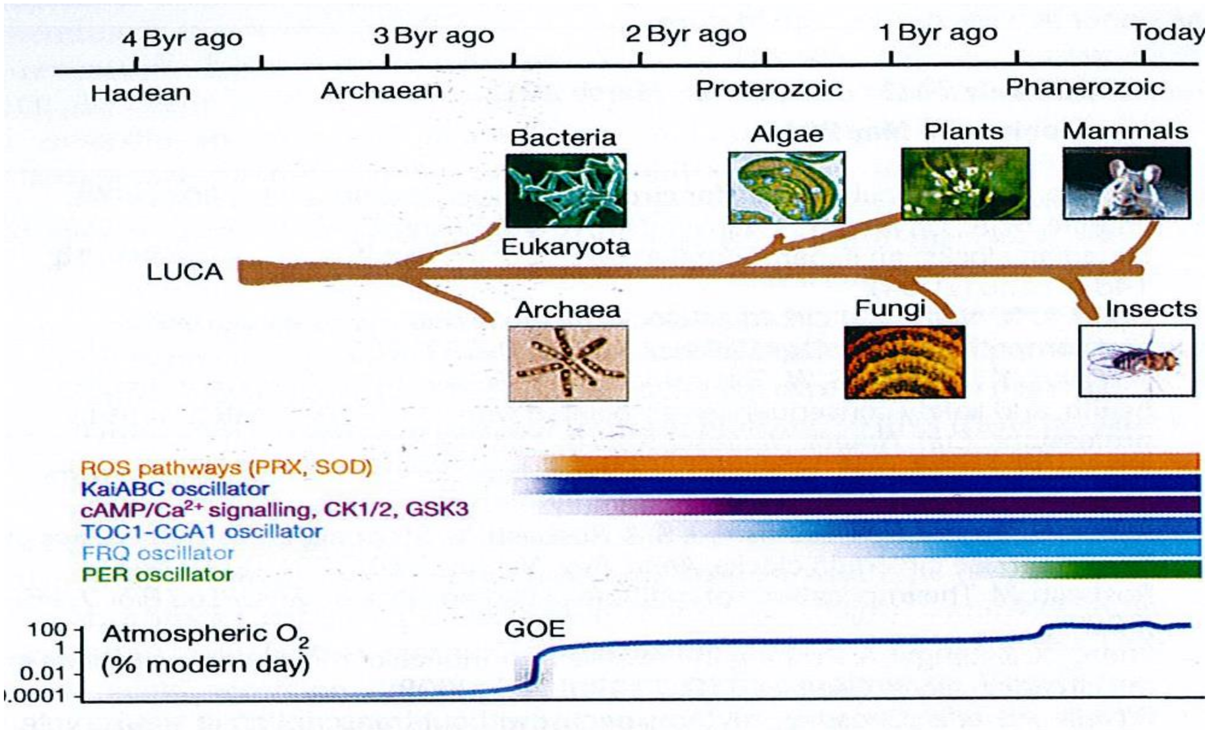
Cirkadiansk rytm, Sömn och Medvetande

Eric Hanse HT 2025

Circadian rhythms appeared 2-3 billions years ago



Article

Mitochondrial origins of the pressure to sleep

https://doi.org/10.1038/s41586-025-09261-y
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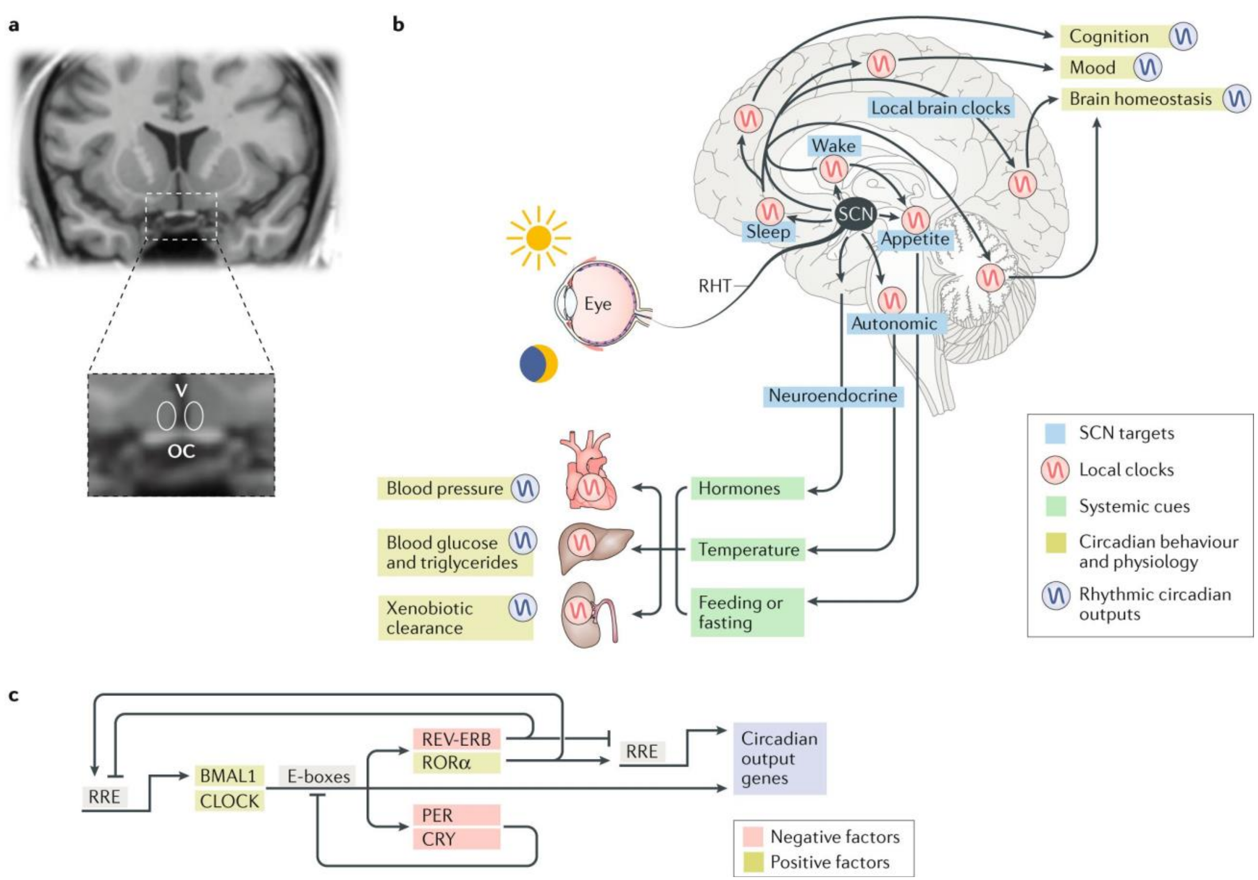
To gain a comprehensive, unbiased perspective on molecular changes in the brain that may underlie the need for sleep, we have characterized the transcriptomes

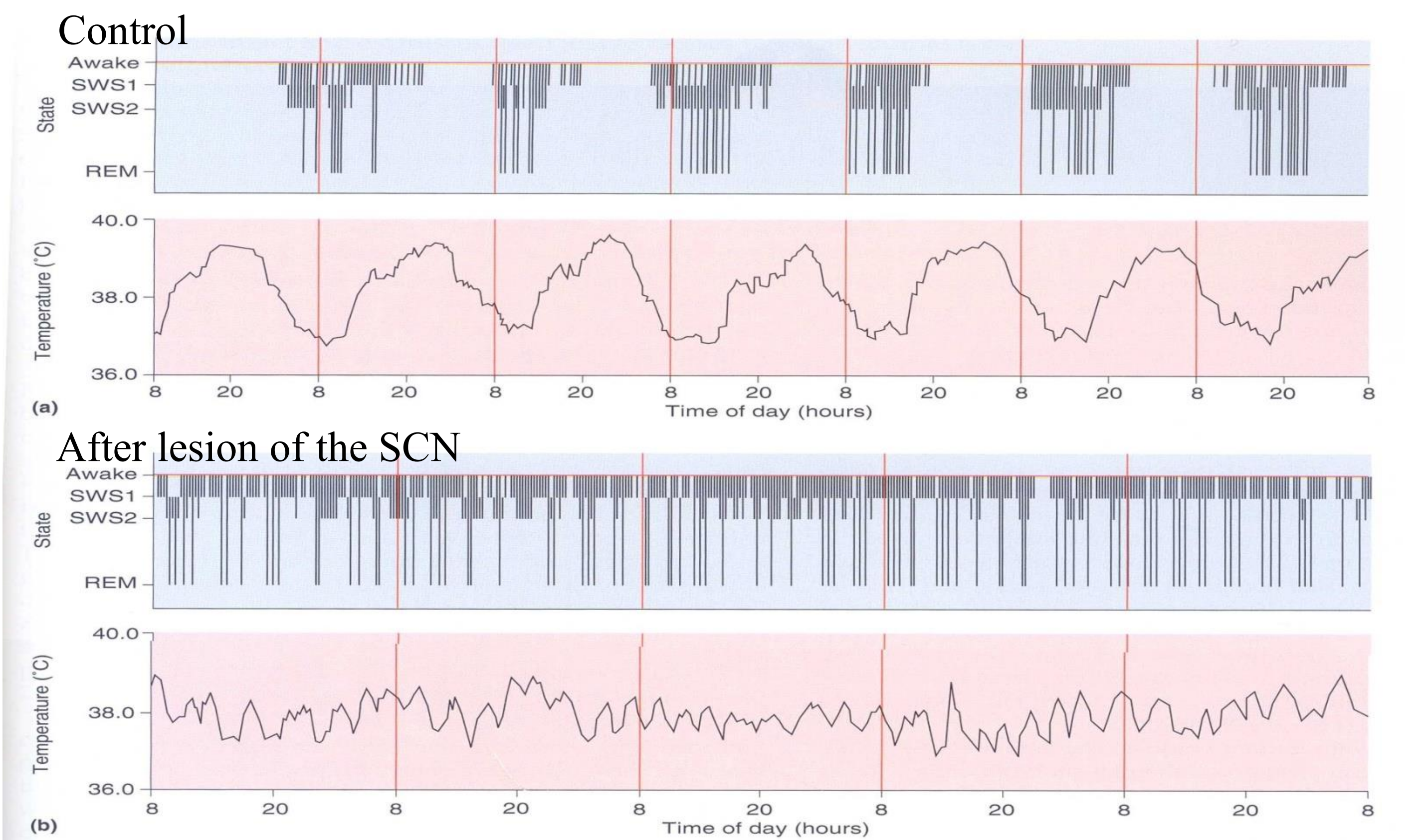
Sleep, like ageing[17,18], may be an inescapable consequence of aerobic metabolism.

Circadian organization in mammals

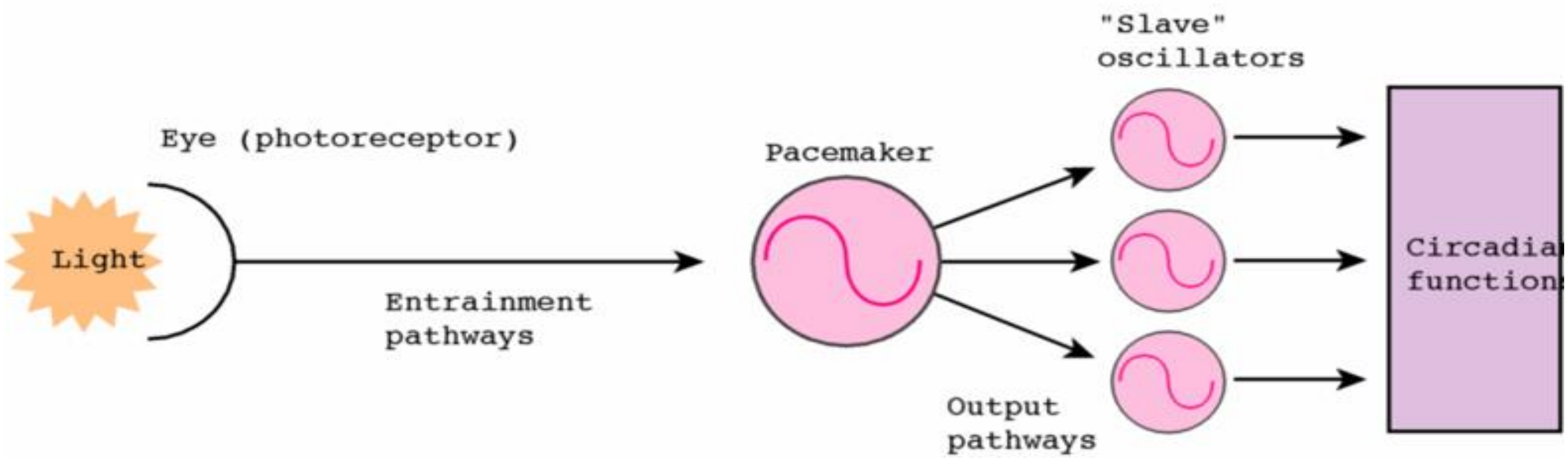


Hastings et al 2018 Nat Rev Neurosci 19:453-469

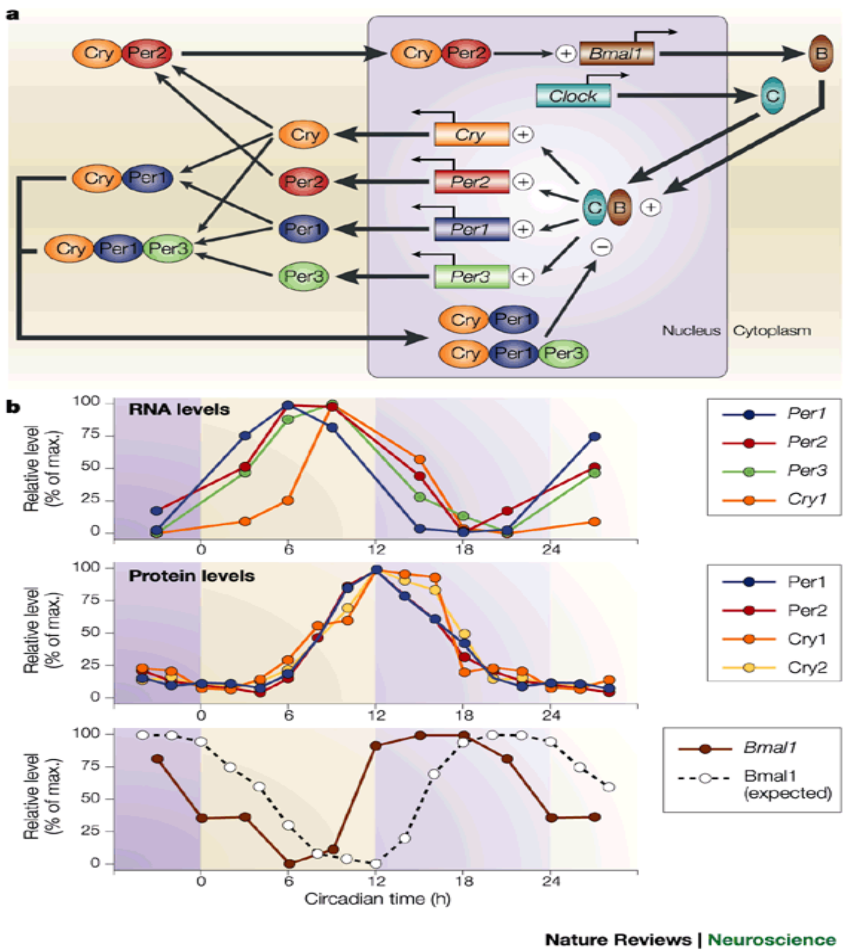
The central clock in nucl. suprachiasmaticus (SCN) synchronizes circadian rhythms



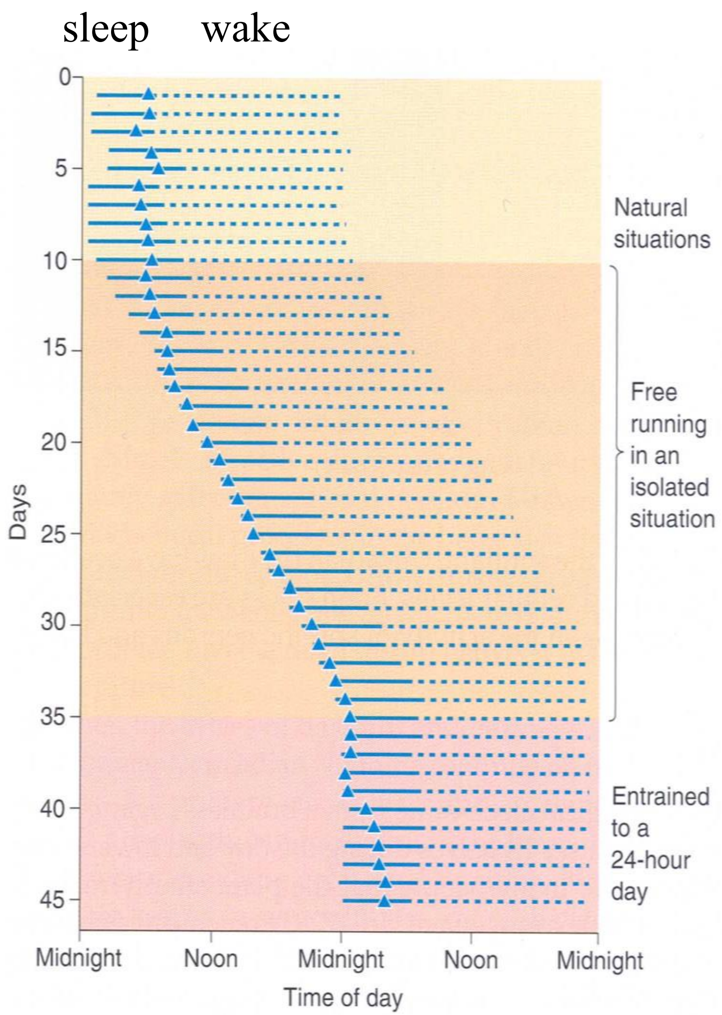
Model for the circadian clock



The molecular clock is based on delayed negative feedback

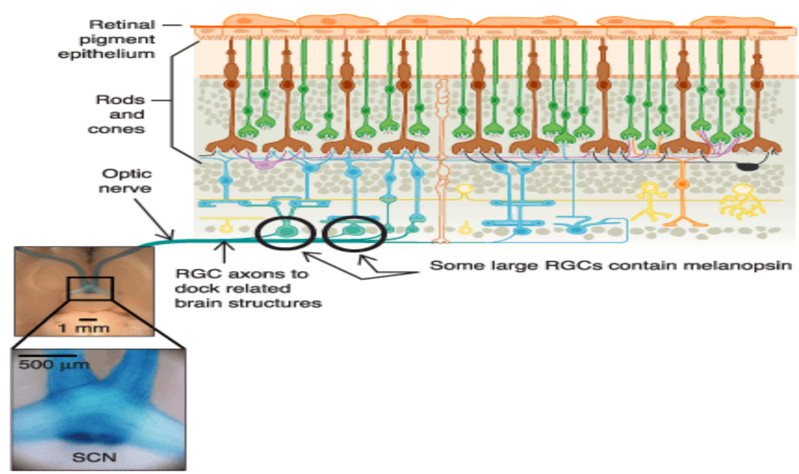


The SCN does not keep an exact 24 hour cycle if not entrained



"The third eye"

-melanopsin-containing ganglion cells



SCN signals to the rest of the brain and body both electrically and with hormones

Higher frequency of action potentials during the day

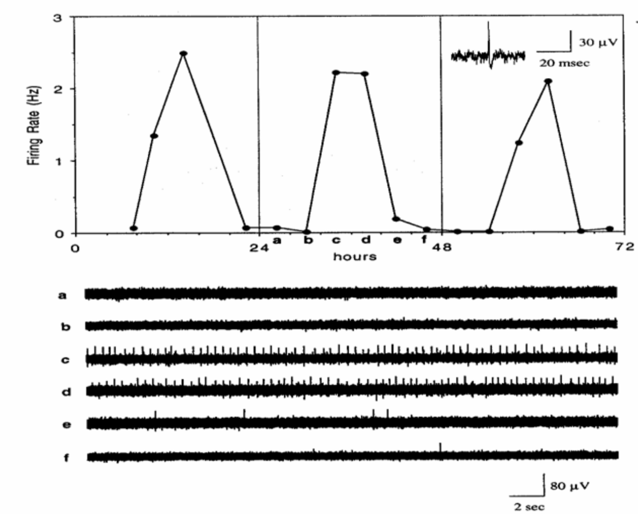
Homones, for example:

Cortisol – highest levels when we wake up

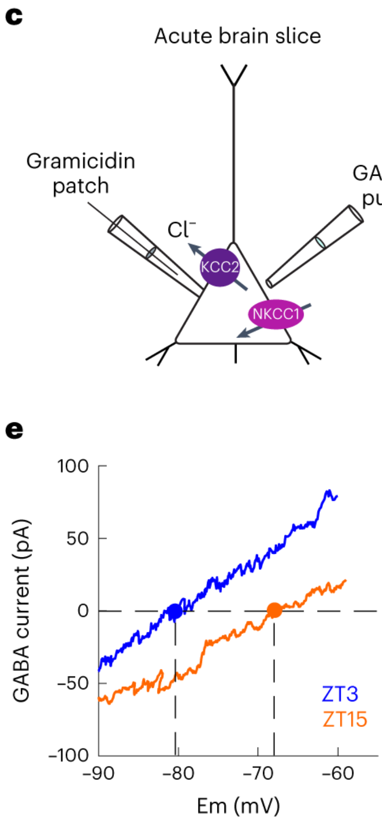
Melatonin – a “dark hormone”, released from corpus pineale

Circadian Firing Rhythms of Individual SCN Neurons
699

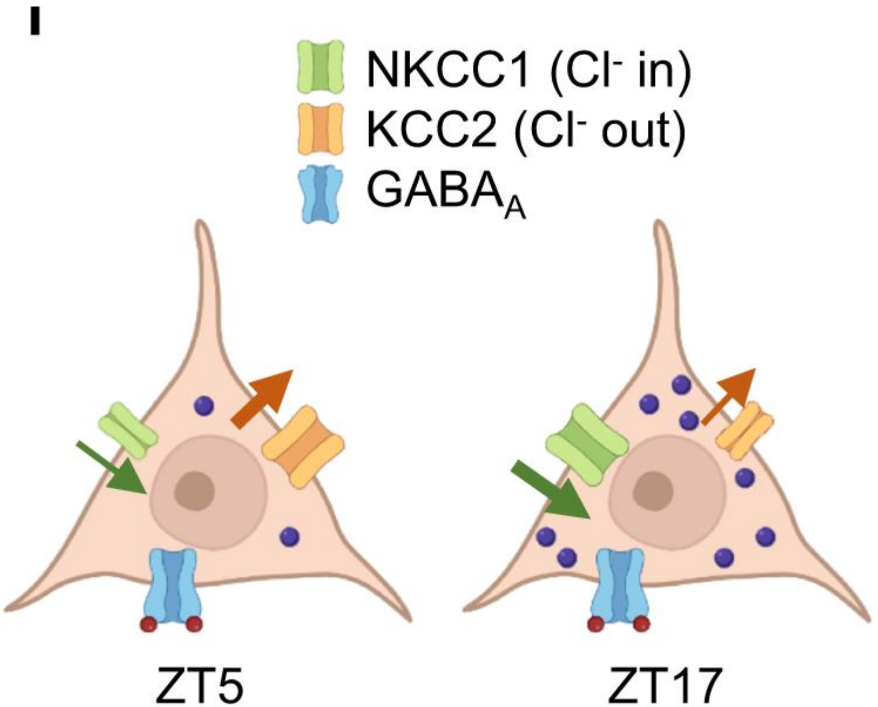
Welsh et al (1995) Neuron 14:697



I.c.[Cl⁻] is higher during wake and lower during sleep in cortical pyramidal neurons

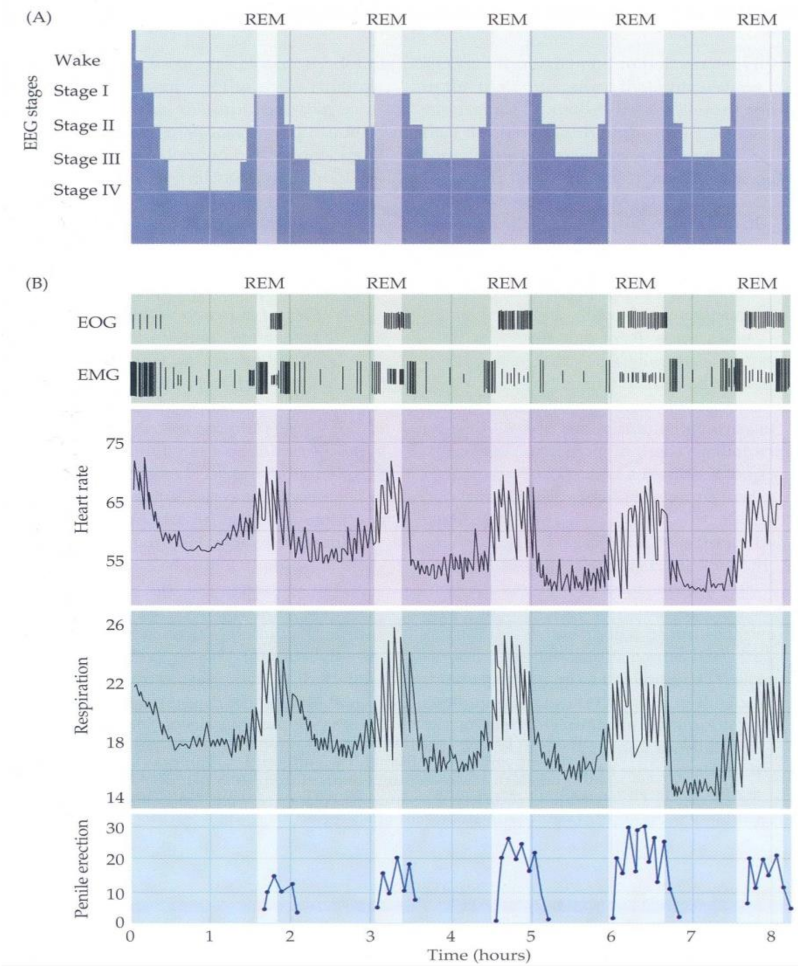


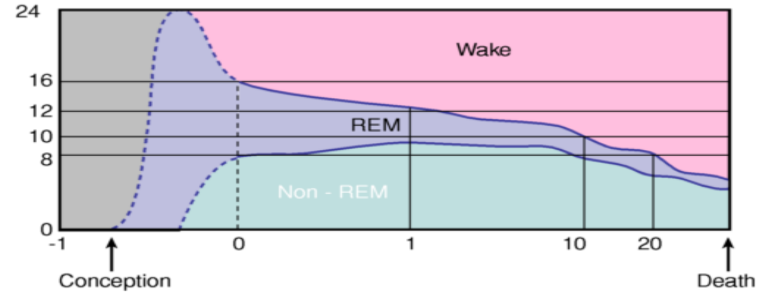
Alfonso et al 2023 Nat Neurosci 26:64-78



Pracucci et al 2023 Nat Comm 14:7108

Sleep

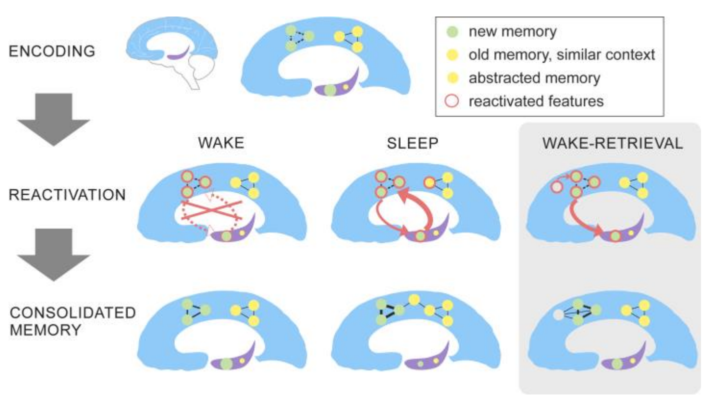




"Sleep is the readily reversible state of reduced responsiveness to and interaction with the environment"

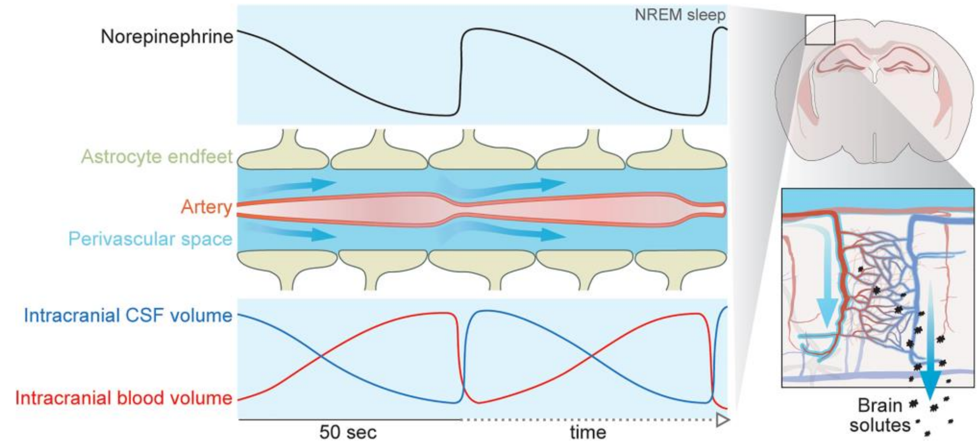
Why do we sleep?

Processing of memories



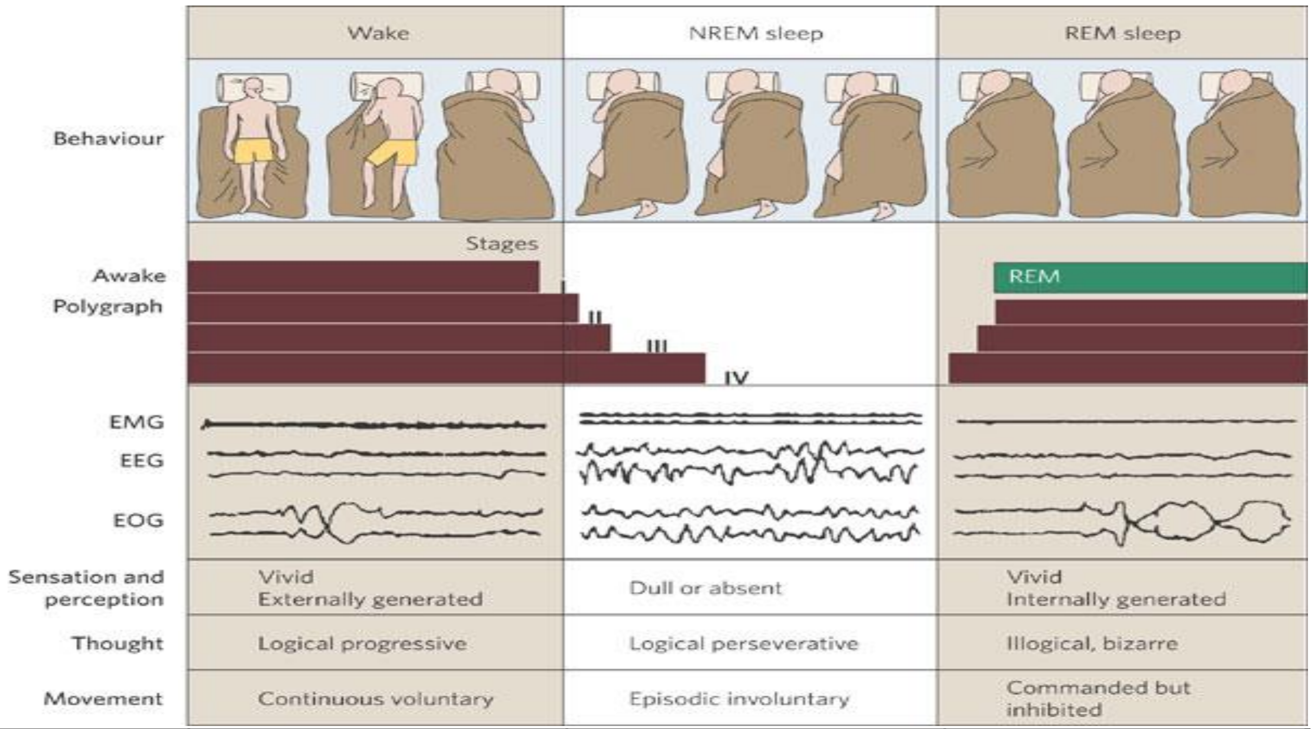
Brodt et al 2023 Neuron 111: 1050-1075

”Brain wash”



Hauglund et al 2025 Cell 188: 1-17

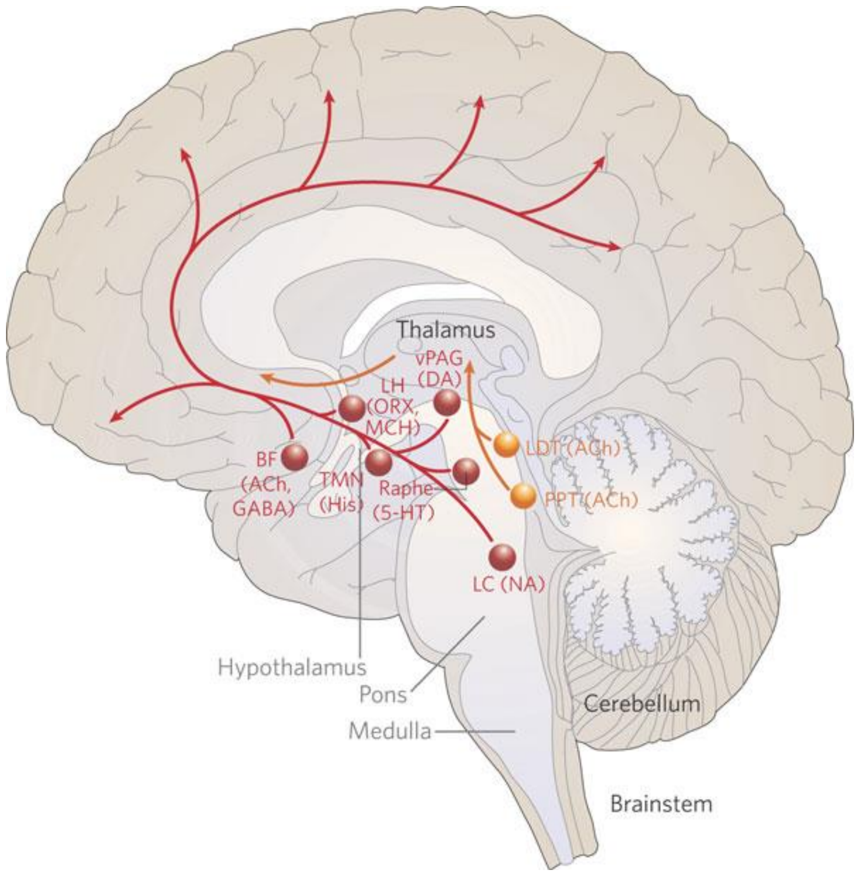
Awake, NREM and REM



NA, 5-HT, Histamin	High	Low	Very Low
Ach	High	Low	High
Orexin	High	Low	Low
Energy consumption	High	Somewhat lower	High

Hobson (2005) Nature 437:1254

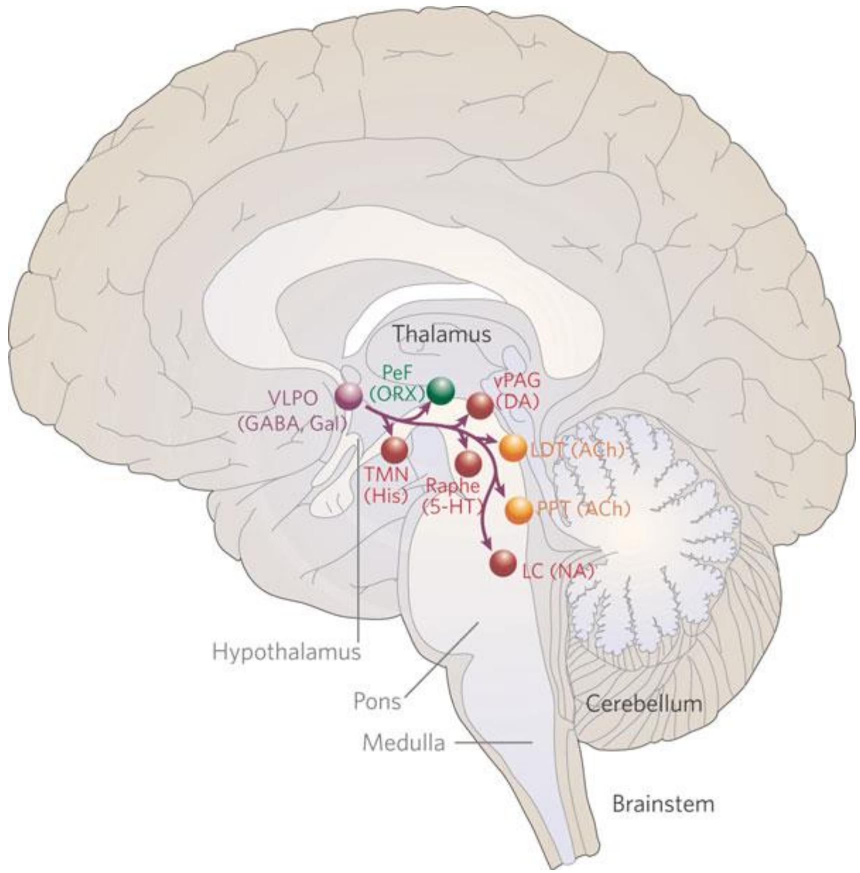
The ”wake nucleus” in the hypothalamus (LHA) excites the modulatory transmitter systems using Glu/Orexin



Saper et al (2005) Nature 437:1257

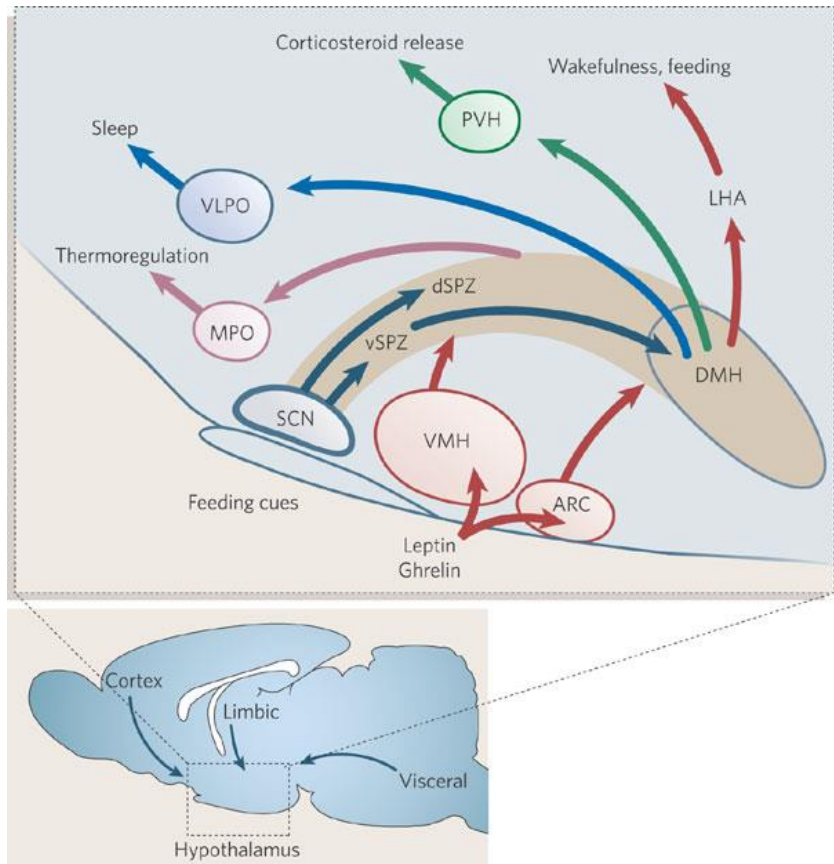
LC –Locus Coeruleus
BF – Basal forebrain
LH – Lateral Hypothalamus
VLPO – VenteroLateralPreOptic
TMN - TuberoMammillary Nucl
LDT/PPT – LateroDorsal- and PeduncoPontine Tegmental nucl

The ”sleep nucleus” in the hypothalamus (VLPO) inhibits the modulatory transmitter systems using GABA/Galanin



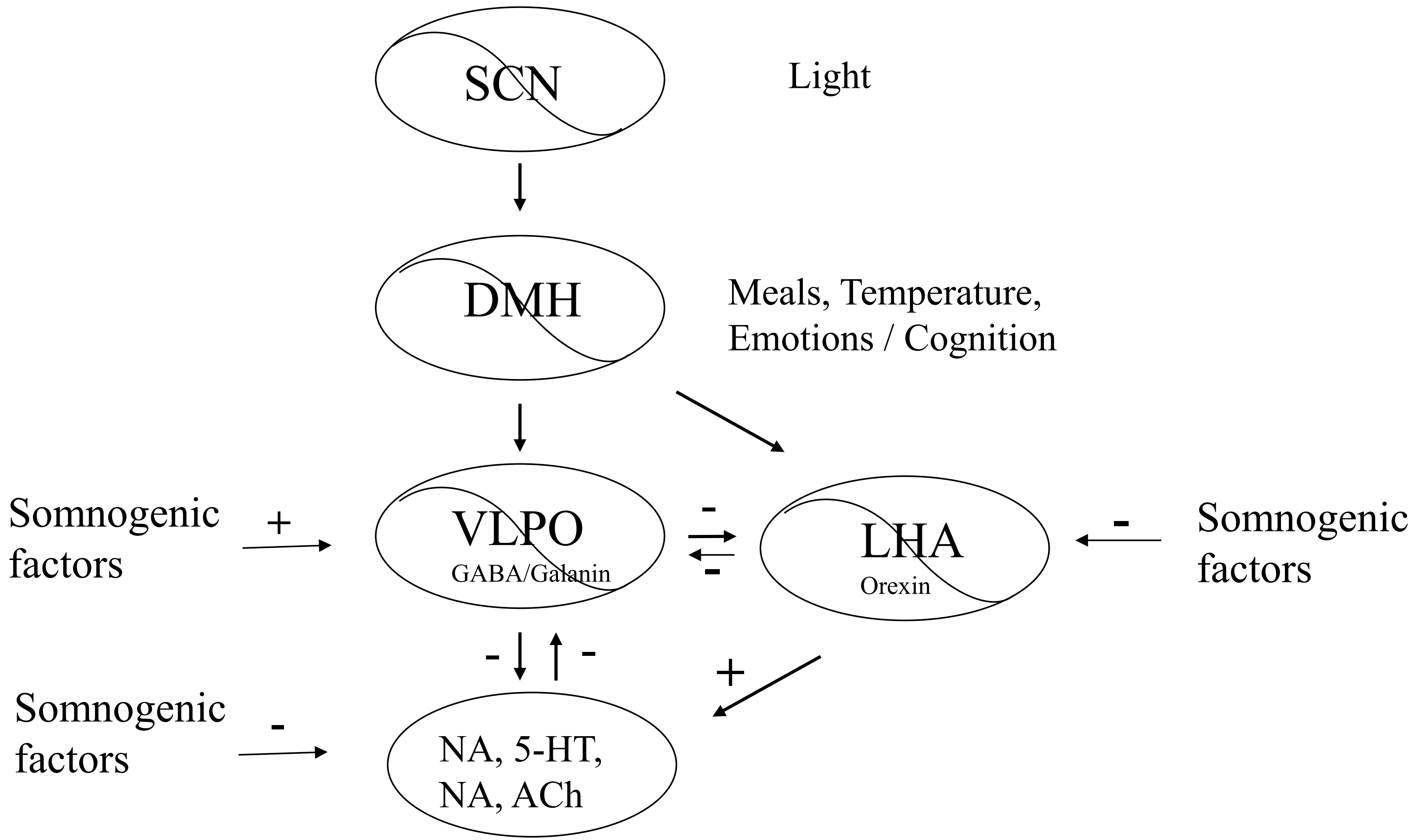
Saper et al (2005) Nature 437:1257

The cells in LHA and VLPO are under circadian control by the SCN via the DMH in the hypothalamus

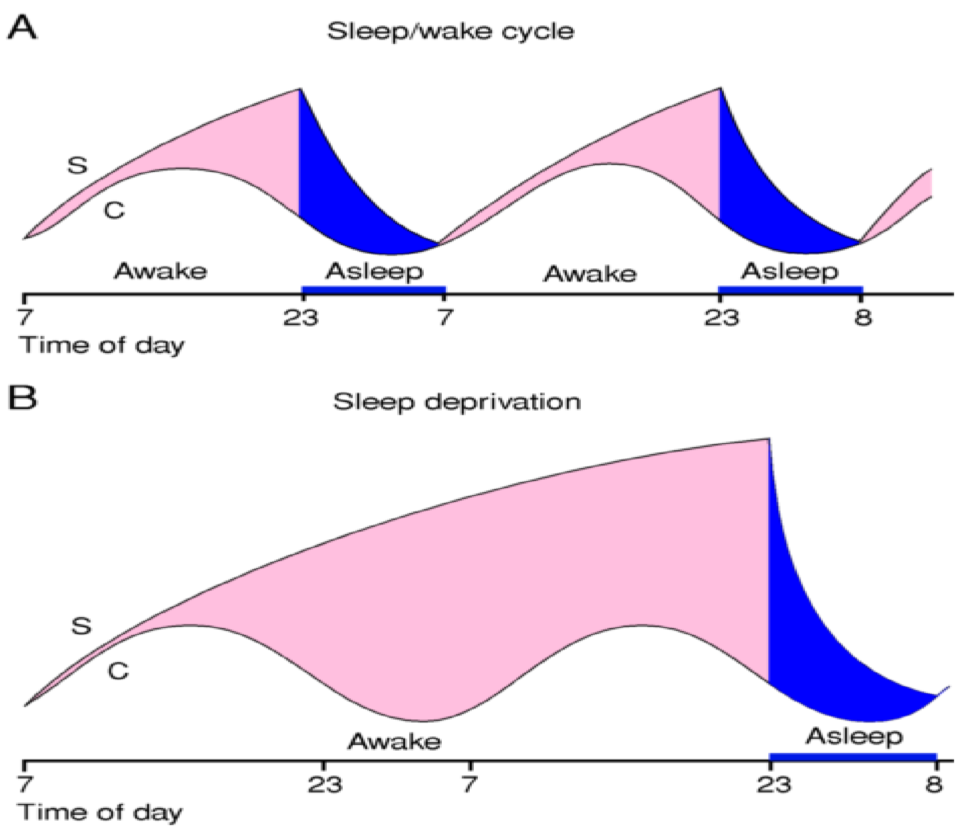


Saper et al (2005) Nature 437:1257

Sleep control



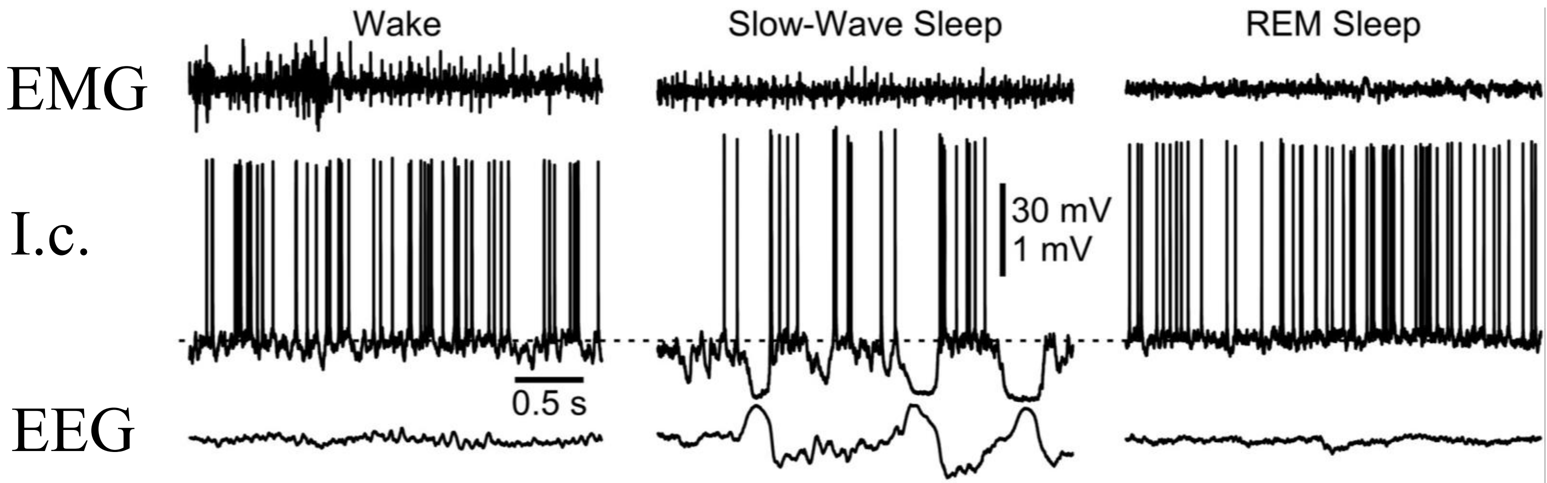
Adenosine is an ”somnogenic” factor contributing to sleep pressure



Three different brain states: Wake, NREM & REM

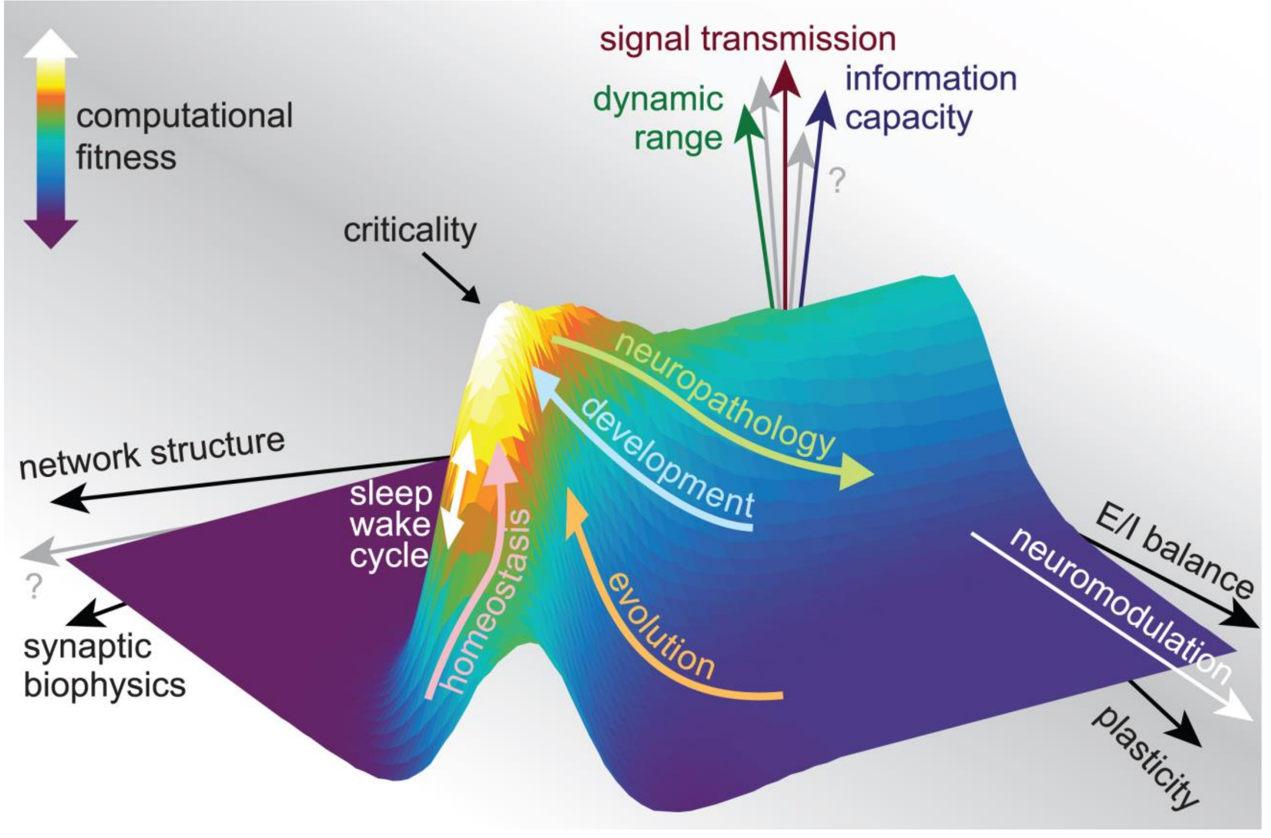
	Wake	**Non-REM**	**REM**
NA, 5-HT, Histamin	High	Low	Low
ACh	High	Low	HIGH
Orexin	High	Low	Low
EEG	Desynchronized	Synchronized	Desynchronized
Energy consumption	High	Moderate	High
Muscle tonus	High	Moderate	Low
Breating / Heart rate	Regular	Regular	Oregelbunden
Temperature regulation	Functioning	Functioning	Non-functioning
Eye movements	Vision	Slow	Fast (REM)

Modulatory transmitters and changes of e.c. ion conc. regulate the activity of cortical neurons



Timofeev & Chauvette (2018) Neuron 97:1200-1202

An optimal level of neuronal network activity in the brain - Criticality



Hengen & Shew (2025) Neuron 113:1-17

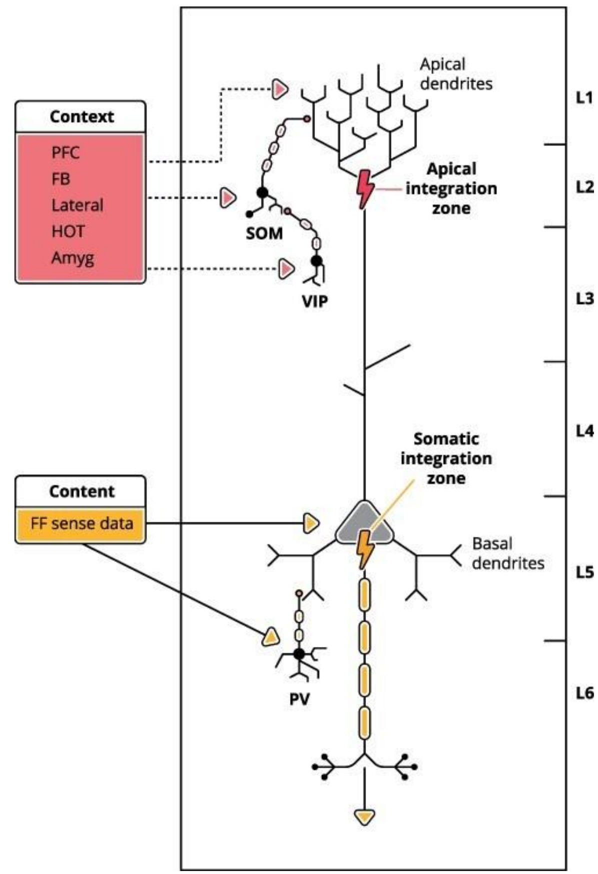
Loss of consciousness during sleep and anaesthesia because ”decoupling” of cortical pyramidal neurons?

Cell

General Anesthesia Decouples Cortical Pyramidal Neurons

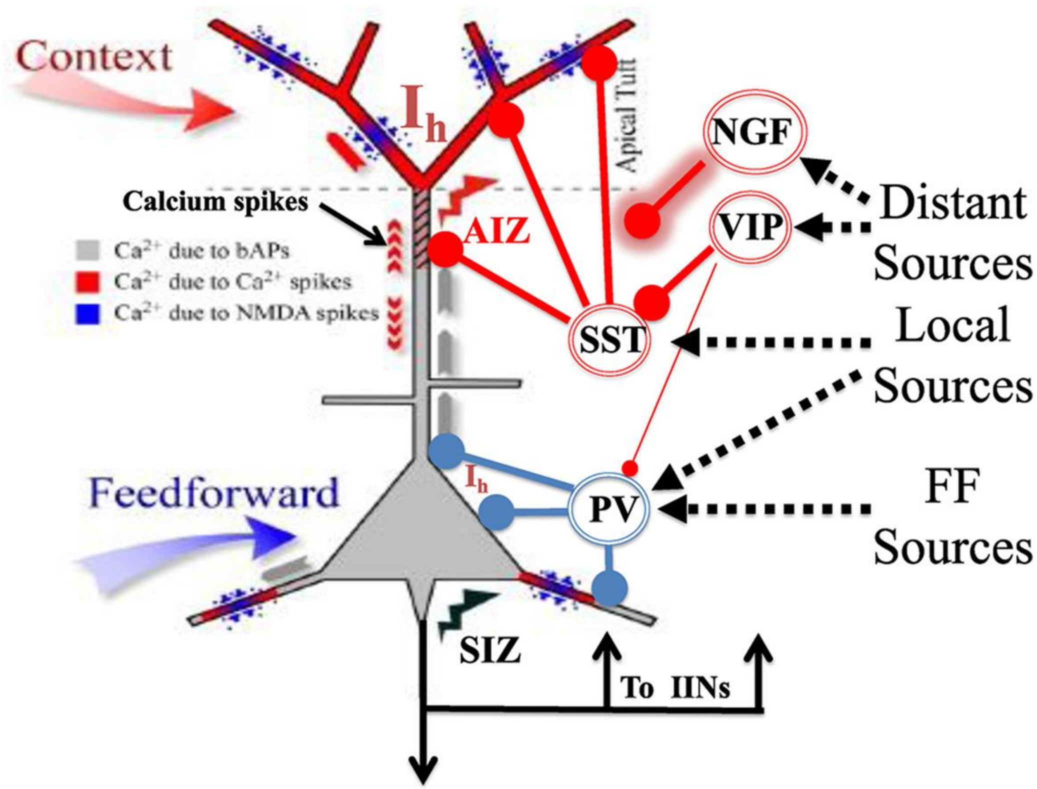
Mototaka Suzuki[1,2,*] and Matthew E. Larkum[1]

Cell 180, 666–676, February 20, 2020

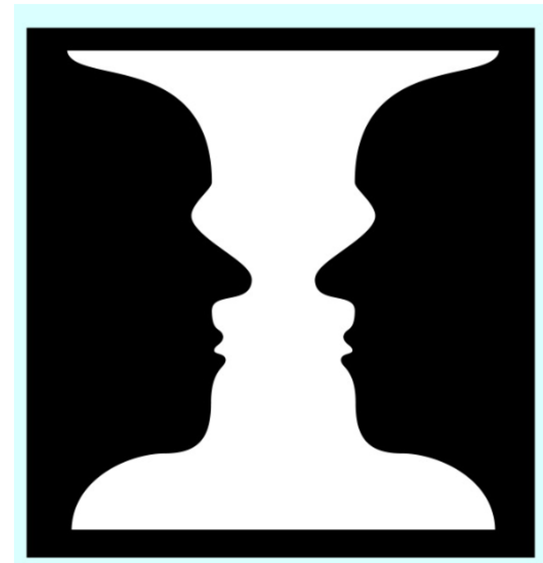


Marvan et al (2021) Neurosci Conscious 7: 1-17

Cortical pyramidal neuron with two action potential initiation zones comparing Content with Context

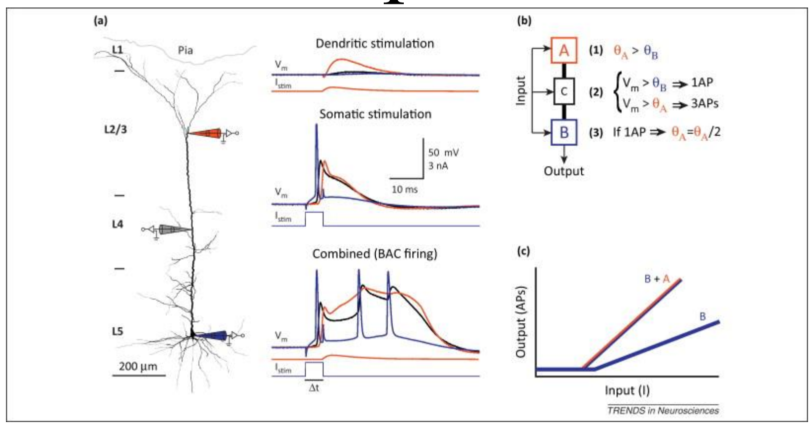


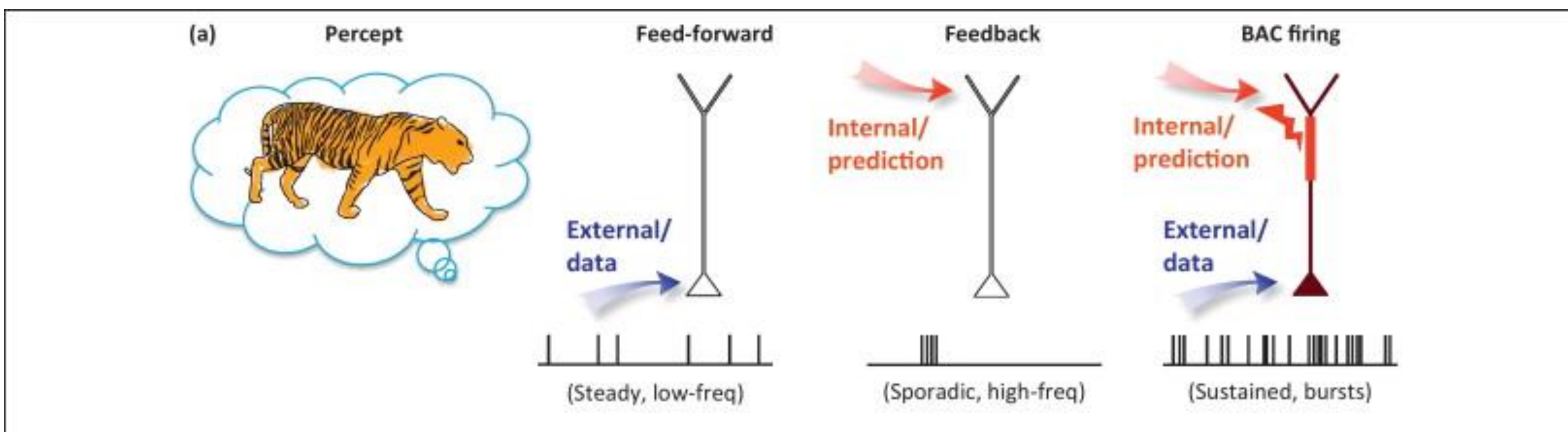
Granato et al 2024 Neurosci and Biobehav Rev 161: 105688



”Predictive coding” and
”Predictive error”

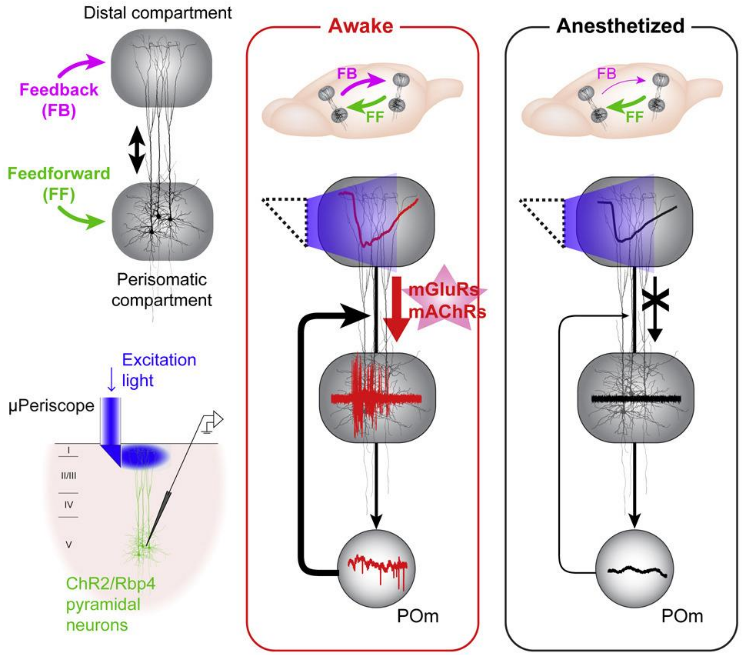
Simultaneous apical feedback and basal feedforward inputs provide synergistic firing output





Larkum (2012) TiNS 36:141-149

Promoting apical and basal coupling enables consciousness



Suzuki & Larkum (2020) Neuron 180: 666-676

Neuroscience and Biobehavioral Reviews 119 (2020) 440–455

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Review article

Apical drive—A cellular mechanism of dreaming?

Jaan Aru[a,b,1,*], Francesca Siclari[c,d,e,1,**], William A. Phillips[e,***], Johan F. Storm[f,***]