

Sleep, Cognition and the Brain

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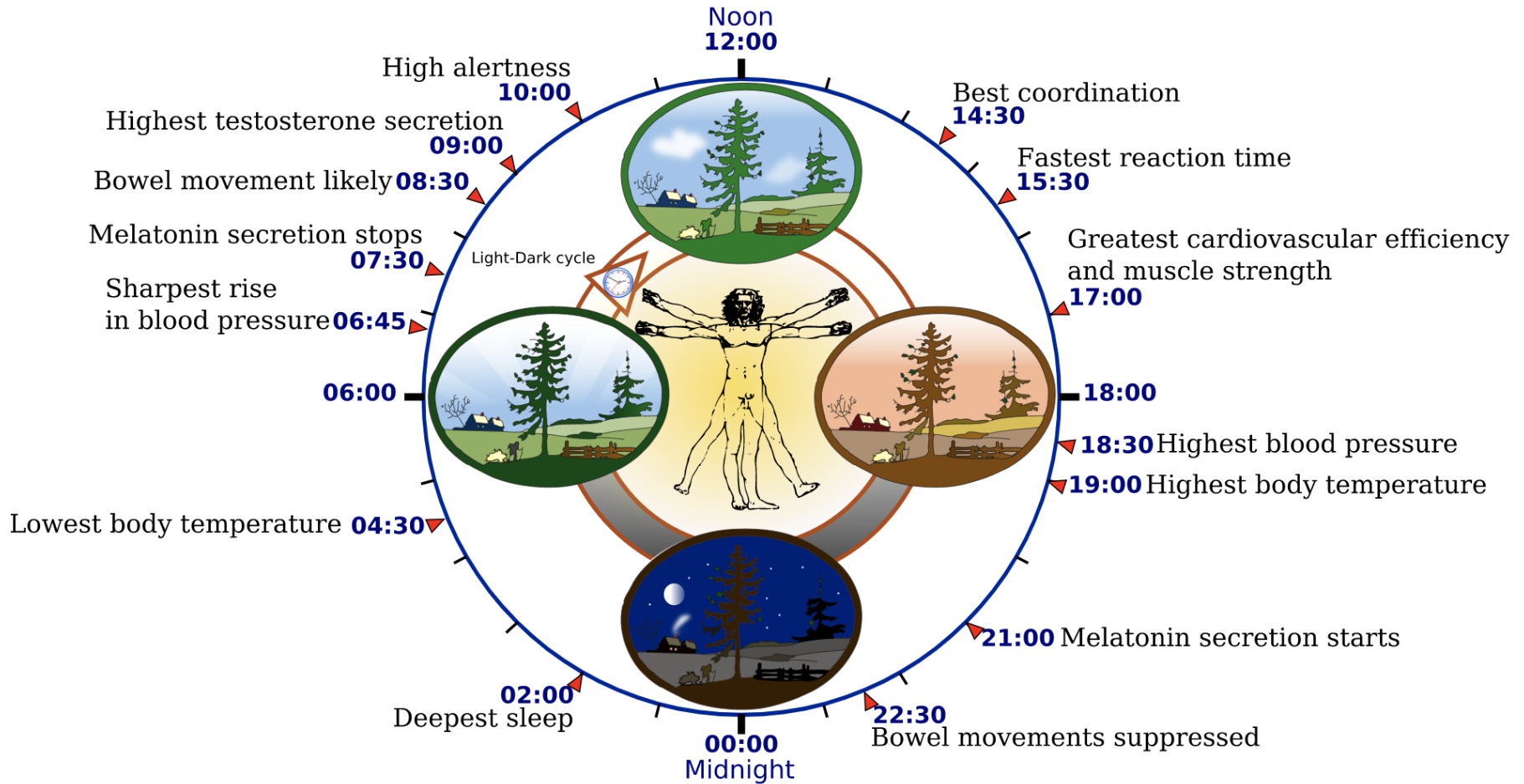
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Sleep

- *Sleep is the interest we have to pay on the capital which is called in at death; and the higher the rate of interest and the more regularly it is paid, the further the date of redemption is postponed.*

Arthur Schopenhauer (1788-1860)

Circadian Rhythm



Public domain image from: https://en.wikipedia.org/wiki/Circadian_rhythm#/media/File:Biological_clock_human.svg

Light

v

v

v

Photosensitive ganglion cell in the retina

v

v

v

Suprachiasmatic Nucleus (SCN) in the
hypothalamus

v

v

v

Pineal Gland

v

v

v

Melatonin is released by the Pineal Gland in
low light conditions.

v

v

v

Melatonin tends to induce sleep

Melatonin facilitates sleep

- Darkness leads to melatonin release
- Blue or short wavelength light inhibits melatonin release and sleep
- Melatonin supplements?
 - A few hours before sleep
 - Best to reset circadian rhythm
 - Start small .5mg – 3mg

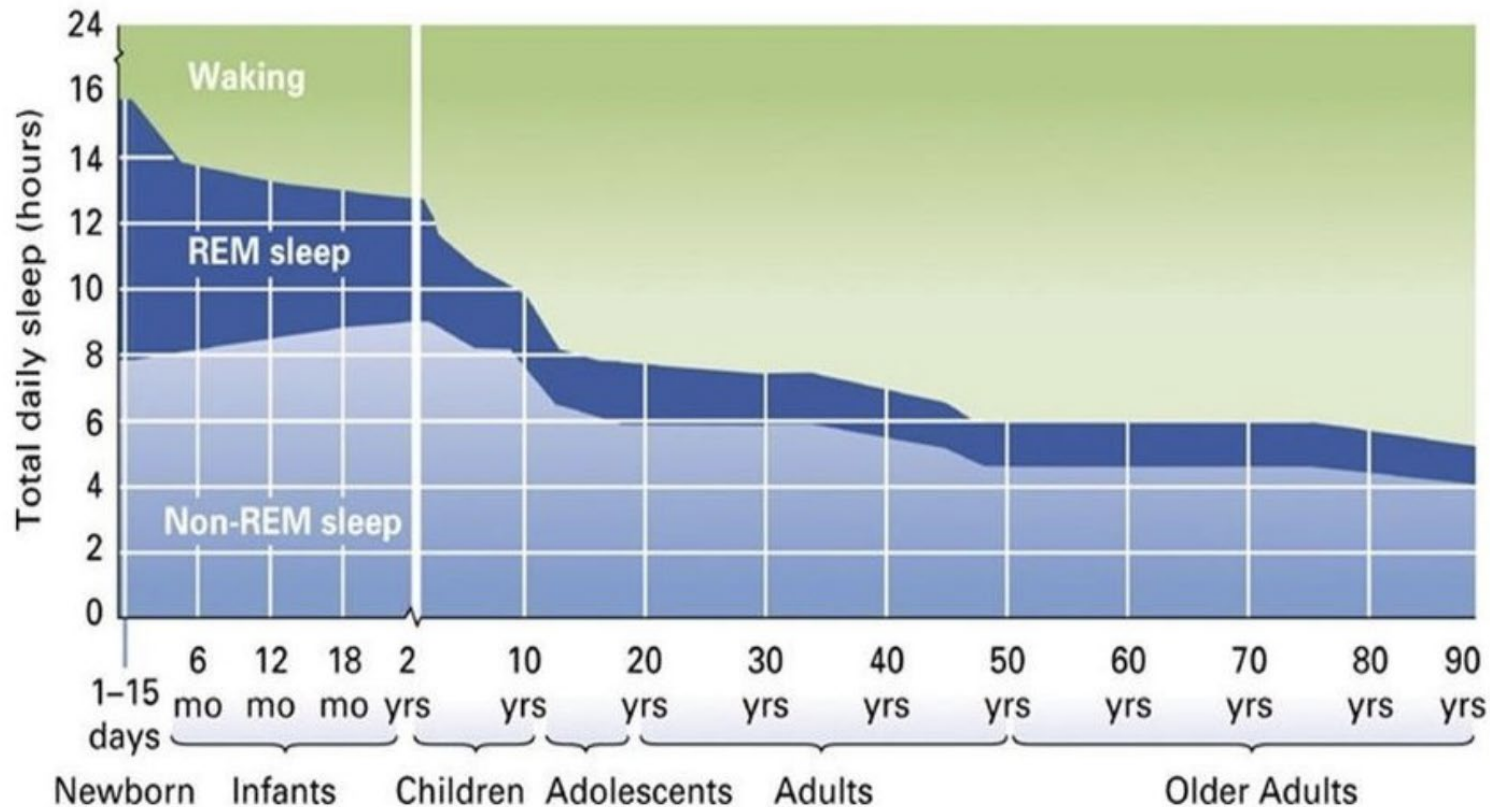
Social Jet Lag

- Social jet lag is a new concepts among sleep researchers
 - Defined as a bad fit between the sleep timing preferred and the one dictated by society (e.g., work or social)
 - Can lead to insomnia and sleepiness during the day

Social Jet Lag

- 46% of U.S. adults report social jet lag of one hour
- 19% of U.S. adults report social jet lag of two hours
- Worse for night owls

Sleep Changes Across the Lifespan

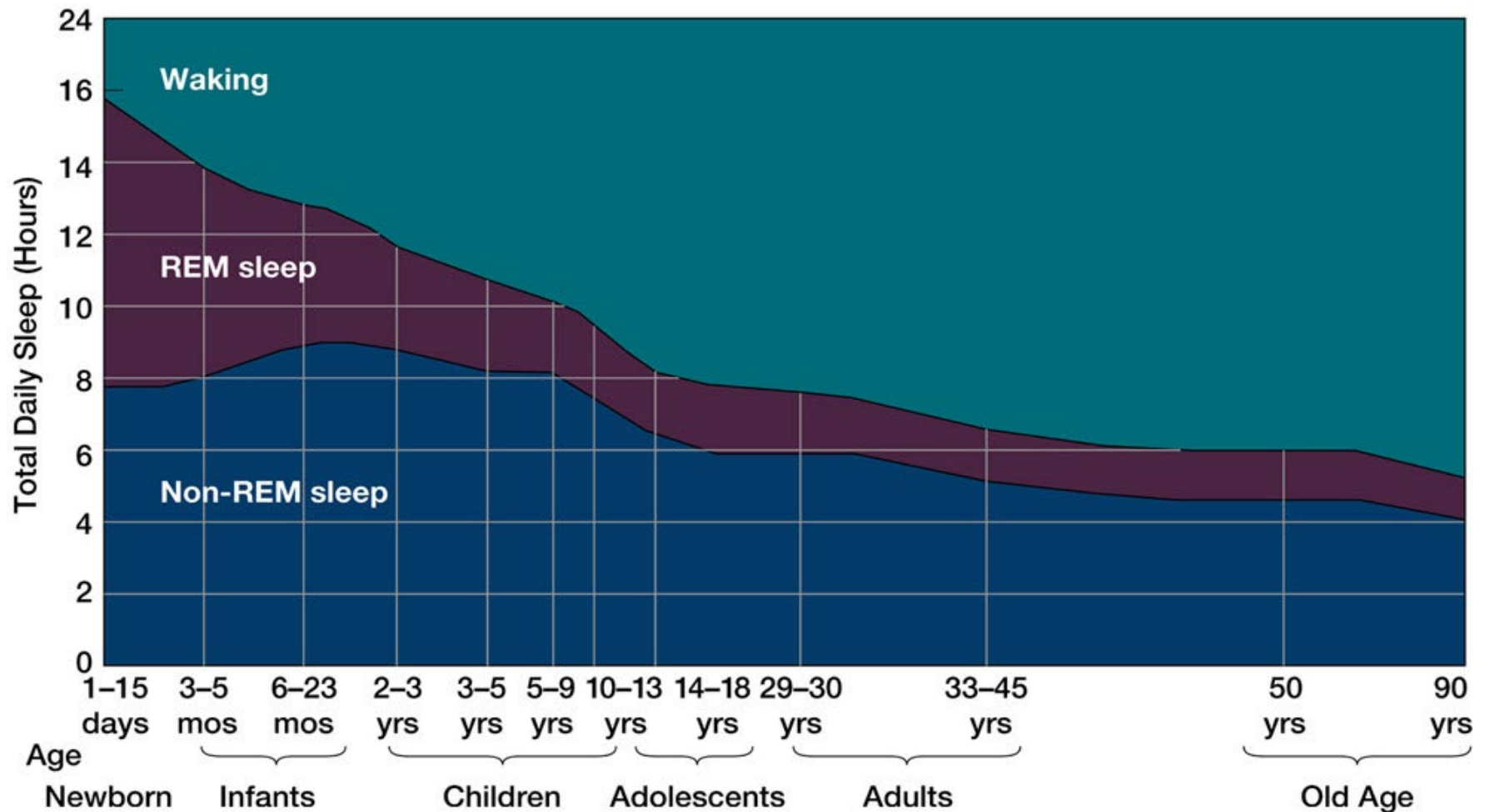


From: https://www.researchgate.net/figure/Sleep-pattern-across-the-human-life-span-3-PROPOSED-MODEL_fig2_344348856

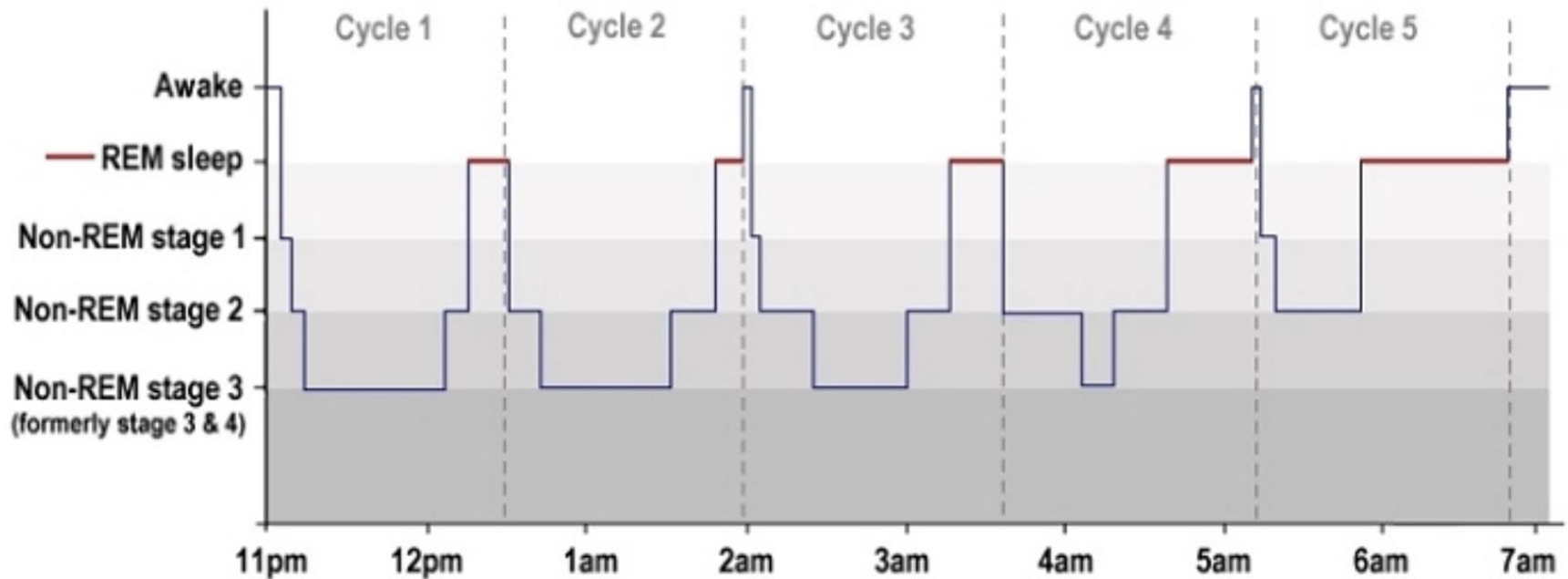
Sleep Stages

There are two general types of sleep: rapid eye movement (REM) sleep and non rapid eye movement (NREM). It appears that both REM sleep and NREM sleep are needed to consolidate or cement new explicit memories into place. Adults spend about 80% of their sleep time in NREM sleep.

Sleep Changes as a Function of Age



Sleep Stages



From: <https://www.mattressadvisor.com/sleep-stages/>

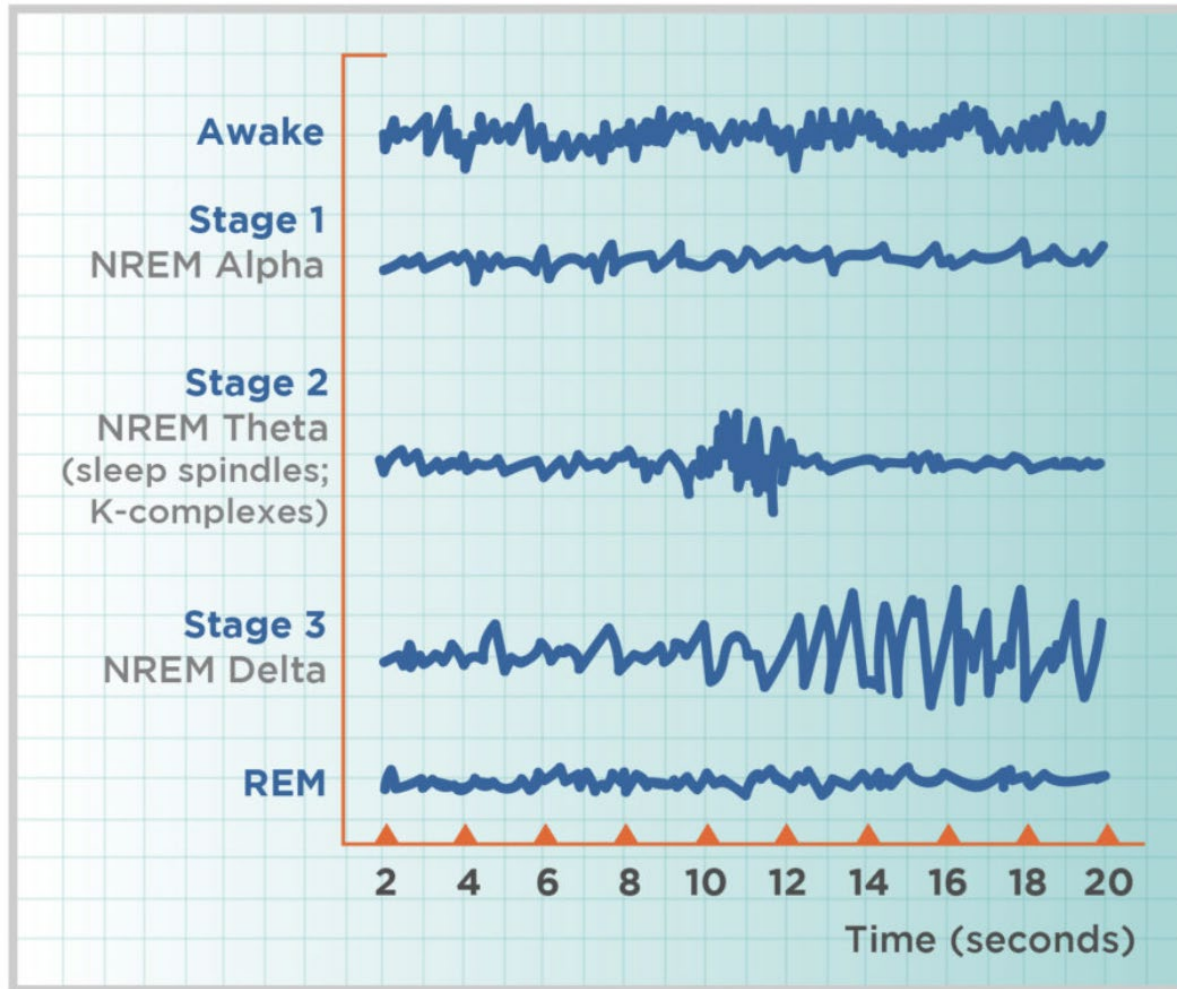
EEGs

- Electroencephalography (EEG) is the measurement of electrical activity produced by the brain as recorded from electrodes placed on the scalp.



Public domain image from: https://commons.wikimedia.org/wiki/File:EEG_cap.jpg

Brain Activity (EEGs) and Sleep



From: <https://courses.lumenlearning.com/waymaker-psychology/chapter/stages-of-sleep/>

Ultradian Rhythms

We not only cycle through being more awake and less awake in a 24-hour period, but we also have a sub-rhythm that we cycle through every 90 minutes. This sub-rhythm is known as an ultradian rhythm.

Ultradian Rhythms

If you are wide-awake at 8:00 a.m., you are likely to be a little less awake at 8:45 a.m., and then more awake again at 9:30 a.m. (i.e., 90 minutes after 8:00 a.m.).

Ultradian Rhythms

Let's practice:

On Sunday you woke up at 10:00am. What time should you set your alarm for on Monday?

- a. 7:00am
- b. 6:15am
- c. 7:45am

Ultradian Rhythms

Let's practice:

On Sunday you woke up at 10:00am. What time should you set your alarm for on Monday?

- a. 7:00am (3 hours earlier)**
- b. 6:15am (3 h 45 min earlier)
- c. 7:45am (2 h 15 min earlier)

Glymphatic Clearance

- Glymphatic clearance was described and named in 2013 and refers to the body's ability to remove waste from the central nervous system.
- We believe this occurs most efficiently during slow wave sleep.
- During sleep we have lower levels of epinephrine which leads to expansion of the extracellular space and facilitates clearance.

Glymphatic Clearance

- Much more research needs to be done, but some hypothesize that some neurodegenerative diseases may be related to poor functioning of the glymphatic system (e.g., amyloid proteins and Alzheimer's).
- Staying hydrated and engaging in regular exercise is believed to also facilitate better glymphatic clearance.

Sleep Debt

- If the average adult needs 7 hours of sleep and gets 6, that is a one hour sleep debt.
- Sleep debt has been associated with similar negatives outcomes to insomnia
 - Obesity
 - Heart disease
 - Mood disorders

Common Sleep Disorders

- Insomnia
- Sleep Apnea
- Narcolepsy

Insomnia

- About 1/3 of people will suffer from insomnia at some point in their lives. For some it is chronic or reoccurring.
- There are three main types:
 - Difficulty falling asleep (most common)
 - Difficulty staying asleep
 - Early waking

Sleep Apnea

- Sleep apnea involves frequent, reflexive gasping for air that awakens a person and disrupts sleep.
 - Associated with loud snoring and obesity
 - Prevalence
 - 2% of women
 - 4% of men

Narcolepsy

- Narcolepsy is a disease marked by sudden and irresistible onsets of sleep during normal waking periods.
- In the United States, it is estimated that narcolepsy afflicts as many as 200,000 Americans, but fewer than 50,000 are diagnosed.
- Narcolepsy is often mistaken for depression, epilepsy, or the side effects of medications.

Sleep and Aging

Older adults spend more time in bed than younger adults, but older adults actually get less sleep. Insomnia only affects about 9% of people between the ages of 20 and 30, but 35-50% of people over the age of 65 report having sleep problems. Nearly half of people over the age of 65 complain about chronic sleep problems.

Problems associated with insomnia or poor sleep

1. Increased mortality risk
2. Decreased quality of life
3. Increased cardiovascular risk
4. Increased risk of obesity
5. Increased risk of Type 2 diabetes
6. Increased anxiety and perceived stress
7. Increased depression
8. Increased risk of motor vehicle accidents
9. Decreased ability to identify odors
10. Higher levels of the stress hormone corticosterone, which may impair memory and immune system functioning
11. Fewer new neurons made in the brain
12. Decreased ability to inhibit aggression
13. Reduced language abilities

Sleep and Memory

- Insomnia appears to lead to memory impairment, especially when it comes to learning new things, paying attention, and ignoring distracters.
- Recently, researchers have asserted that insomnia is yet another **risk factor** for developing memory problems.

Sleep and Memory

- In one study, researchers found that if people miss just one night of sleep, their ability and likelihood of recognizing things they had seen since the sleepless night decreased from 86% to 74%.
- One might therefore infer that insomniacs who didn't sleep much the night before would have approximately a 12% reduction in their ability to make new memories.

Sleep and Memory

- Impaired sleep quantity and quality might affect cognition through:
 - Inflammatory processes
 - Reduced synaptogenesis
 - Reduced neurogenesis
 - Decreased clearance of neurotoxic metabolites
 - Decreased clearance of amyloid proteins
 - Sleep disordered breathing may lead to a hypoxic state

Sleep and Memory: Risk Factors

- Watch out for depression because it is a risk factor for sleep problems and insomnia.
- There is evidence that older adults are more likely to develop insomnia if they are depressed.
- Chronic pain is another risk factor for insomnia.

Sleep and Memory

- Sleep problems may be a risk factor for memory problems that can be dealt with through simple behavioral changes.
- We will review these behavioral changes, but first, let's discuss Sleep Apnea.

15 Ways to Improve Sleep

1. Keep regular hours
2. Exercise everyday

One study found that a four month exercise program led to improvements in sleep quality, time it took to fall asleep, and duration of sleep.

15 Ways to Improve Sleep

3. Don't drink too much alcohol after dinner; it will impair the quality of sleep.
4. Avoid nicotine and caffeine, which are both CNS stimulants. Jefferson et al. found that insomniacs were more likely to smoke cigarettes as compared to non-insomniacs. Some studies have found that caffeine consumption, especially later in the day, causes people to fall asleep slower and stay asleep for shorter periods of time (5.6 hours vs. 6.9 hours).

15 Ways to Improve Sleep

5. Take a nap during the day. This recommendation is different from what has been suggested during the past 30 years, but new research shows it generally increases total daily sleep duration and quality of night sleep. Earlier and shorter naps might be better.

In a recent study, the researchers gave some older adults an opportunity to nap for two hours everyday. Those who napped experienced improvements in their ability to pay attention, which can lead to improvements in memory. The participants who napped also slept more time asleep in a 24-hour period (average = 7.4 hours)

15 Ways to Improve Sleep

6. Unwind in the evening. Create a sleep ritual (that doesn't involve screens), possibly including dimmed lights, book, audio book, music, meditation, simple preparations for the next day, or even sudoku.
7. Don't go to bed starved or stuffed.
8. Don't associate the bedroom with wakefulness. Don't eat, drink, or watch television in bed. If you can't go to sleep then get up and do something else besides worrying about not going to sleep.
9. Don't ruminate in bed. If you have thoughts that you would like to remember, jot them down and stop thinking about them. Some people call this a "worry journal."

15 Ways to Improve Sleep

10. Use the ultradian cycles to predict optimal times to go to sleep.

11. Control light and thus melatonin release. This is true in the morning, during the day, and at night.

A recent study found that exposure to high level blue or short wave length light, like those emitted by modern screens, reduced total sleep time by 16 minutes and increased the number of wakings.

15 Ways to Improve Sleep

12. Be sure to make the sleeping environment as comfortable as possible (e.g., bedding). Studies have shown people fall and stay asleep better when the temperature is 60-68 degrees Fahrenheit.
13. Make sure the sleeping environment meets your standards of tidiness.
14. Get more exposure to natural light during the day.
15. Try to reduce noise exposure during the night. Ear plugs?

Sleeping Medication

Benzodiazepines can cause a range of side effects, including:

- reduced attention and alertness
- stumbling or falling
- memory loss
- drowsiness
- light-headedness
- a hangover effect (i.e., feeling the effects the next day)
- lethargy
- loss of behavioral control leading to irritability and agitation
- increased insomnia after the person stops taking the medication

Sleeping Medication

So called Z-drugs are now the most common class of drugs used to treat insomnia. They are called Z-drugs because their non-trade names begin with 'z' (and zzz's are associated with sleep): *zolpidem* (Ambien), *zaleplon* (Sonata), and *eszopiclone* (Lunesta). Z-drugs are not technically benzodiazepines, but they have similar effects in the brain.

Sleeping Medication

Z-drugs are metabolized by the body more rapidly and therefore don't have the same "hangover" effects the next day as we see with the older benzodiazepines.

Some Z-drugs, such as zaleplon (Sonata) are very rapidly metabolized by the body and therefore are useful in treating insomnia associated with having a difficulty falling asleep. Given that zaleplon (Sonata) is metabolized so quickly people taking it are very unlikely to feel any residual effects the next day, however the drug will do little to prevent frequent awakenings.

Sleeping Medication

The other Z-drugs are not metabolized as rapidly, therefore they should prevent frequent or early awakenings, but they are more likely to have some residual effects, albeit less severe than traditional benzodiazepines.

Sleeping Medication

Z-drugs cause fewer side effects or reduced severity of side effects, but they can cause:

- drowsiness

- nausea

- memory loss

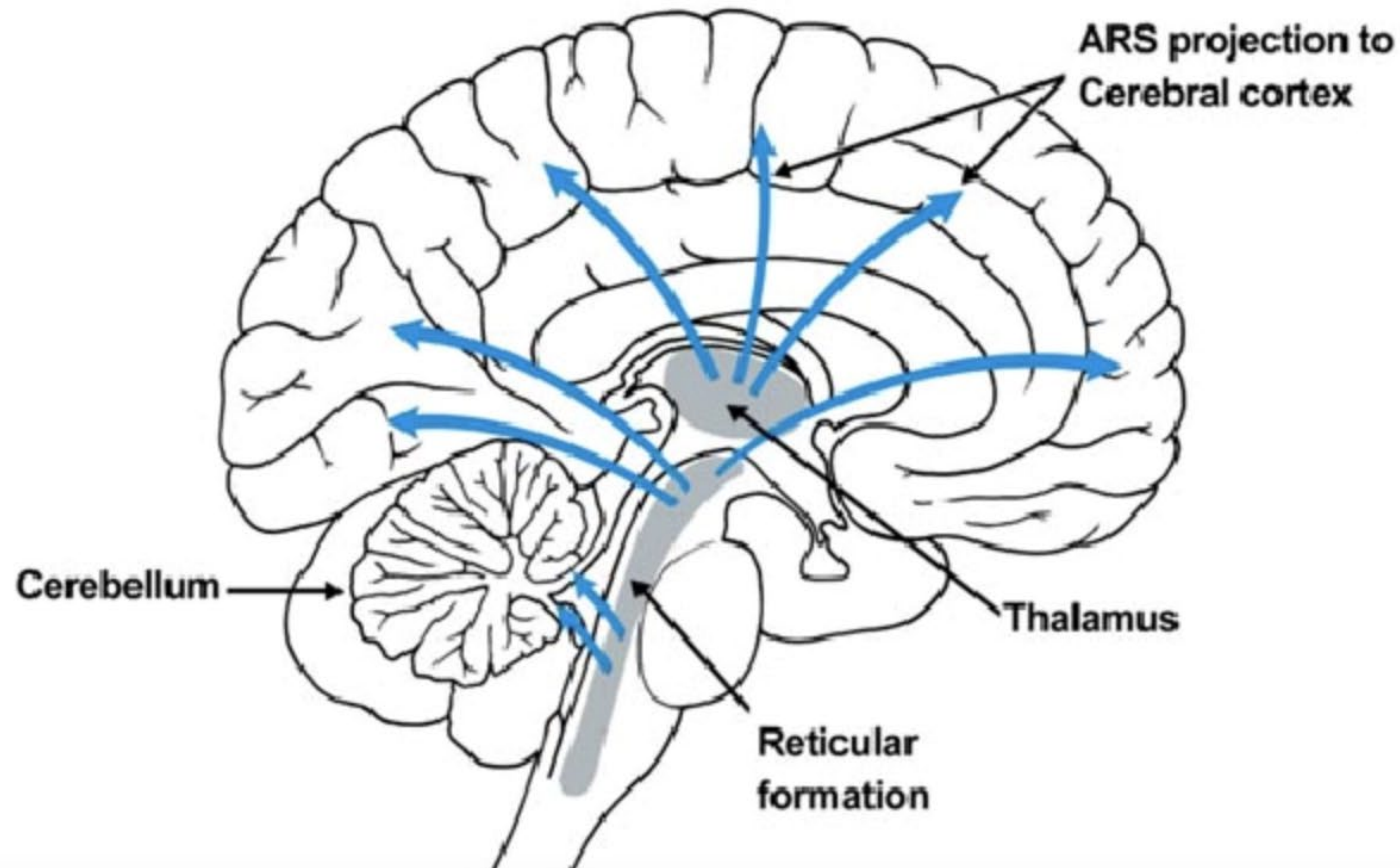
- some people report a short (i.e., one or two days) of rebound insomnia after the person stops taking the medication, but many do not experience this

- unpleasant taste in the mouth for a minority of patients

Activation-Synthesis Theory of Dreaming

- This theory asserts that dreams are the by-product of neural activation, which is synthesized into a relatively coherent narrative.

When we go into REM sleep the reticular formation sends activating signals up to the brain.



Activation-Synthesis Theory of Dreaming

- External stimuli are often incorporated into the content of dreams.
- Can't run or scream during a dream?
- Emotional centers can be activated...

Summary

- Sleep is important for good mental and physical health
- We can improve the quality and quantity of our sleep
- Avoid long term use of sleeping medication
- Use good sleep hygiene

Up Next

Next, we will discuss Stress, Cognition and the Brain