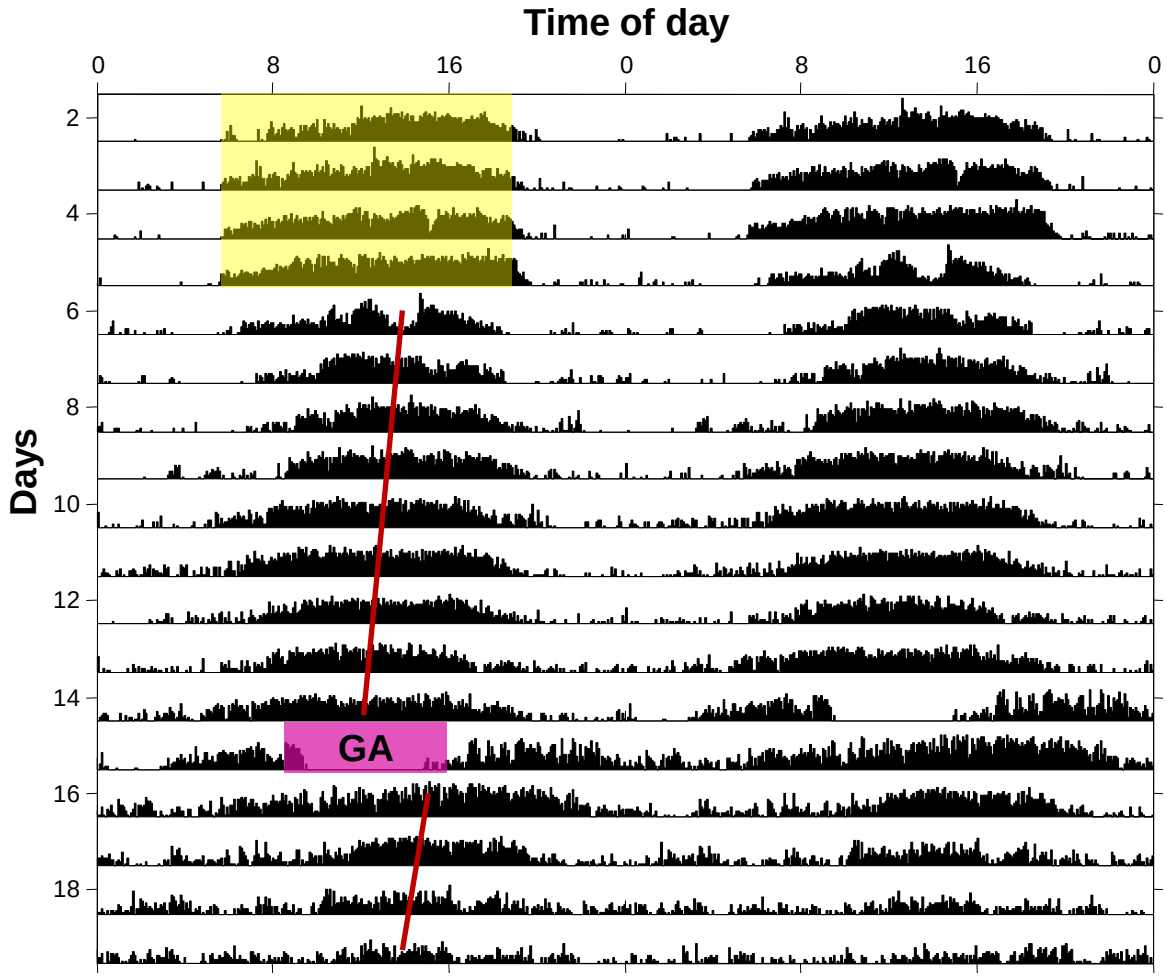
Controlled conditions



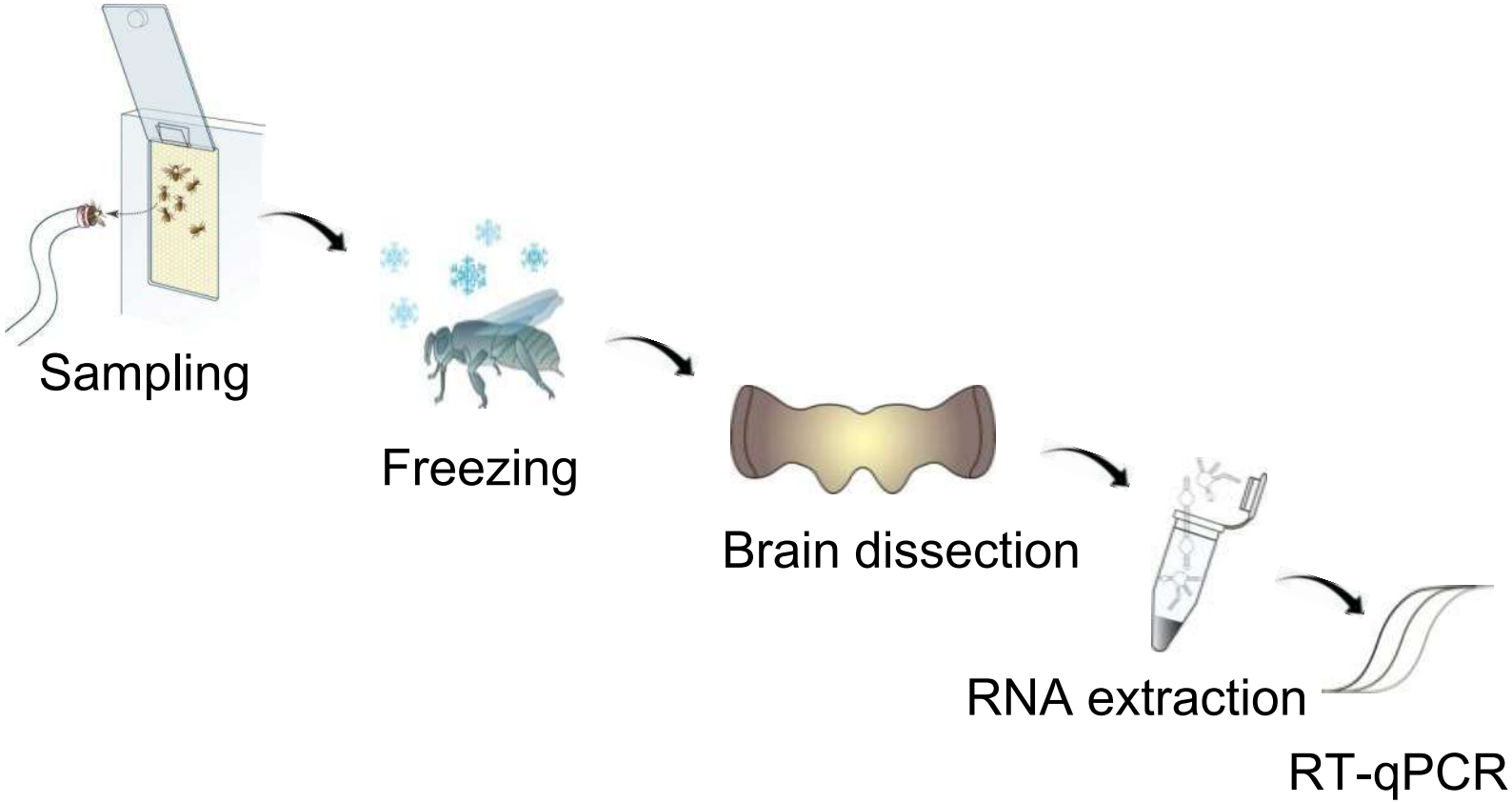
Activity recording

Anaesthesia

Effect of anaesthesia on the clock



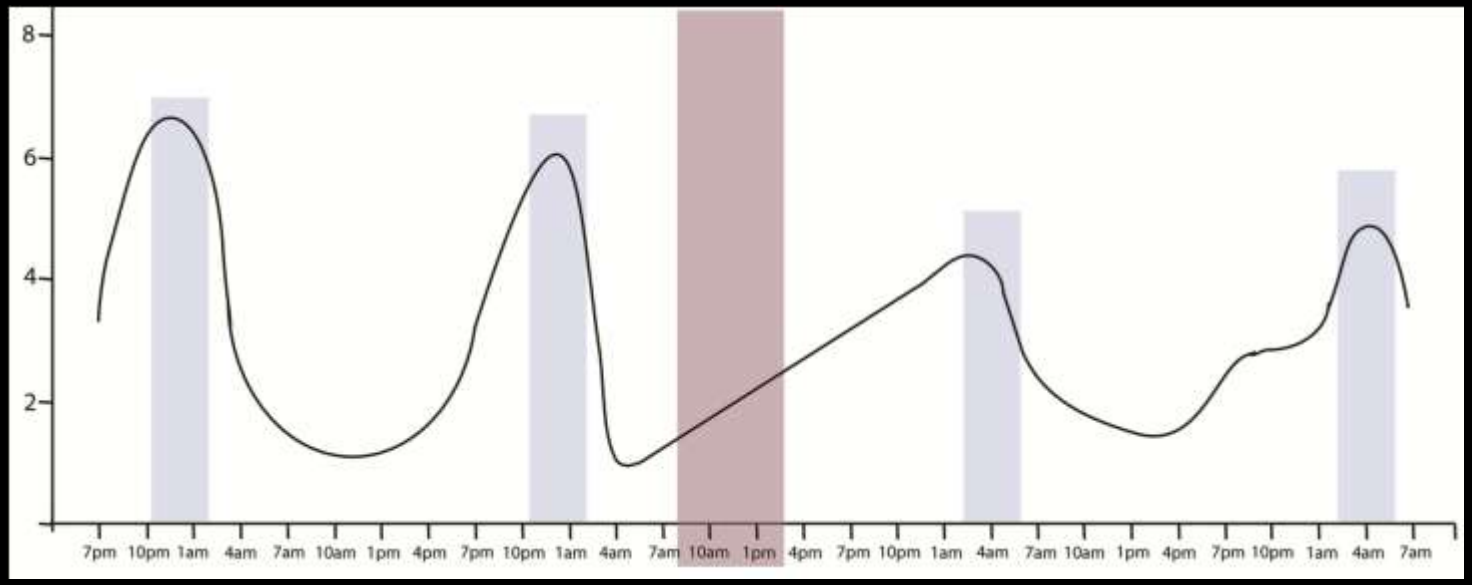
Molecular analysis of clock gene expression



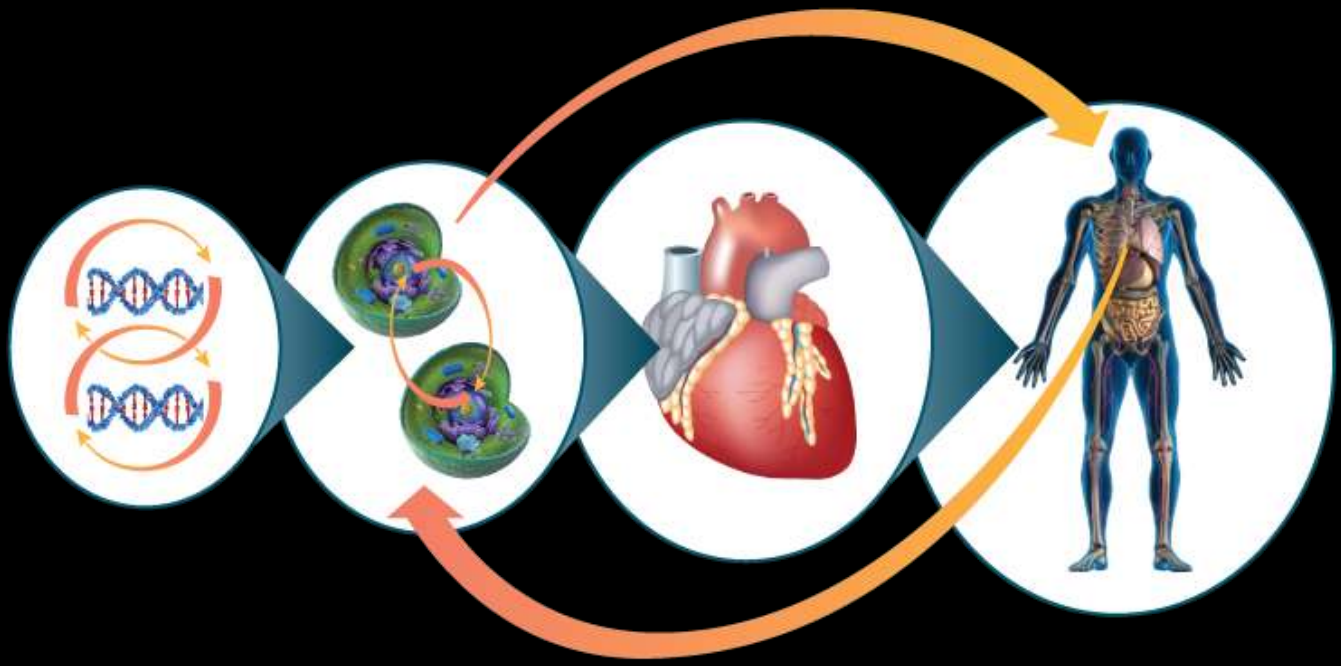
Effect of general anaesthetic on clock gene expression

Pre Anaesthesia Anaesthesia Post Anaesthesia

Relative mRNA levels



Time of Day



Acknowledgements

The University of Auckland

- Dr James Cheeseman,
- Dr Craig Millar,
- Ms Eva Winnebeck

the Free-University of Berlin, Germany

- Professor Randolf Menzel
- Mr Konstantin Lehman

The period of most circadian rhythms is not exactly 24 hours.
Explain the need for the entrainment of circadian rhythms and the role of environmental cues in this process.

Challenge 2

(i) Explain why people are affected by the change in time that occurs when daylight saving starts and finishes and why this is particularly difficult for teenagers.

(ii) Which end of daylight saving (April or October) is more likely to have a negative effect on teenagers and why?

(iii) Explain the quickest way for someone to adjust to the new time at the start and end of daylight saving.

Challenge 3

Using your knowledge of the ability of the bee to use the sun as a compass, discuss the differences seen in the results from the different treatments (in Figure 5) and predict the results of further treatments carried out using different durations of anaesthesia.

Challenge 4

Figure 7 shows the levels of mRNA expression from the clock gene cryptochrome. Use your knowledge of gene expression and the regulation of gene expression to discuss how clock genes can act as a biological clock.

http://lens.auckland.ac.nz

Sean P

Hutt Valley High School

Why is the human free running period (24.3 hrs) longer than the actual 24 hr day length? Is there any link to seasons?


kordia™
people & technology as one

Steven X

Hutt Valley High School

Is there any evidence that human ancestors ever hibernated, particularly during Ice age periods or in polar regions?


KAREN

Jenny Loader

Unlimited Paenga Tawhiti

This species of Kelp is unique because it floats by a honeycomb like structure which is unique. It prevents the kelp from being damaged by strong waves. Is this further evidence that the kelp is more likely to by dispersed by currents (because it survives for a longer time)?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Unlimited Paenga Tawhiti

Some currents are warm or cool and rise and fall- they also reverse in el nino/nina events. Would these variables have a significant effect on the dispersal patterns of the kelp?

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