
Circadian rhythm and Sleep

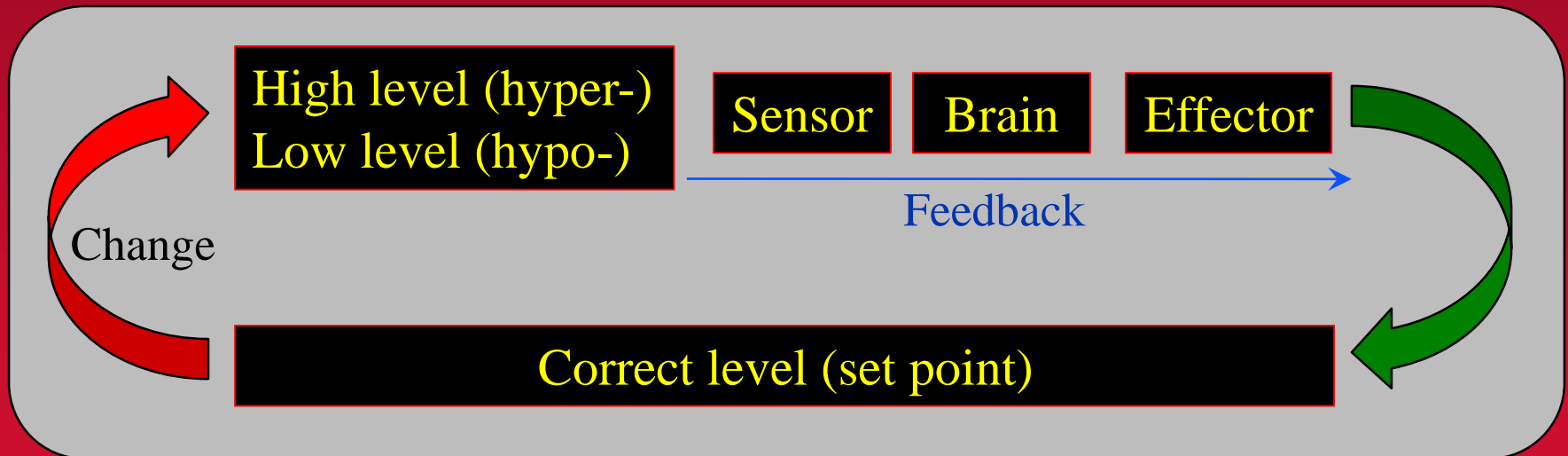
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Homeostasis

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Maintenance of equilibrium by active regulation of internal states:

- Cardiovascular function (blood pressure, heart rate)
- Body temperature
- Food and energy regulation
- Fluid regulation



Summary of homeostatic control

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Multiple mechanisms control homeostasis

- Emphasises the importance to survival

Set points are not fixed

- Many homeostatic functions show daily rhythms
- Maintain levels appropriate for the level of activity
- Therefore efficient in energy use.

Example

- During sleep body temperature decreases
- Heart rate decreases
- Respiration rate decreases
 - **Energy conservation**

Biorhythms

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Many functions show natural biological rhythms

- Circadian rhythms (daily cycle)
 - Body temperature, heart rate, respiration, sleep
- Circannual rhythms (yearly cycle)
 - Hibernation, mating behaviour, migration

Linked to:

- Light/dark cycle
- Season (day length probably critical)

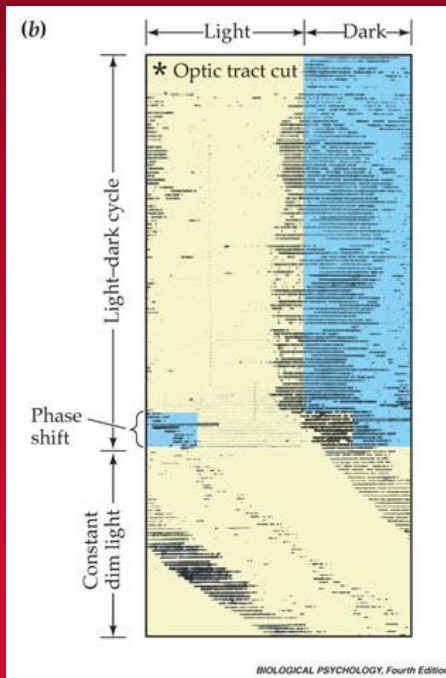
Circadian rhythms

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Bodily functions linked to day length

Light/dark cycle important determinant.

How does light/dark information affect body systems?



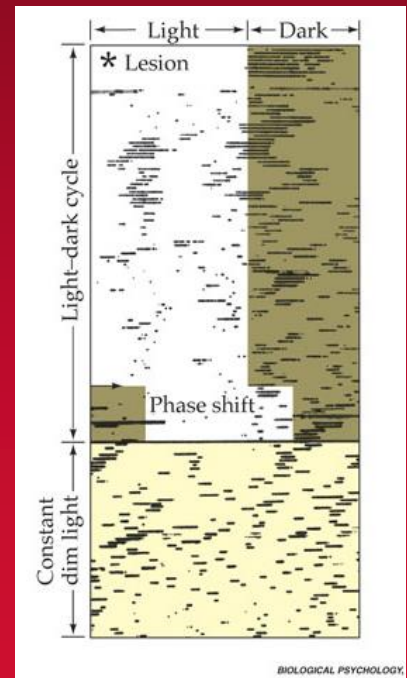
Optic tract lesion

- Circadian rhythm maintained, even in constant light
- Periodicity changed

Suprachiasmatic nucleus lesion

- Circadian rhythm abolished
- No periodicity

Therefore suprachiasmatic nucleus important for circadian rhythm



Suprachiasmatic nucleus (SCN)

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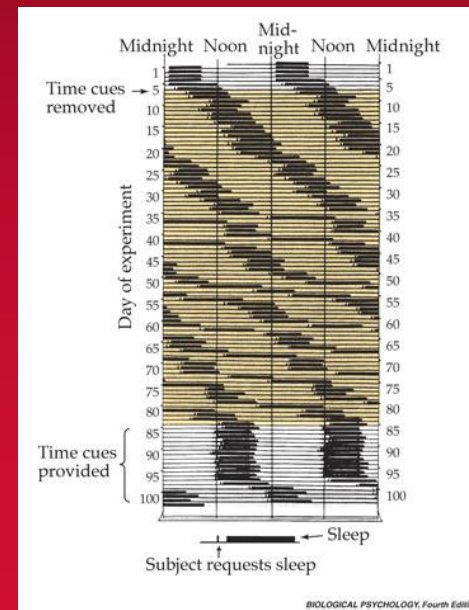
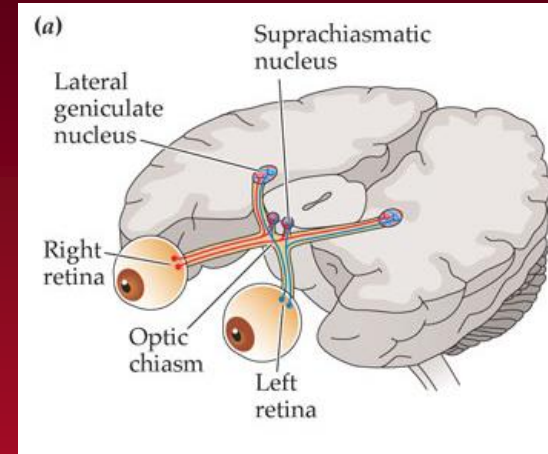
Located in hypothalamus, just above optic chiasm

Cells in SCN show oscillations of activity

- Related to circadian rhythm
- Believed to form the ‘biological clock’

Many functions (e.g. sleep wake cycle) are maintained in constant light or constant dark

- Periodicity may not be 24 hours
- In normal light/dark cycle SCN rhythm is ‘phase locked’ to light dark



How does light information reach SCN

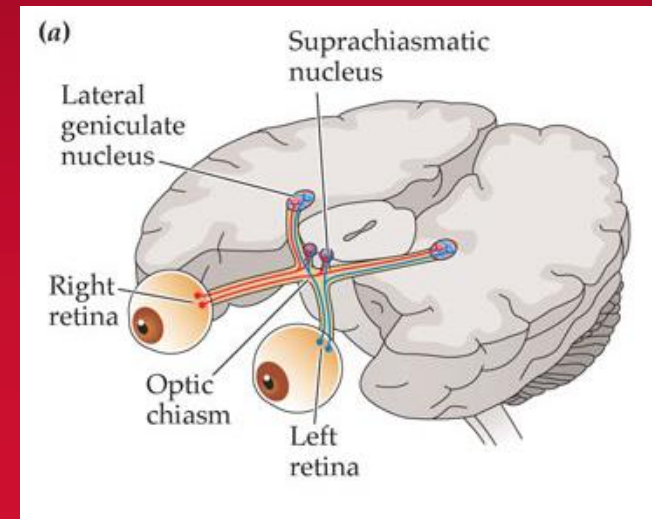
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Many non-mammalian species have photoreceptors outside the eye

- e.g. amphibians and reptiles – pineal gland is light sensitive

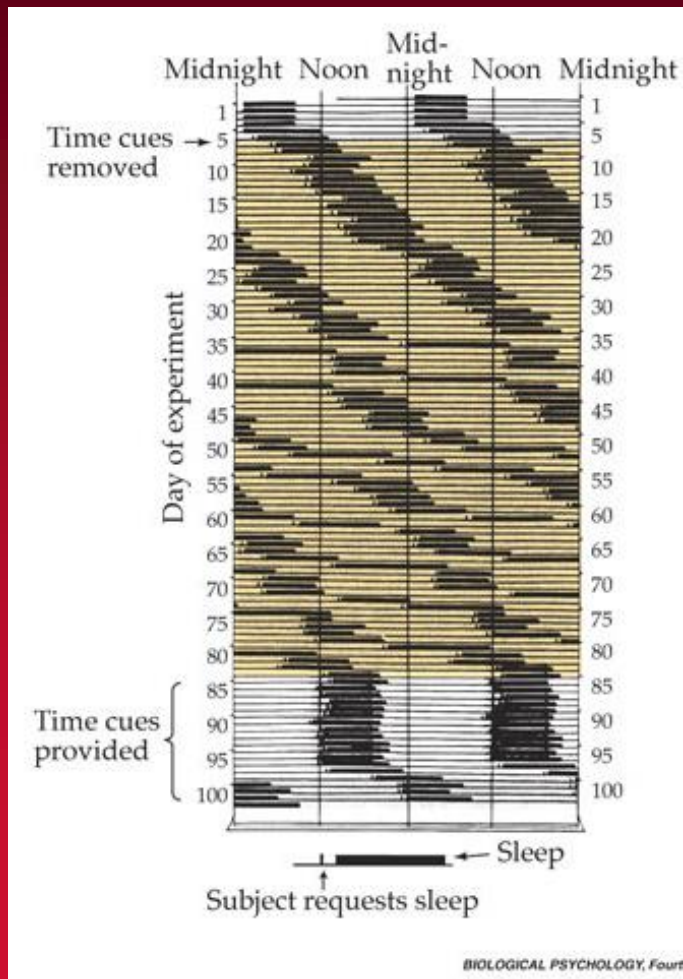
In mammals a direct pathway from eyes to SCN has been identified

- Carries light information to SCN
- Rods and cones do influence SCN function
- Light sensitive information still reached SCN in the absence of rods and cones
 - Therefore other light receptors also present in eye.



Circadian rhythms in action: sleep

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‘Free running’ sleep rhythm about 25 hrs
Entrainment to light dark cycle maintains
a 24 hr periodicity
Mediated through SCN activity

Jet-lag

- Rapid shifts in light dark cycle
- Takes a few days for endogenous rhythm to re-entrain

Passive onset of sleep

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Bremer (1930)

- Surgically separated midbrain from forebrain in cats
 - Animals remained permanently asleep
- Proposed that in the absence of sensory input the cortex became quiescent (i.e. sleep)

Moruzzi & Magoun

- Electrical stimulation of the midbrain woke sleeping animals
- Lesions to this area caused persistent sleep
- Activating system in the midbrain, which activates the cortex
- Lack of tonic activating influence of midbrain causes cortical neurones to cease firing, and sleep to ensue





Normal Sleep

- ◆ Normal sleep consists of 1-4 series of phases of increasing depth(Non REM) and REM phases.
- ◆ Each phase has a characteristic EEG.
- ◆ There is a decrease with age in sleep length.

Characteristics of sleep

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Slow-wave sleep(NON REM)

- Progressive decrease in spinal reflexes
- Progressive reduction in heart rate and breathing rate
- Reduced brain temperature and cerebral blood flow
- Increased hormone secretion (e.g. growth hormone)
- Synchronised cortical activity

Characteristics of sleep

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REM sleep

- Spinal reflexes absent
- Rapid eye movements behind closed eyelids
- Increased body temperature and cerebral blood flow
- Desynchronised cortical activity
- Dreams

Dreams

- ◆ REM sleep dreams : sexual, clear, sleep paralysis, connected to external stimuli easy to be recalled.
- ◆ Nightmares
- ◆ Non REM sleep dreams : No story and no recall(Night terrors).



Normal night Sleep

In the first cycle:

- * 15-20 minutes to fall a sleep.
- * Over the next 45 min. one descends to stage 3 & 4(Non REM)
- * After 45 min. after stage 4 reaches the first REM stage.
(REM latency = 45 + 45 = 90 min.)



Normal sleep

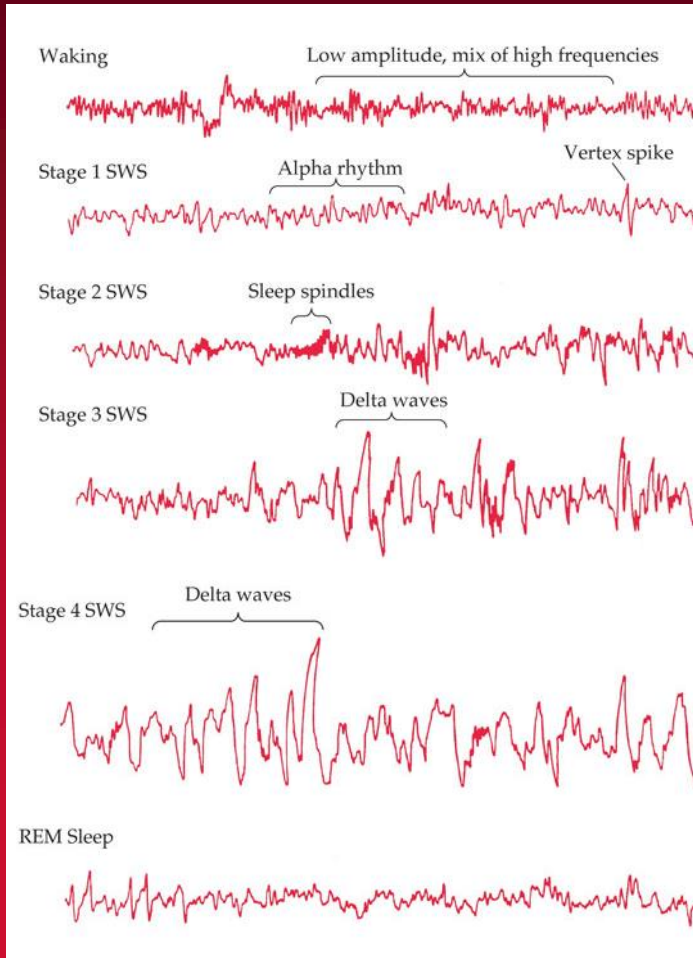
As the night progresses:

- * Each REM period gets longer.
- * And stage 3+4 gets shorter until they disappear.
- * Further into the night sleep becomes lighter and dreams become more.



Brain activity during sleep

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Awake

Low amplitude high frequency EEG



Light sleep

Increasing amplitude decreasing freq. EEG



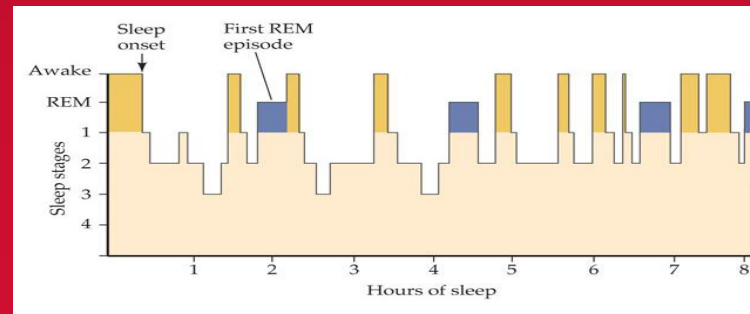
Deep sleep

High amplitude low frequency EEG



Rapid eye movement (REM) sleep

Low amplitude high frequency EEG



Sleep as an active process

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Electroencephalographic (EEG) recordings showed abundant neuronal activity in cortex during sleep

- Therefore not passive neuronal quiescence

Pattern of the EEG was very different in sleep than in waking

- Waves of activity, indicating synchronous firing of cortical neurones
- Synchronising stimulus coming from sub-cortical areas
- Reticular formation still seen as important

Several different levels of sleep

- Sleep is a complex combination of different aspects

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Neuronal circuitry controlling sleep

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Cortex “kept awake” by ascending activation from midbrain

5HT inputs inhibit midbrain ‘activating system’ areas

- therefore promotes sleep

Stimulation of area surrounding SCN induces slow wave sleep

- mechanism unclear: Probably involves SCN

No one stimulation site can promote REM sleep

- but lesions to specific brainstem areas abolish REM sleep

Neurochemistry of sleep

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Neurotransmitters

- 5HT - promotes slow wave sleep – inhibition of ‘activating system’
- Noradrenaline - ? inhibition of muscle tone during REM sleep
- Dopamine - general arousal
- Acetylcholine - induces REM sleep

Also ‘sleep-promoting substances’

- Factor S, DSIP (delta-sleep inducing peptide), melatonin
- Not much known about their action
- May modulate circadian rhythmicity rather than sleep *per se*

Disorders of sleep

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Insomnia - reduction or absence of sleep - transient or persistent

Hypersomnia (narcolepsy) - excessive drowsiness and falling asleep

Sleep-wake schedule disturbance - transient or persistent

Partial arousal - e.g. sleep-walking, nightmares

- Often associated with anxiety, psychological disturbance or drug taking
- Little known about causes
- Limited capacity for pharmacological treatment of sleep disorders

Summary

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Homeostasis

- Maintenance of constant conditions
- e.g. hunger / satiety system

Circadian rhythms

- Biological rhythms with 24 hour periodicity
- Role of SCN as circadian clock: entrainment to light/dark cycle

Sleep

- Sleep as an active process – EEGs in different stages of sleep
- Characteristics of slow wave sleep and REM sleep
- Disorders of sleep