Lesson 2
Endogenous Pacemakers and Exogenous Zeitgebers

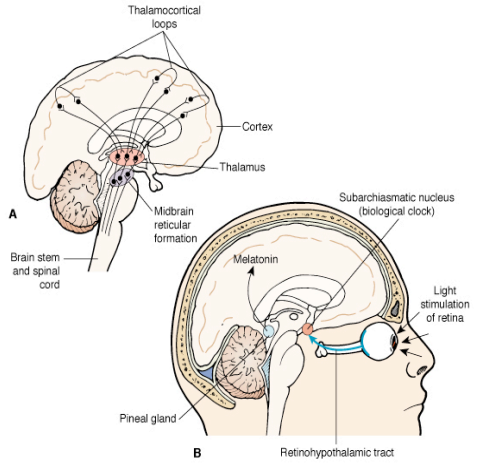


Figure 13-1 (**A**) Brain structures involved in sleep. (**B**) Location of the suprachiasmatic nucleus (biological clock) with input from the retina and its association with the pineal gland and melatonin production.

Lesson 2 – Endogenous pacemakers and Exogenous Zeitgebers

BATs

A01 - Define (E) and compare (C)endogenous pacemakers and exogenous zeitgebers

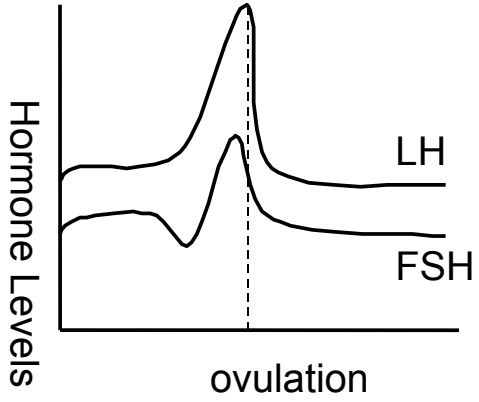
A02 - Analyse and evaluate evidence of endogenous pacemakers and exogenous zeitgebers

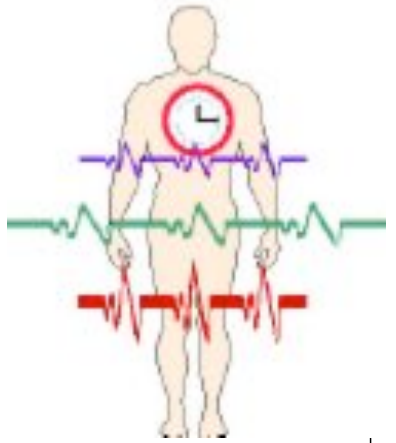
(C+)

Starter

- List 3 differences between
- Circadian and Infradian

Rhythms

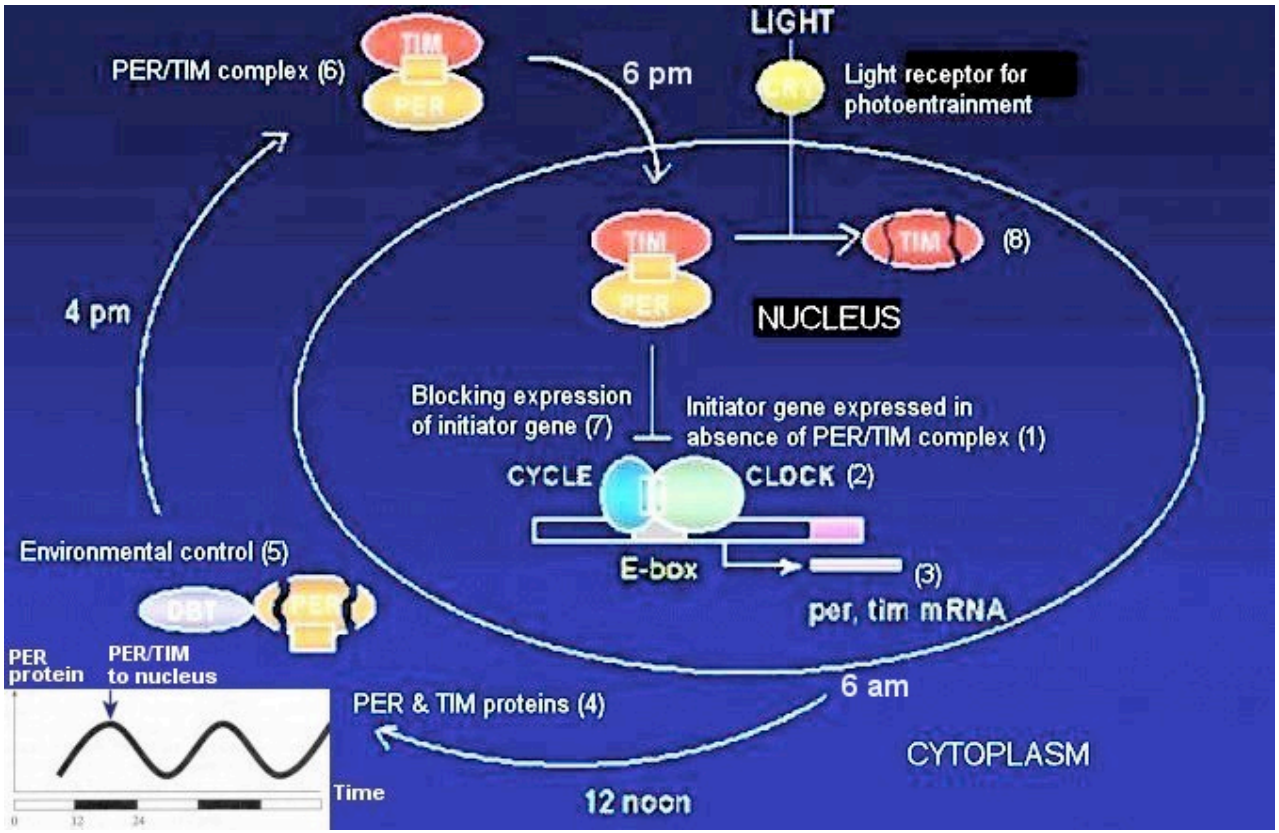




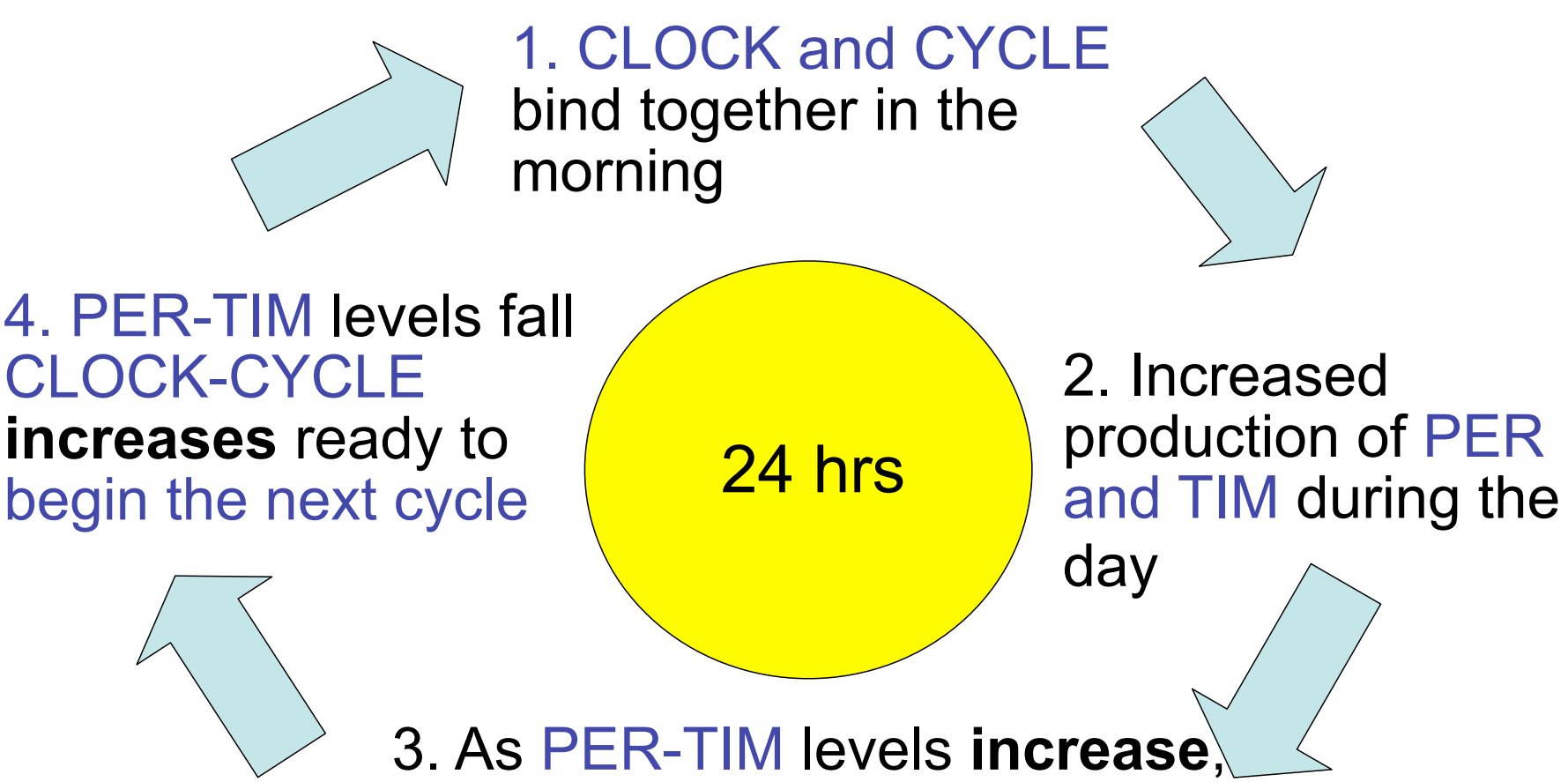
Endogenous Pacemakers

Internal biological clocks

Darlington et al 1998 – clock 'ticking' created by the interactions between certain proteins in the nucleus.



Endogenous Pacemakers



The Suprachiasmatic Nucleus (SCN)

- In mammals, the main endogenous pacemaker is a pair of tiny clusters of nerve cells called the SCN, which lie in the hypothalamus, just above the optic chiasm (where the optic nerves from each eye cross over)

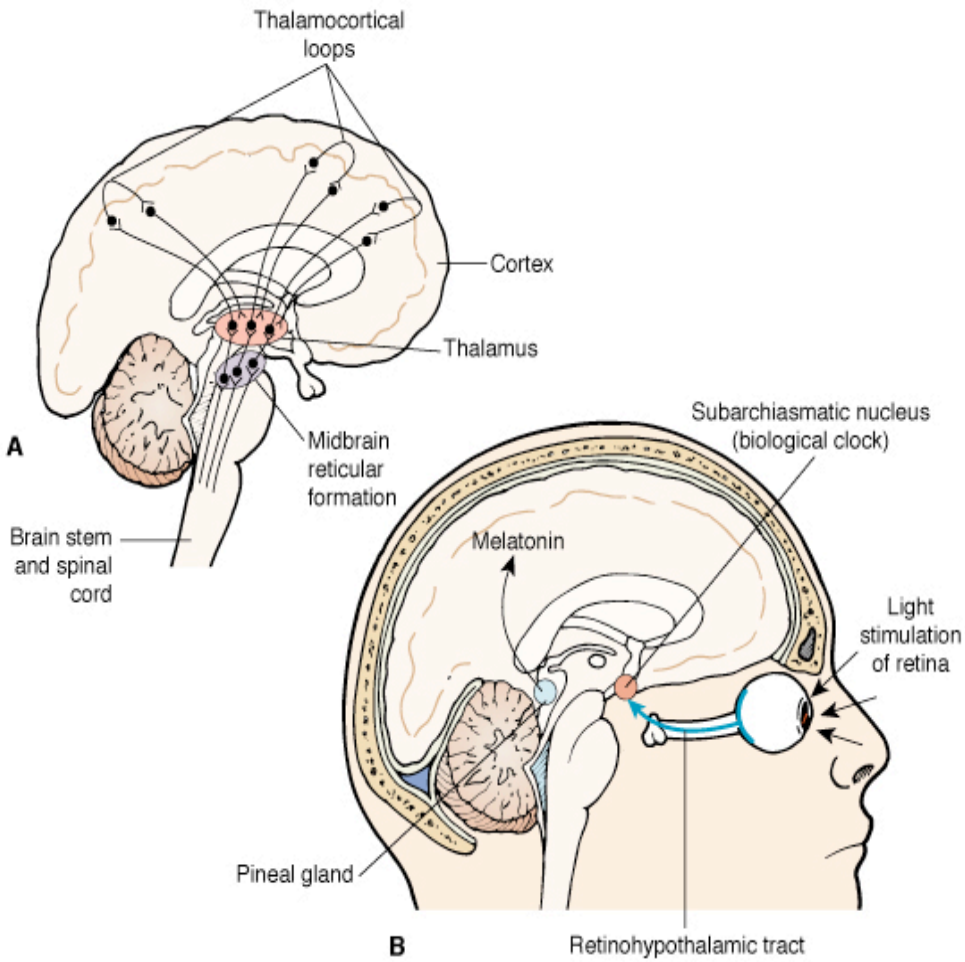
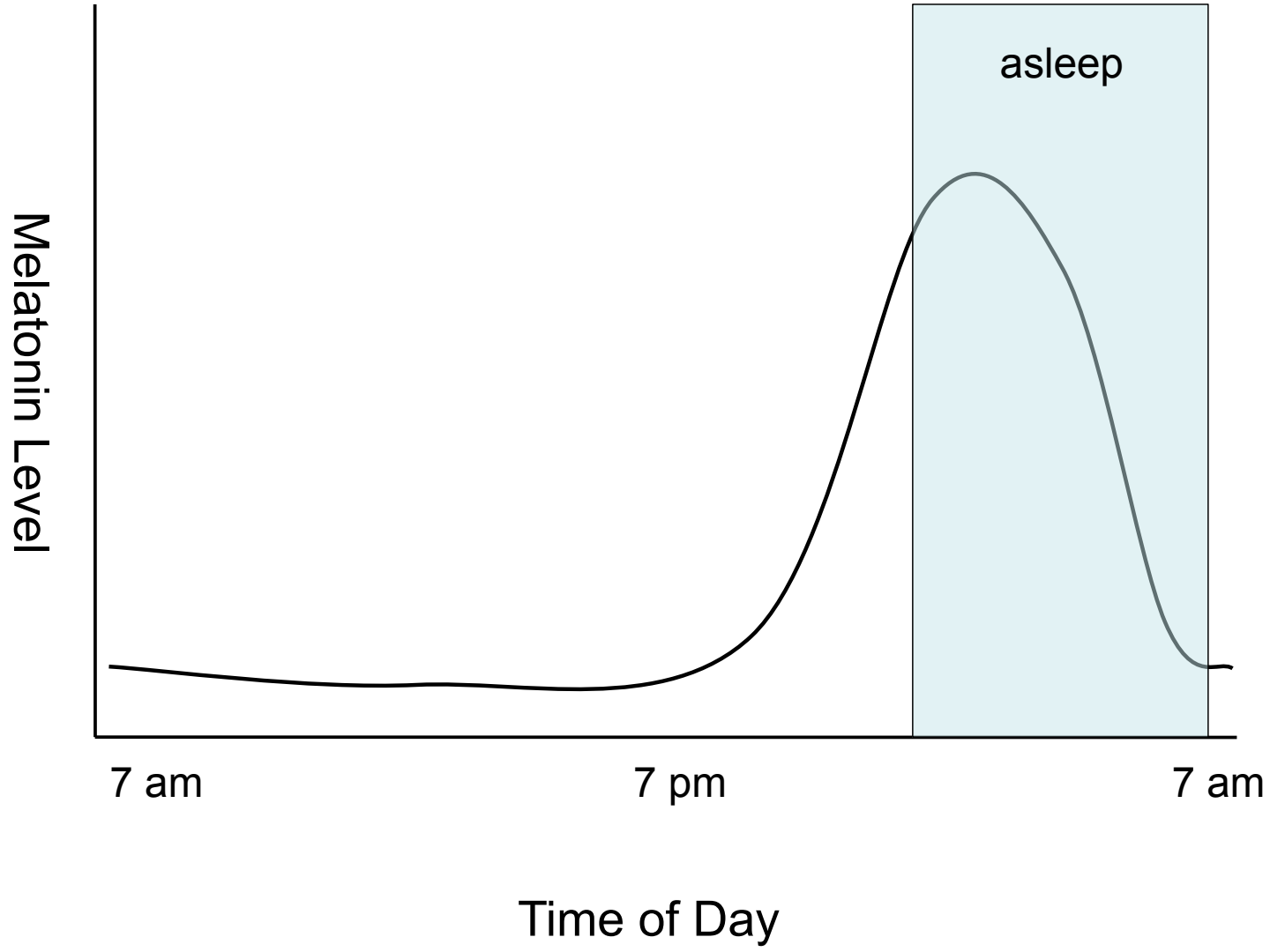


Figure 13-1 (**A**) Brain structures involved in sleep. (**B**) Location of the suprachiasmatic nucleus (biological clock) with input from the retina and its association with the pineal gland and melatonin production.

Melatonin Secretion



Endogenous Pacemakers

- Even when our eyes are shut the SCN gets info on light from the optic nerve. Light can penetrate the eyelids and special photoreceptors in the eye transfer light signals to the SCN.
- If our endogenous clock is running slow – the morning light automatically shifts the clock ahead so it is in synchrony with the world outside

Campbell and Murphy (1998)

Found that when light was shone on the **back of participants' knees** many were able to **shift** the circadian rhythms of body **temperature and melatonin secretion**, suggesting that light can reach the brain without passing through the eyes!

The Pineal Gland

Another endogenous pacemaker that works with the SCN is the **Pineal Gland**.

- Contains **light sensitive cells**.
- When light is sensed **melatonin** production is **inhibited.**
- When light level **falls** melatonin production **increases**
- This **induces sleep** by inhibiting brain mechanisms that promote the awake state.

Light, the pineal gland and melatonin regulate the sleep-wake cycle

Check your knowledge

Read p 6-7 and do the following tasks

1. Where is the pineal gland located in birds and reptiles?
2. Create a diagram of the biological clock idea put forward by Darlington et al in 1998
3. Bullet point sources of evidence that endogenous pacemakers exist - include animal research

Answers

- 1 - Pineal gland is located just below the skull. Lizards have a ‘third eye’ near the pineal gland that protrudes from the skull to receive light
- 3 - The work of chronobiologists
- Morgan (1955) - ‘mutant’ hamsters
- Kate Alcroft (Folkard 1996) desynchronised rhythms fro temperature and sleep suggests separate rhythms
- DeCoursey et al 2000 - chipmunks - more killed when SCN ‘disconnected’ - stayed awake in

Exogenous Zeitgebers

Exogenous = outside the organism

Zeitgeber = time-giver

The biological-clock is **reset** each day by cues in the **environment** – like the light cues of **sunrise and sunset**.

This process is called **entrainment**, (the opposite of **free-running** where the biological clock works free of any exogenous cues, including social cues like clocks).

Which are more important exogenous zeitgebers, social cues or light?

- Until recently biologists believed that daily rhythms were entrained by social convention (set meal and bedtimes), not internal biology.
- Since the discovery that exposure to bright light suppresses melatonin production it is now recognized that light is the dominant zeitgeber in humans (Wever et al 1983).

Light as an exogenous zeitgeber

- Daylight resets the biological-clock, but dim light is less effective.

- Hall (2000), found that proteins called cryptochromes found throughout the body can detect changes in light.

What if you are blind?

Lack of info about light messes up sleep patterns.

Miles et al (1977) – young man, blind from birth had a circadian rhythm of **29.4 hours.** Even with the help of clocks and social cues he was **unable to reduce the pace of his biological rhythm.**

He had to take **stimulants** in the morning and sedatives at night.

Can you think of a problem with this research?

Temperature as a zeitgeber

Bio-rhythms can also be entrained by temperature:

- Leaves fall from **deciduous** trees in autumn because of changes in temperature as well as day length.
- A factor in the onset of **hibernation**.
- No evidence that it affects human bio-rhythms

Plenary Activity

- Do the activity ‘Cut and Paste - Pacemakers and Zeitgebers’

- **Stretch and Challenge -** do the questions on the next slide

Read p 6-7 and do the following tasks

1. How could the discovery of cryptochromes give support to the study by Campbell and Murphy (1998) and explain why some blind people have normal bio-rhythms?
2. Outline evidence that zeitgebers exist.

3. In a table show the advantages and disadvantages of having both endogenous pacemakers and exogenous zeitgebers.

Writing essays

- Discuss the role of endogenous pacemakers and exogenous zeitgebers in biological rhythms. (25 marks)

AO1 – **general** but **accurate description** of the role of endogenous pacemakers and exogenous zeitgebers in bio-rhythms.
-Describe the brain mechanisms underlying endogenous pacemakers and/or the interaction with zeitgebers e.g. light
- base answers on studies e.g. isolation (Siffre), role of pheromones and menstrual cycle, Morgan (95) – hamsters expt - suprachiasmatic nucleus

Both endogenous pacemakers and exogenous zeitgebers must be discussed.

Writing essays

- Discuss the role of endogenous pacemakers and exogenous zeitgebers in biological rhythms. (25 marks)

AO2 – **Do not just describe** the studies.
- Use them e.g the **implications** of Siffre's work.
-How **relevant** are the studies to the role of endogenous pacemakers and exogenous zeitgebers
- How has the use of electric lighting in the last 100 years affected biological rhythms
-Issues and debates – use of non-human animals e.t.c

use the 'Burger' worksheet

Plenary

- Fill in your topsheet
- Have you achieved your BATs
- Is there anything you need clarification on?
- ASK NOW!!!