Neurobiology of

Sleep*

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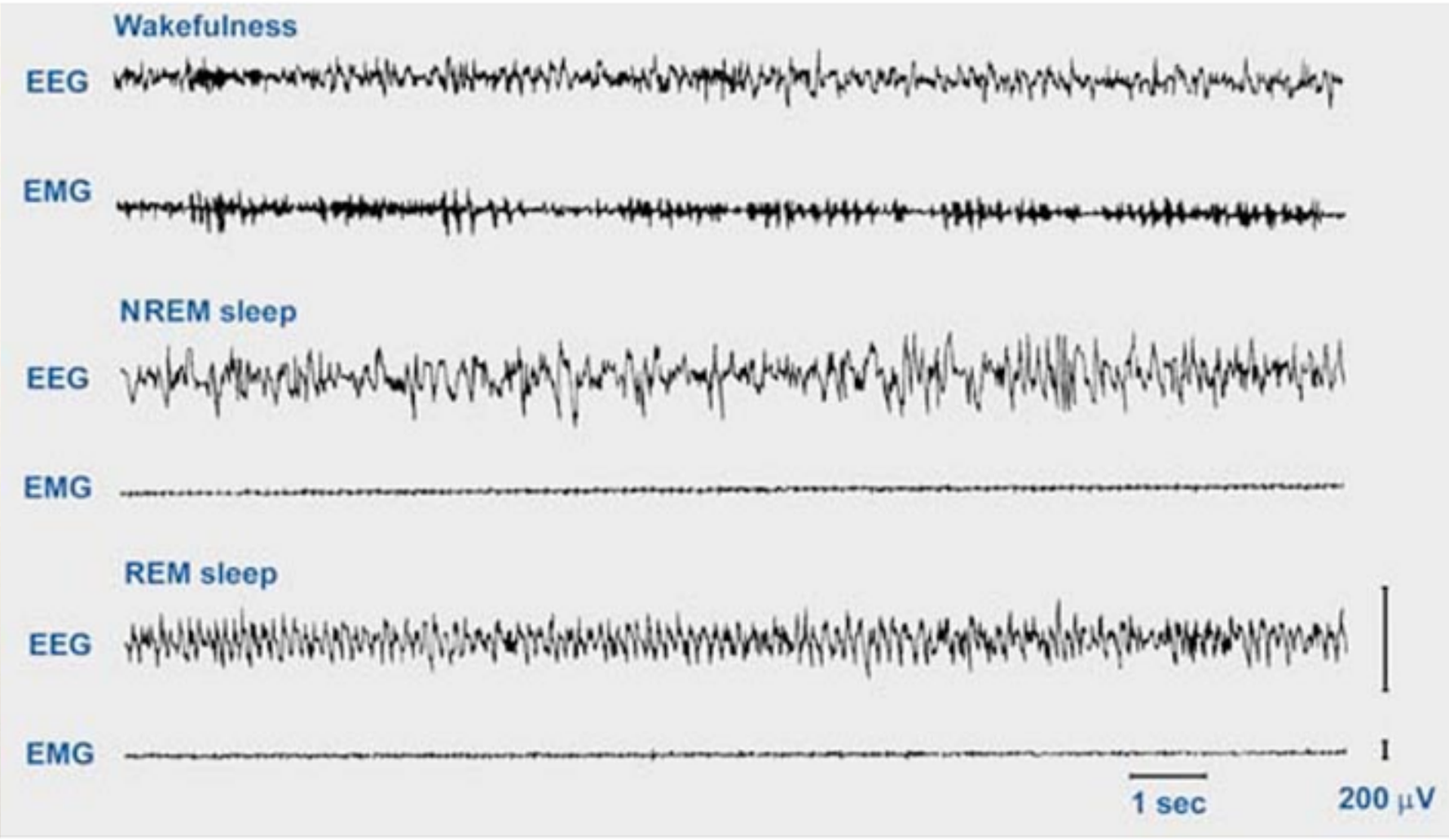
* As I understand it and from my readings, See References

What is Sleep?

- Natural (all animals have it)
- Low Motor Activity
- Suspended sensory activity
- Reversible

What is Wakefulness?

- Complementary to sleep
- Receive and respond to stimulus
- Active Cerebral cortex
- Low voltage high frequency EEG and muscle tone.



EEG/EMG patterns

http://www.scholarpedia.org/article/File:Sch_Figure1.jpg

Sleep and Wakefulness

The Differences from the perspective of a scientist

Why Sleep?

- Intellectual function is impaired.
- Brain is not taking a break.
- Some parts of the brain see more blood flow during sleep than wakefulness esp. during REM

Why Sleep*?

- Recovery and Restoration
- Energy conservation(like hibernation)
- Brain Plasticity Theory

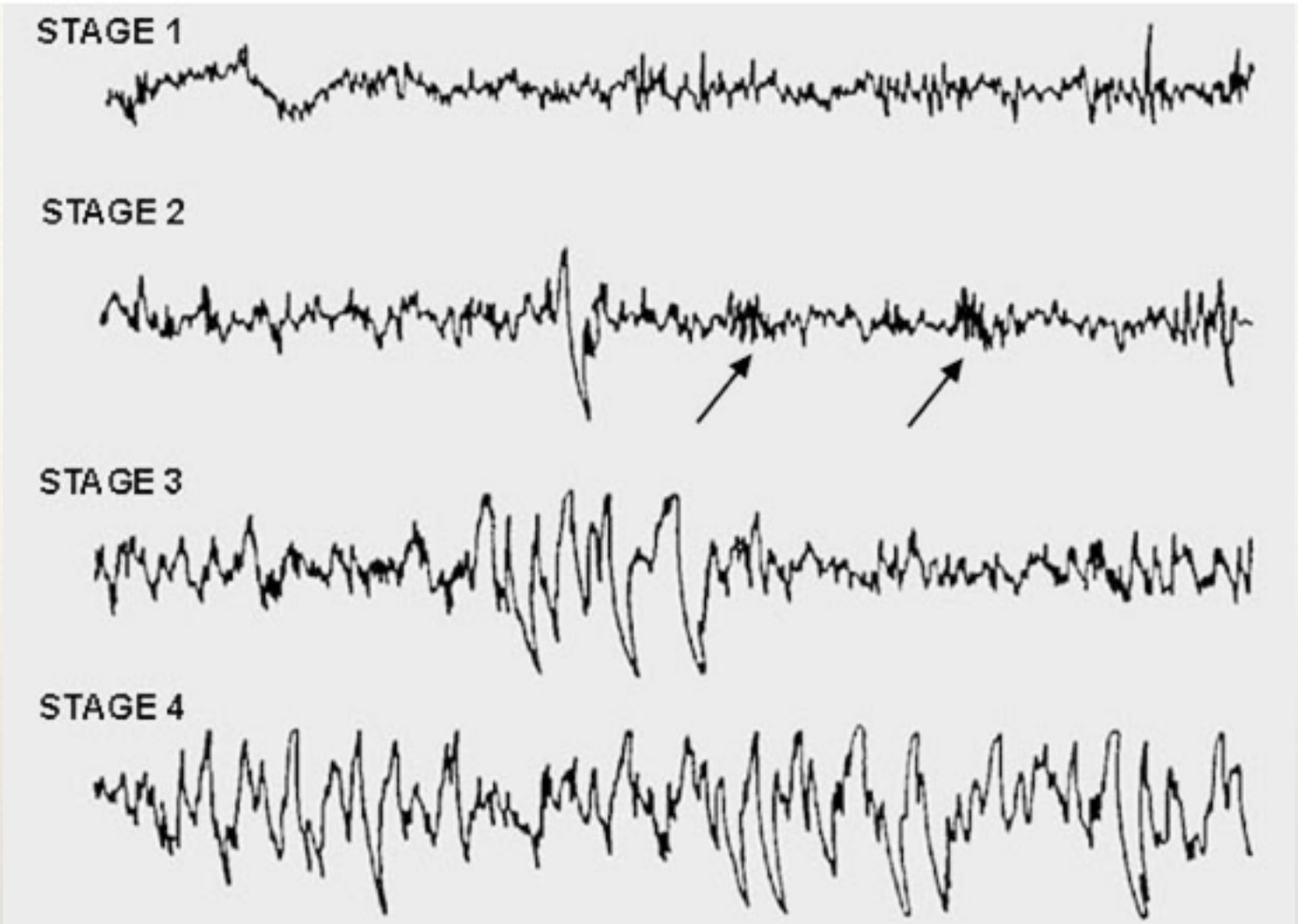
* There are only strong or weak hypotheses

Restoration and Recovery

- Increased Growth hormones at sleep onset
- Increased exercise leads to increased NREM sleep
- REM sleep seems to help rebalance neurotransmitter levels in the brain
- Improved immune system and wound healing

Energy Conservation

- Metabolic rate and body temperature drops to conserve energy during sleep
- Vasodilatation causes temperature to drop(1-2 C)
- Sleep onset leads to reduction of the body thermostat in the Hypothalamus



From wakefulness to sleep

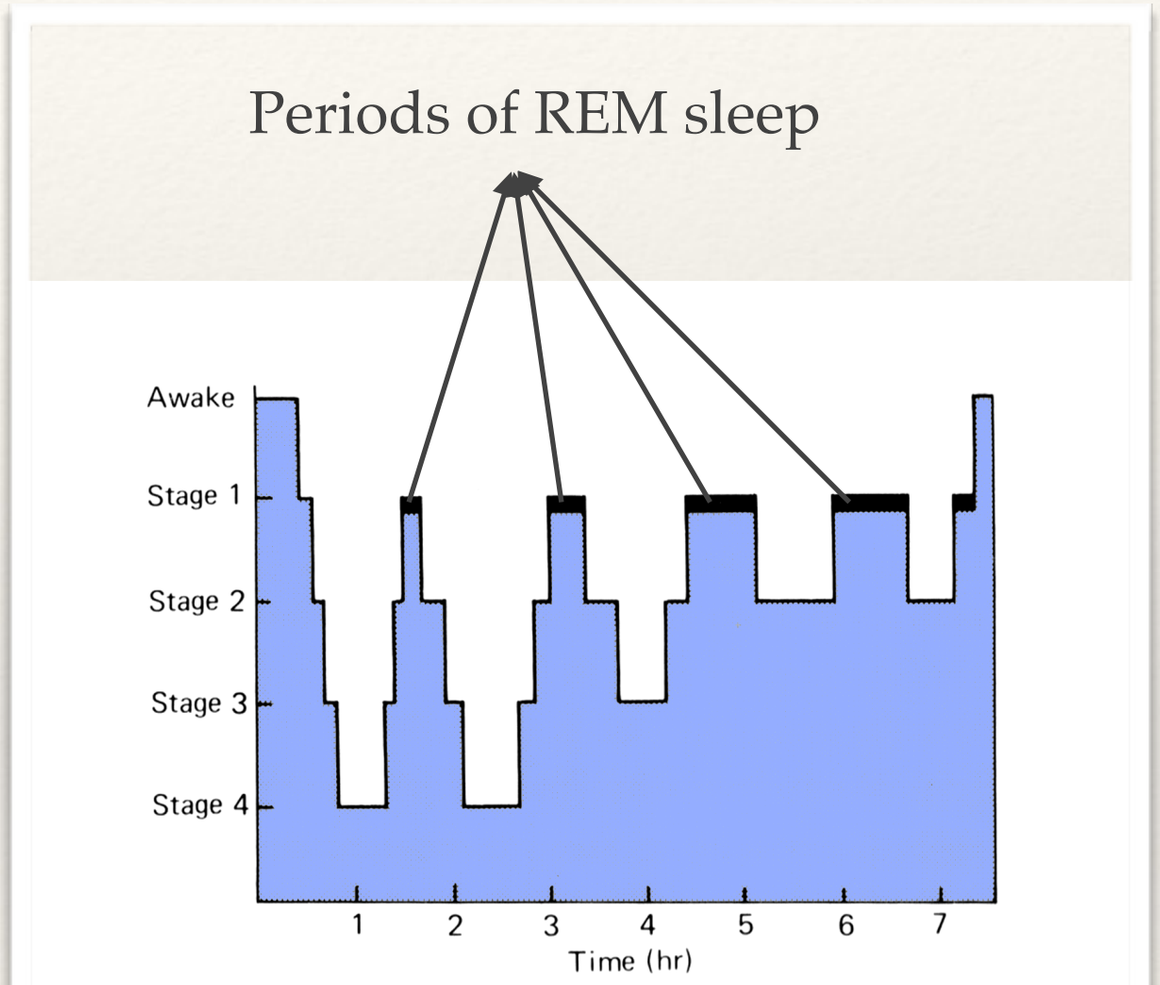
http://www.scholarpedia.org/article/File:Sch_Figure2.jpg

Stages of sleep

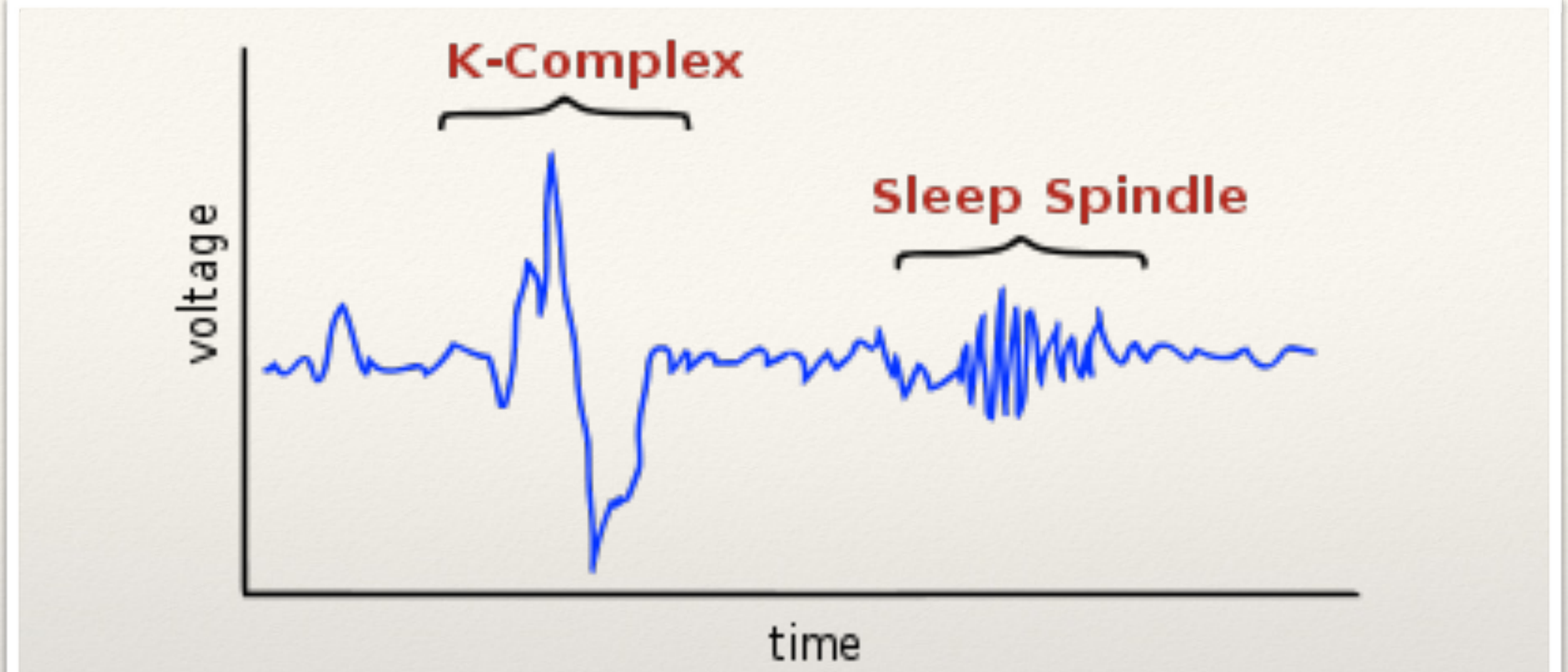
Increased voltage differences
Reduced frequency

REM sleep

- Characterised by Eyes moving rapidly
- Dreams
- Linked to consolidation of memories



Increases progressively



Stage 2 sleep

Sleep Spindles and K Complexes

Sleep Spindles

- Typically beginning or end of NREM stage 2 sleep
- Short burst of high frequency waves
- Brain is activated and ends with muscle twitching
- Possibly mapping motor neurons to muscles
- Maintain tranquil sleep in presence of external sounds

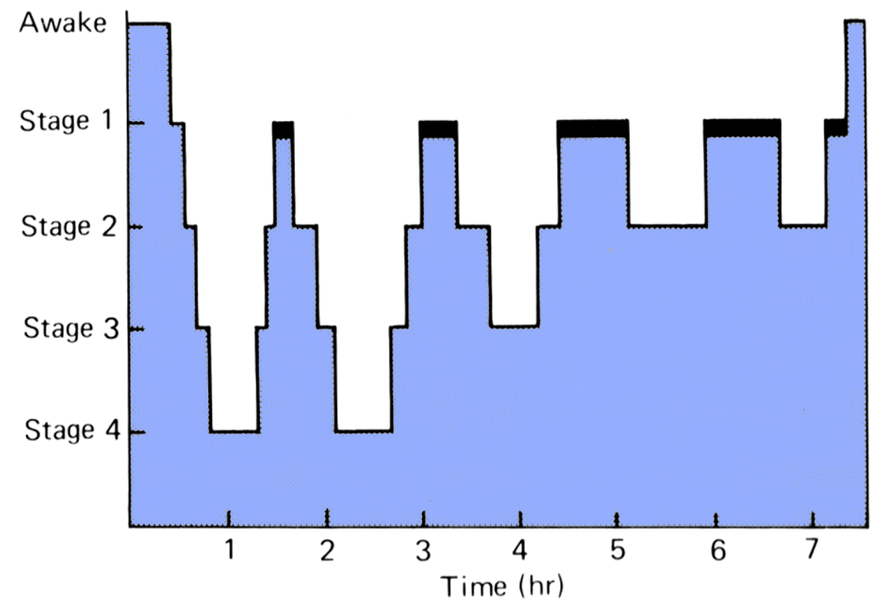
K Complexes

- Typically beginning or end of NREM stage 2 sleep
- Single delta wave(high voltage). It is largest 'healthy' event on an EEG.
- Also occur in response to external stimuli
- Linked to memory consolidation
- Cortical "down" state?

NREM Sleep

- Highly active brain regions
- Consists of multiple stages of varying patterns and length
- Probably important for homeostasis
- Important for Visiomotor and perceptual learning.

Stages of NREM sleep



Reduces progressively
Deep sleep consolidated early

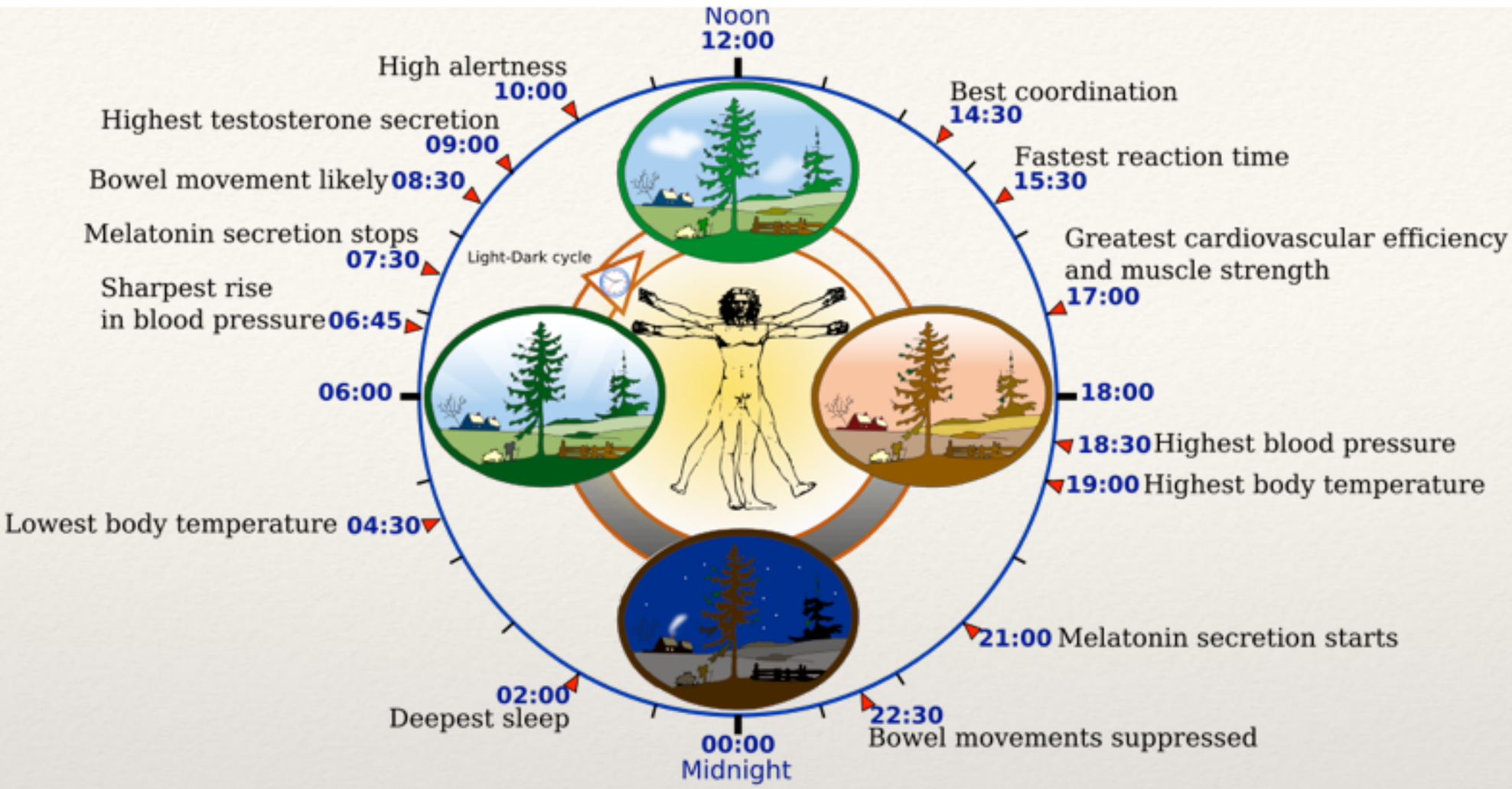
Slow wave sleep

- Stages 3 and 4
- Relates to our experience of deep sleep
- Have "Up" states. Intense firing of cortical neurons
- And "Down" States. Periods of neuronal silence

https://flic.kr/p/jZbArT

What Causes Sleep?

All animals sleep and it's origins are primitive



Humans follow a daily pattern

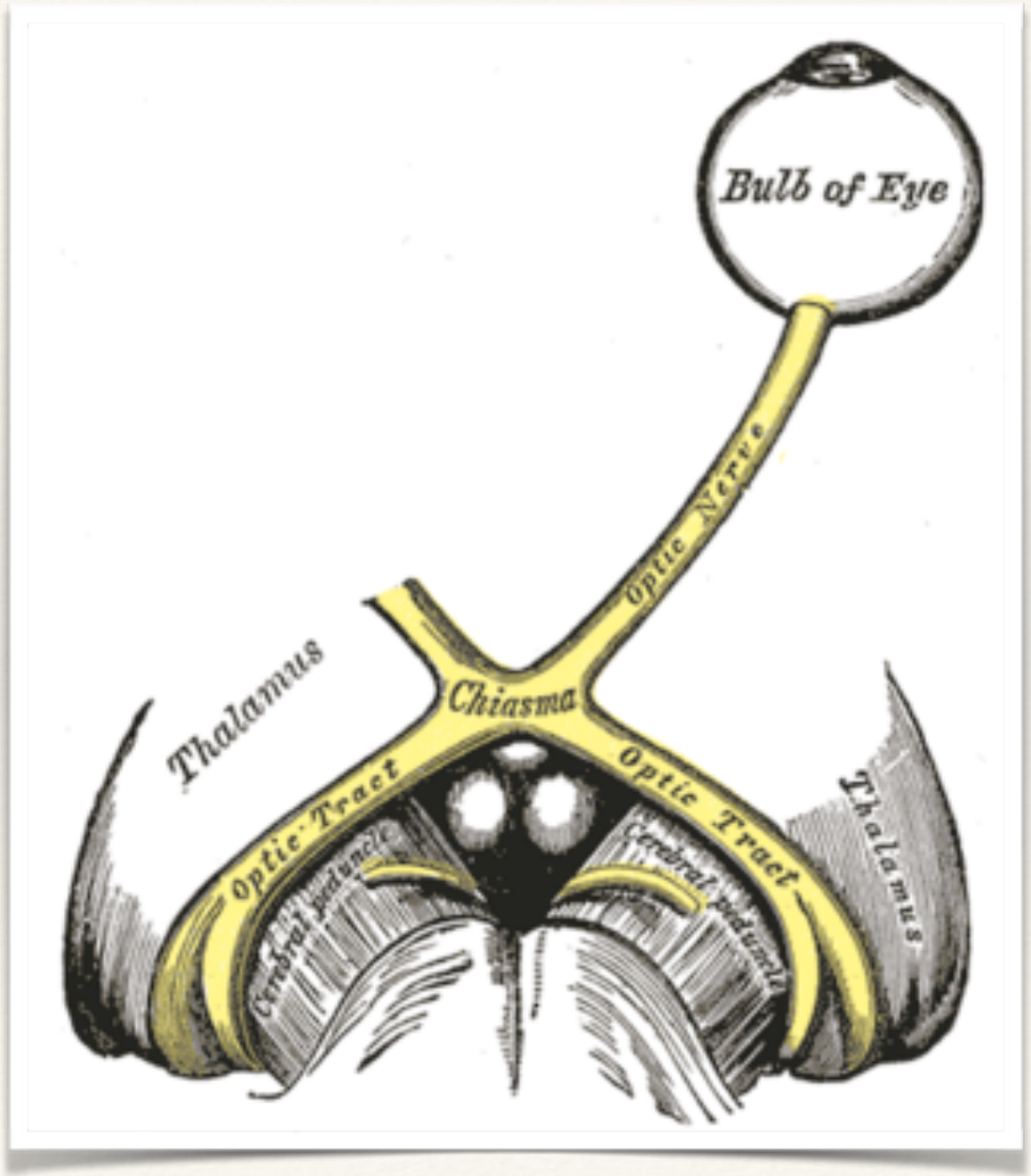
https://en.wikipedia.org/wiki/Sleep#mediaviewer/File:Biological_clock_human.svg

Circadian Rhythm

A lot of biological processes are driven by day/night. These patterns are built in and self sustained

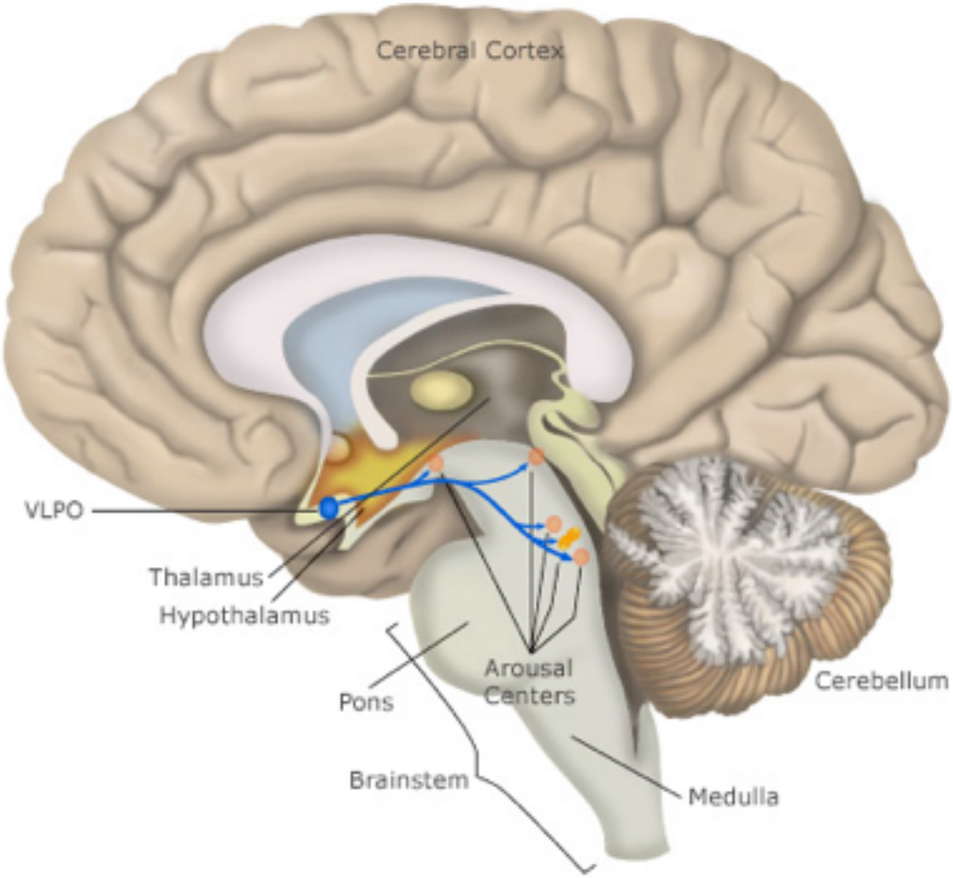
Suprachiasmatic Nucleus(SCN)

- Situated right above the optic chiasma and gets input from retina
- Part of Hypothalamus
- The master clock to control Circadian Rhythms
- Controls endocrinal activities via Pineal gland control to produce melanin



Ventrolateral preoptic nucleus(VLPO)

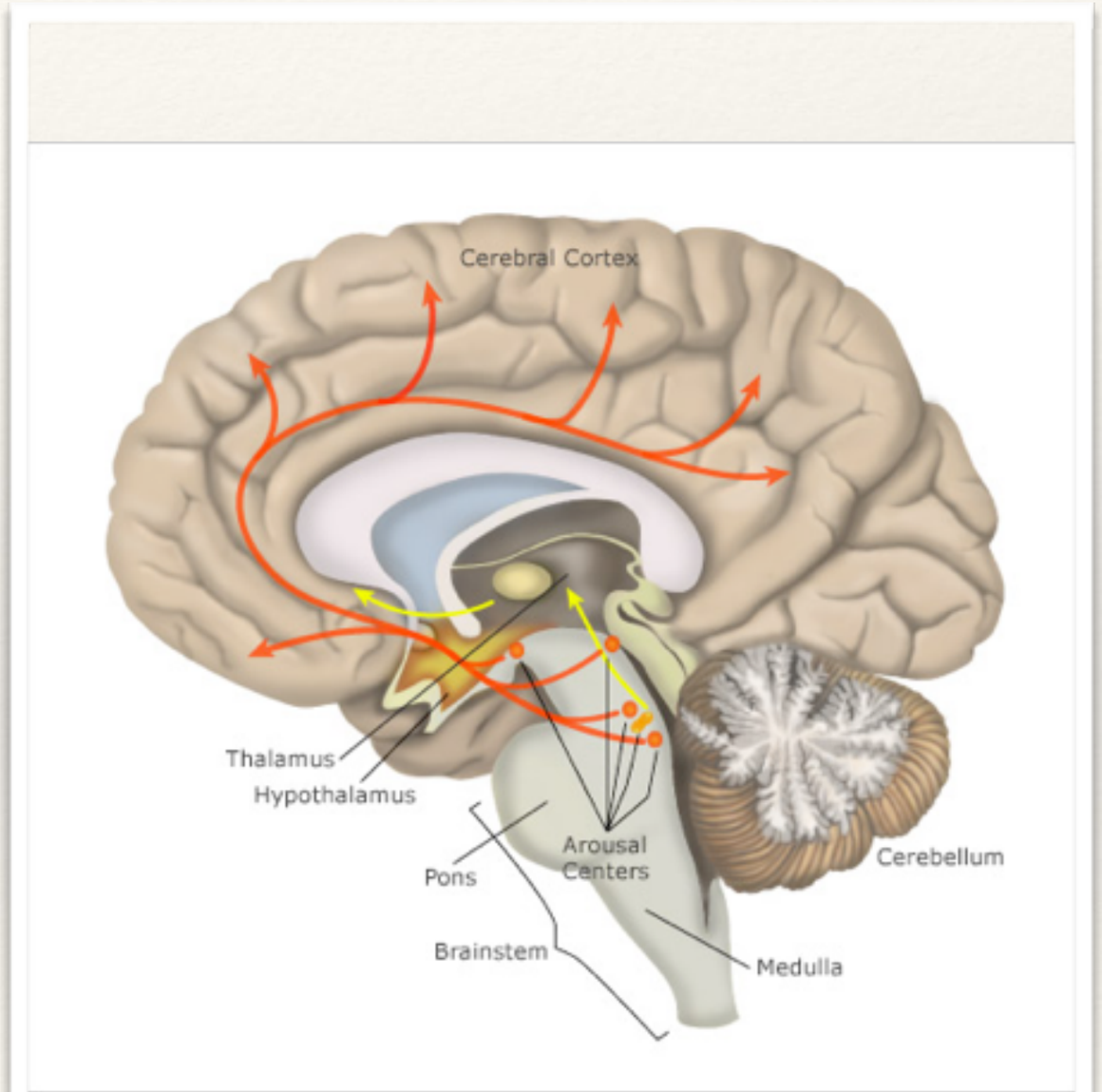
- Part of anterior Hypothalamus on the side of optic chiasm
- Inhibits the arousal systems and promotes sleep
- Inhibited by Orexin neurons during transition to wakefulness



http://healthysleep.med.harvard.edu/healthy/science/how/neurophysiology

Arousal Centers

- Produce alertness and consciousness (wakefulness)
- Start at the brain stem
- Enable cerebral cortex to be active.
- Orexin in Hypothalamus also affects cortex and arousal centres



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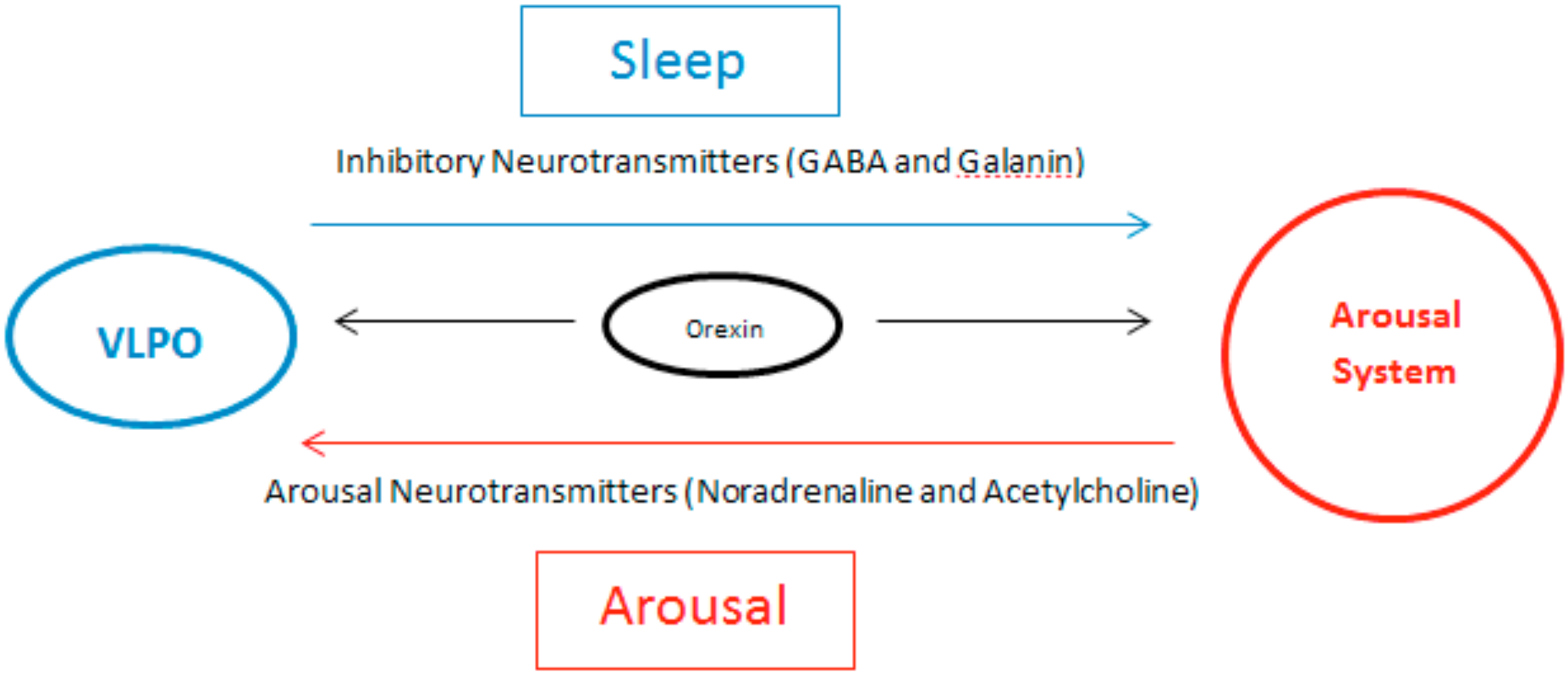


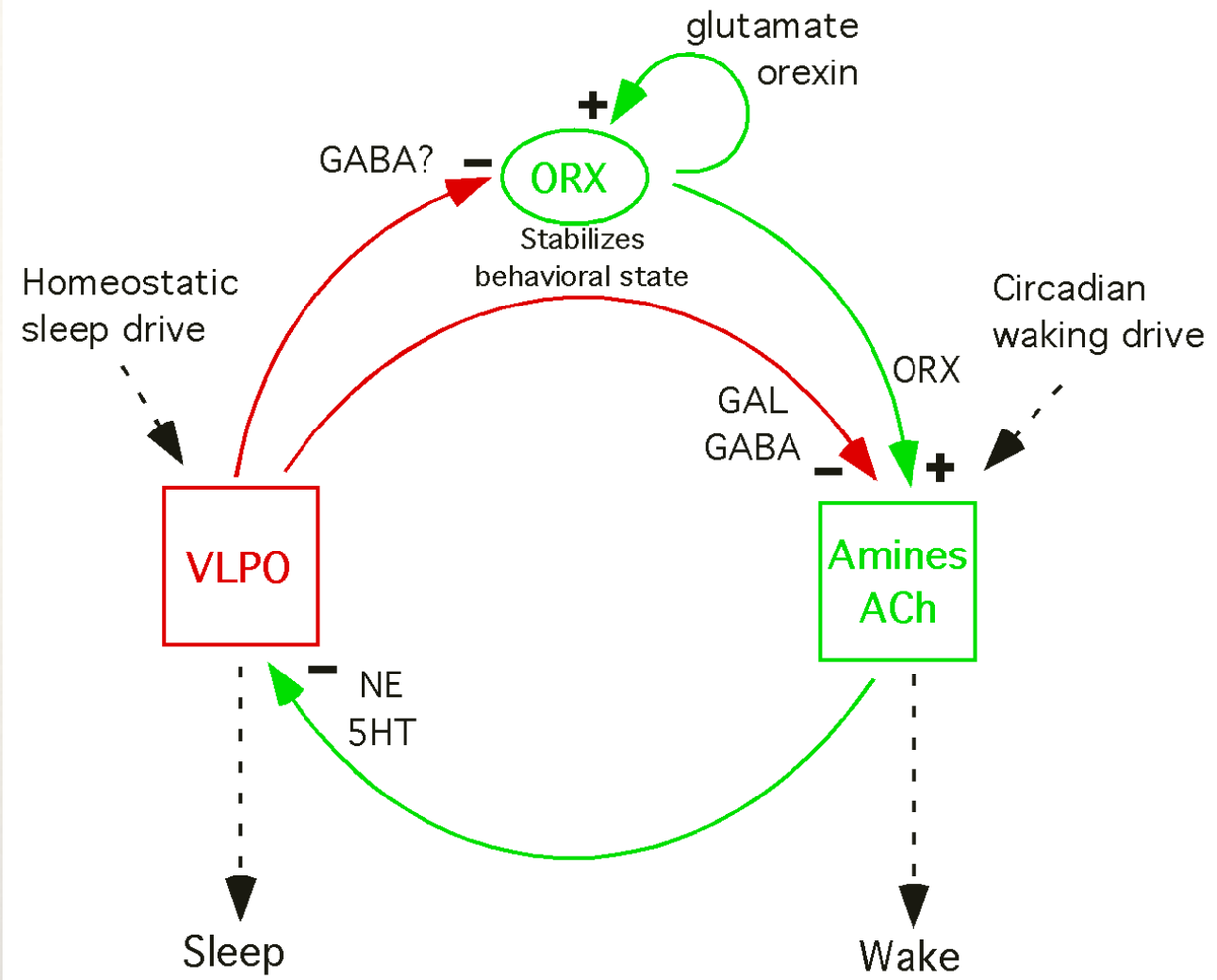
Lorem Ipsum Dolor

Sleep wake Balance

The neurotransmitter Orexin modulates the sleep wake cycle.

Homeostatic sleep need

- Humans need 1 hr of sleep for 2 waking hours
- Long sleep compensates for prolonged wakefulness
- Arousal systems in the brain cause Adenosine accumulation
- This detected in the brain stem and excites the VLPO inhibitory system to promote sleep.



The balancing act

Sleep and Wake balance

The cast

- Cortex
- Brain stem (Pons specifically)
- Hypothalamus
  - SCN
  - VLPO(Anterior Hypothalamus)
  - Orexin

REM sleep activation

- Ultradian oscillator residing in mesopontine junction(pontine taguntum)
- Rem "off" cells : Acetocholine triggered neurons
- Rem "off" cells: monoamine triggered neurons
- Rem "on" and"off" neurons form and A-B feedback to generate the cycles of REM sleep

References

- Circadian Rhythm
- REM sleep
- The science of sleep
- Role of ATP in sleep regulation
- Sleep
- Sleep resources