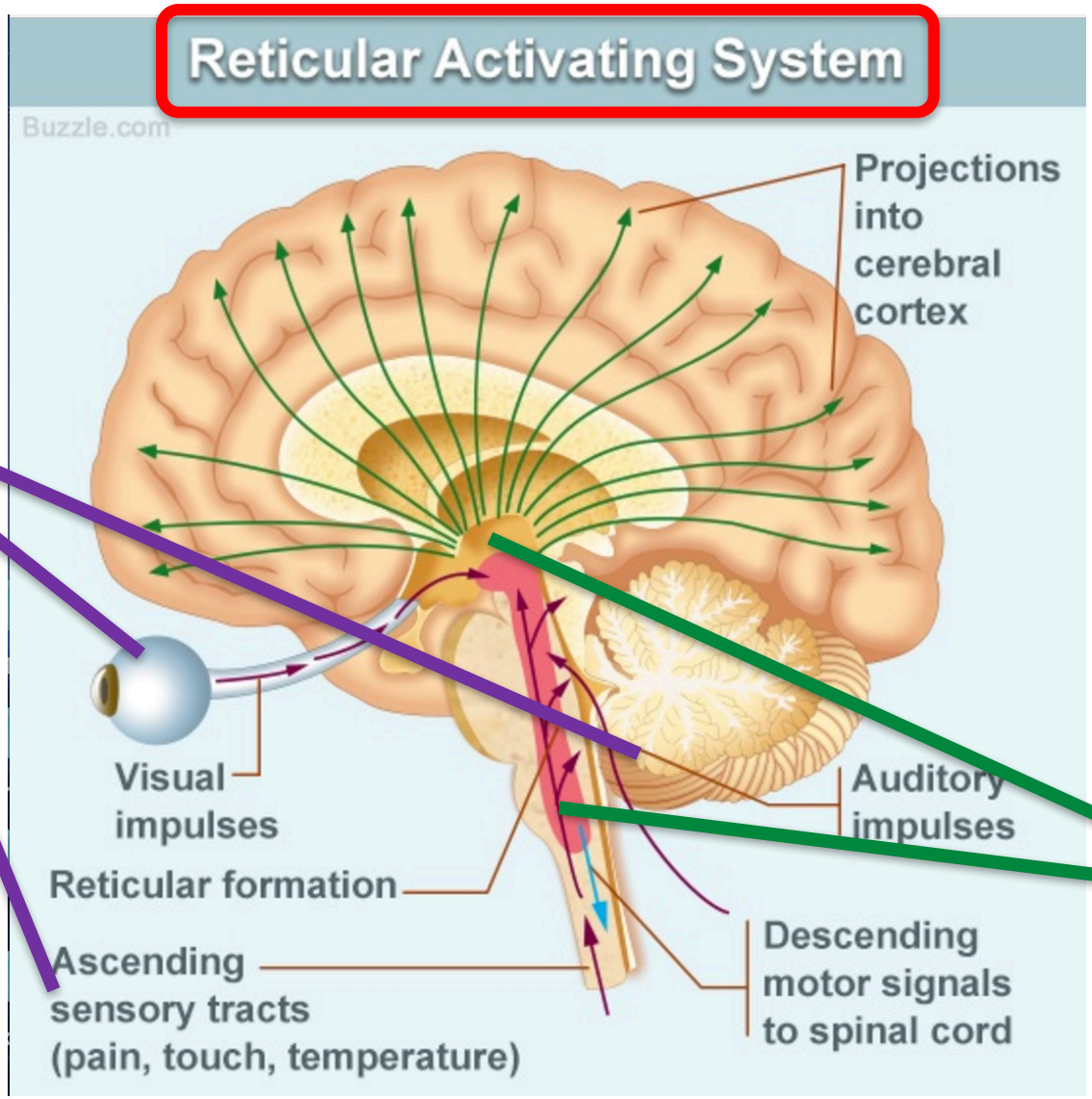
Lecture 8

Arousal & Sleep

Cogs17 * UCSD

Arousal in the Brain



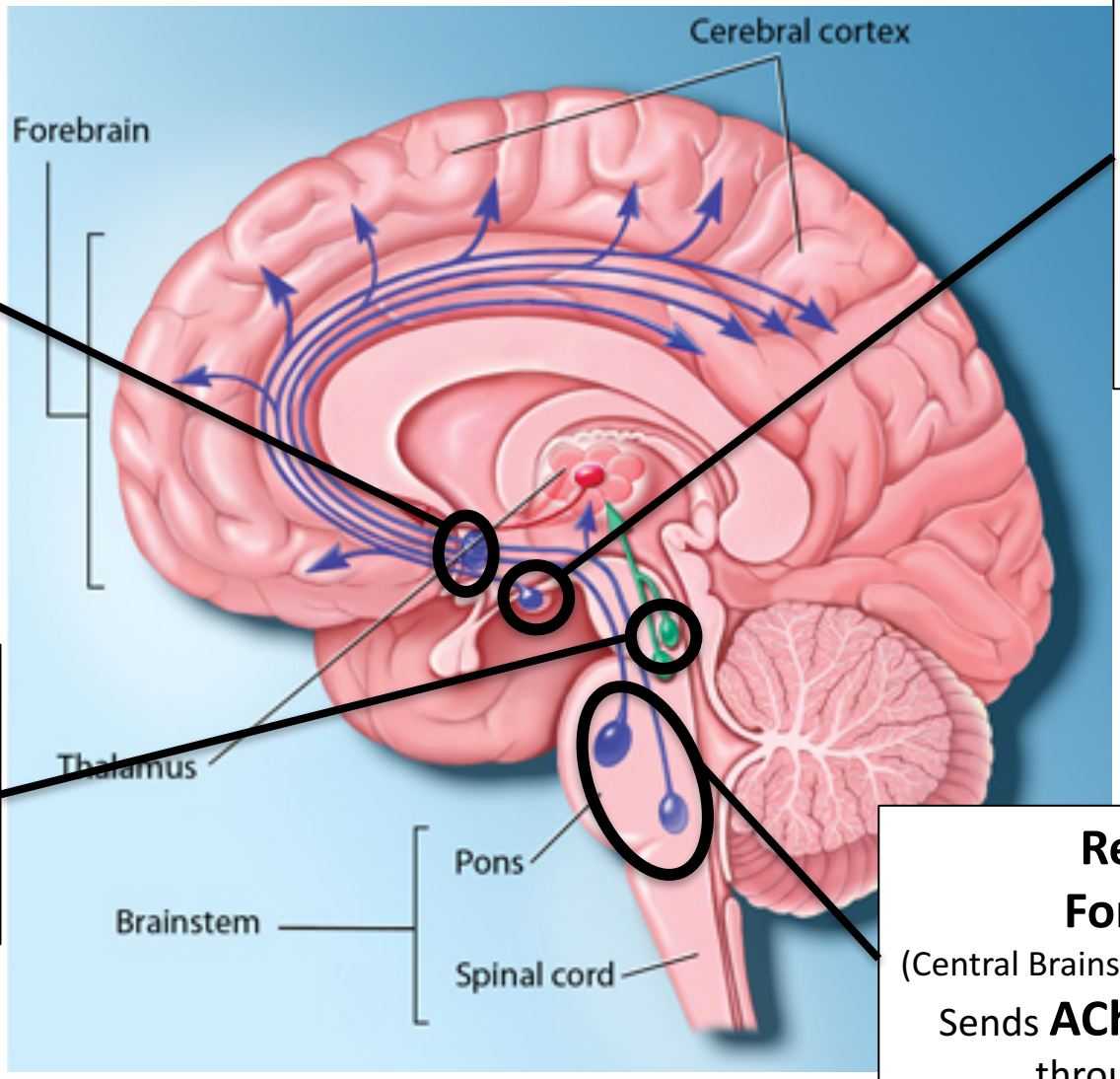
Stimulated by sensory input

Also initiated, maintained endogenously

Arousal in the Brain

Basal Forebrain
Delivers **ACh** throughout cortex

Locus Coeruleus
("Dark Blue Place")
Releases **NE** for Vigilance, Alerts memory

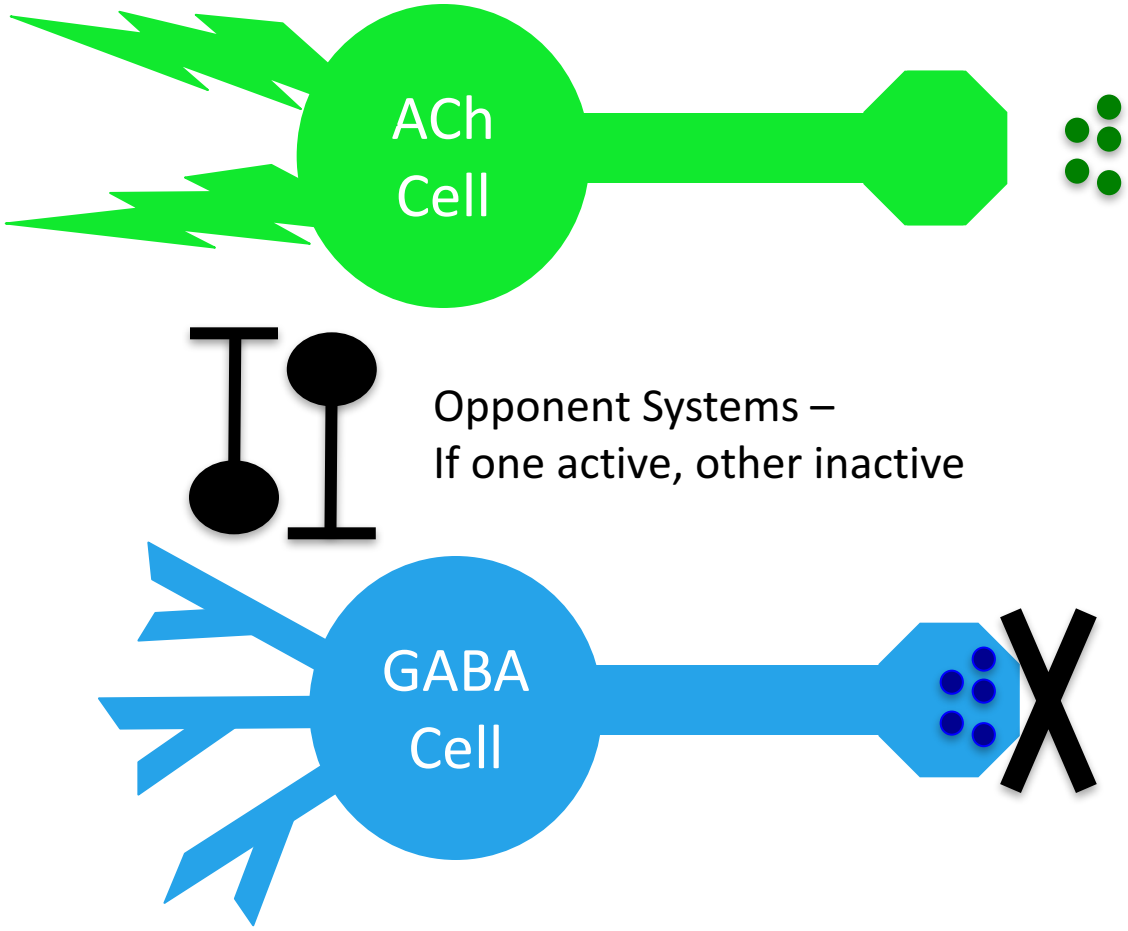


Lateral Hypothalamus
releases **Orexin**, helps maintain arousal in these other systems, based on <u>body conditions</u>

Reticular Formation
(Central Brainstem, Lateral to Raphe)
Sends **ACh** & **Glutamate** throughout brain

How does Caffeine help you wake up?

Basal Forebrain



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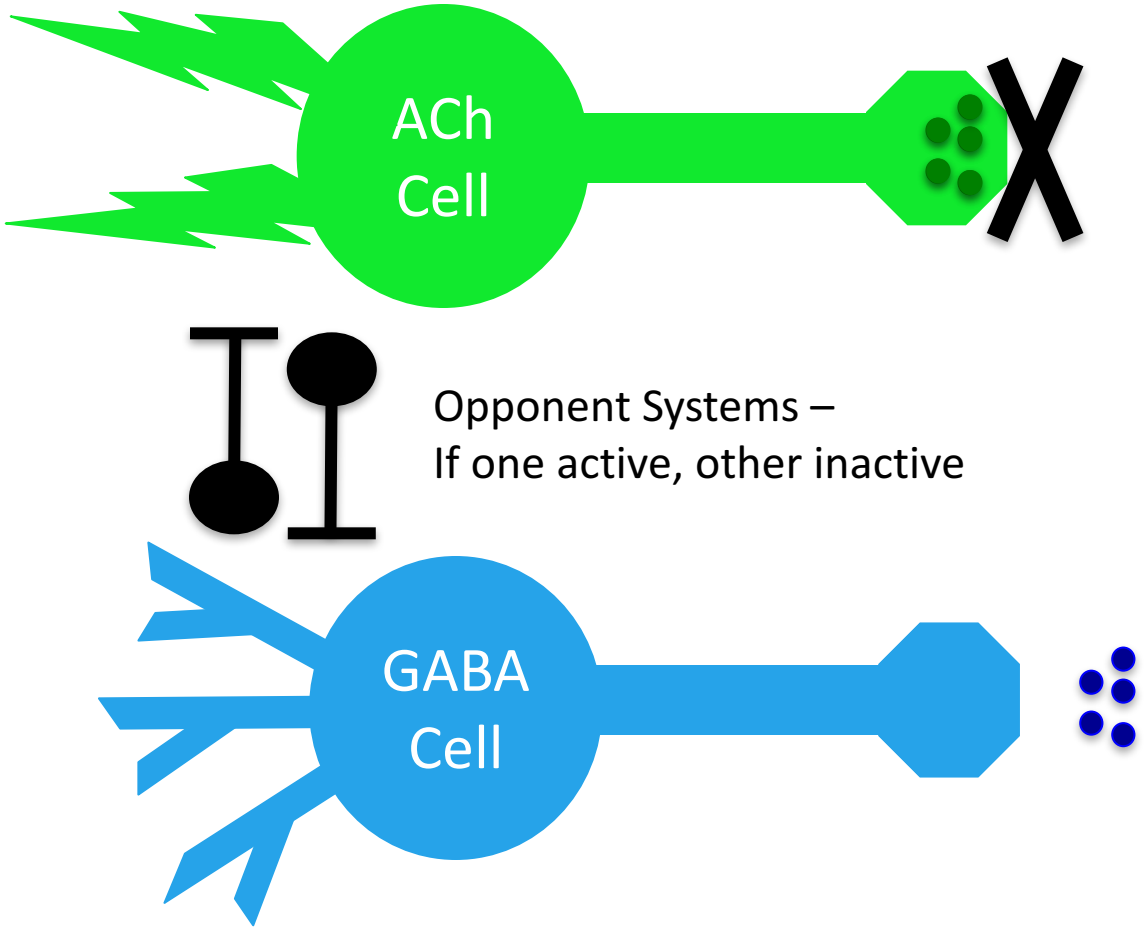

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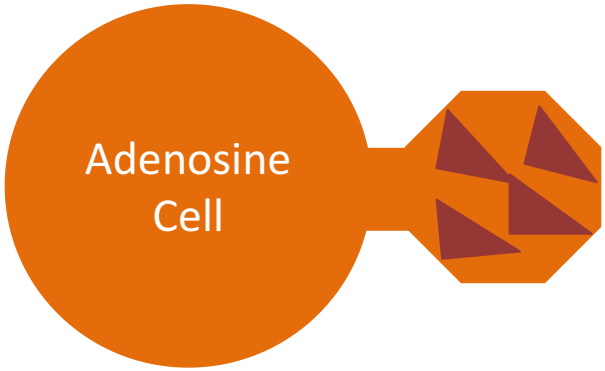
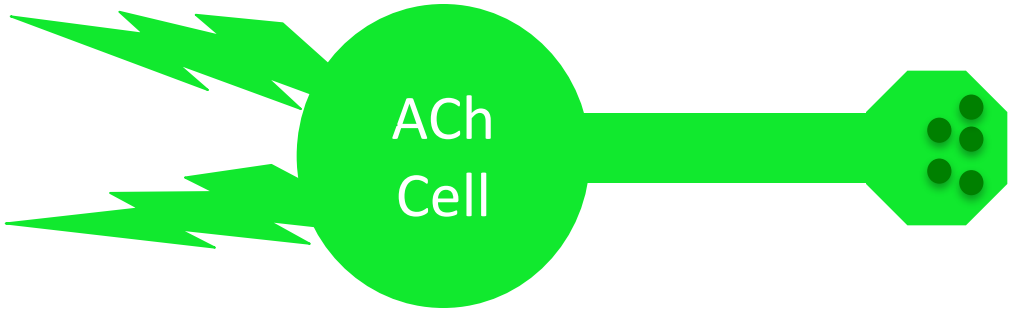
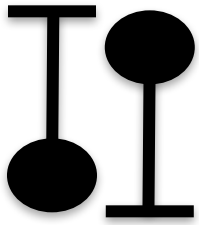
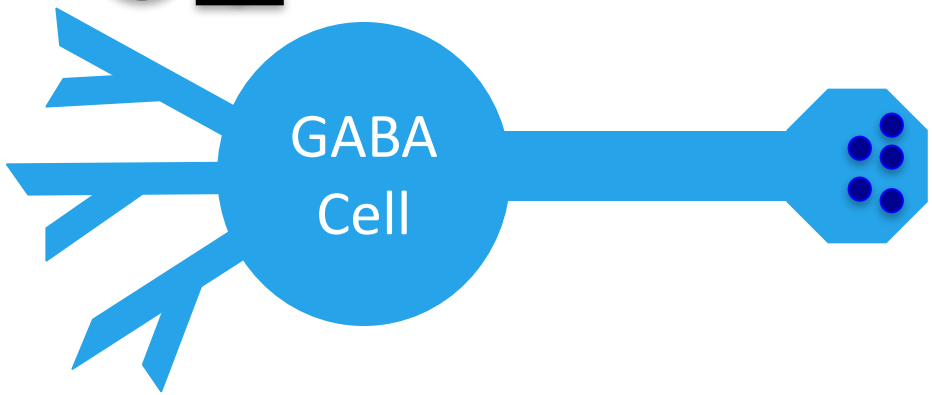




Adenosine
(a metabolic byproduct)
builds up in cells
during the day



Opponent Systems –
If one active, other inactive



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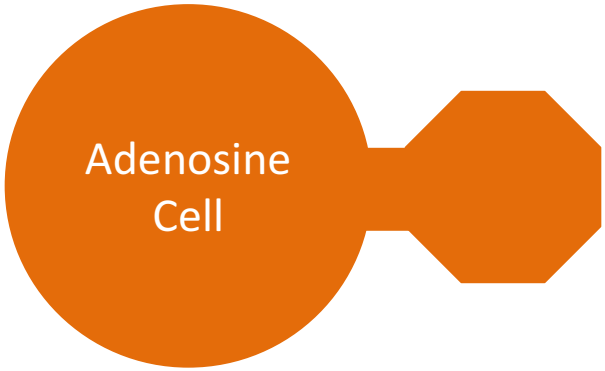
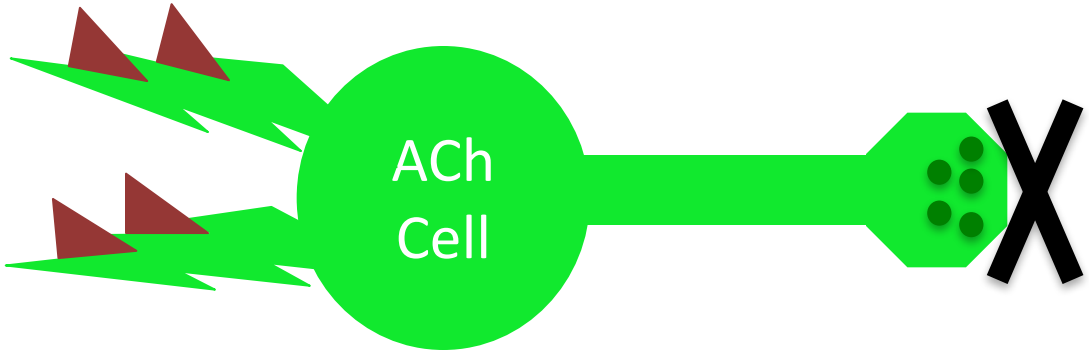
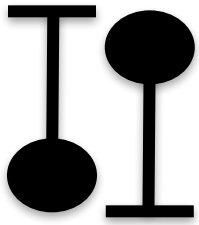




Adenosine
(a metabolic byproduct)
builds up in cells
during the day

Its release
Inhibits ACh cells
in Basal Forebrain,
allowing **GABA** system
to dominate
>> **Sleep**



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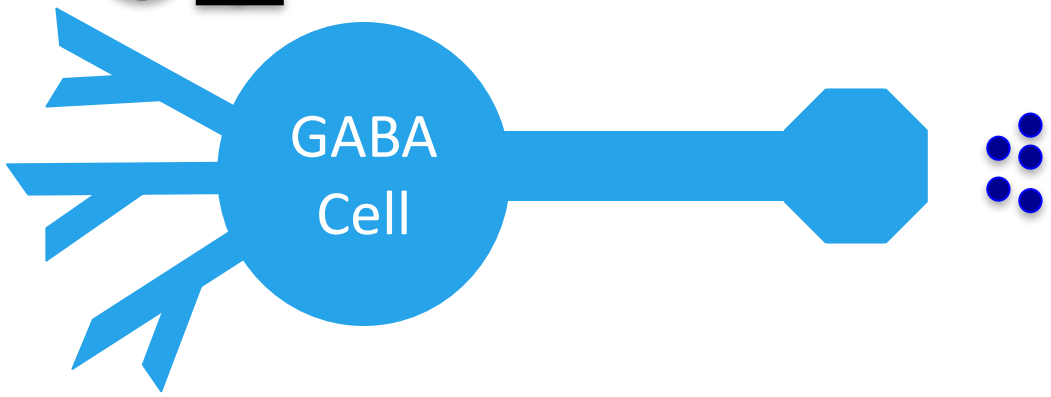

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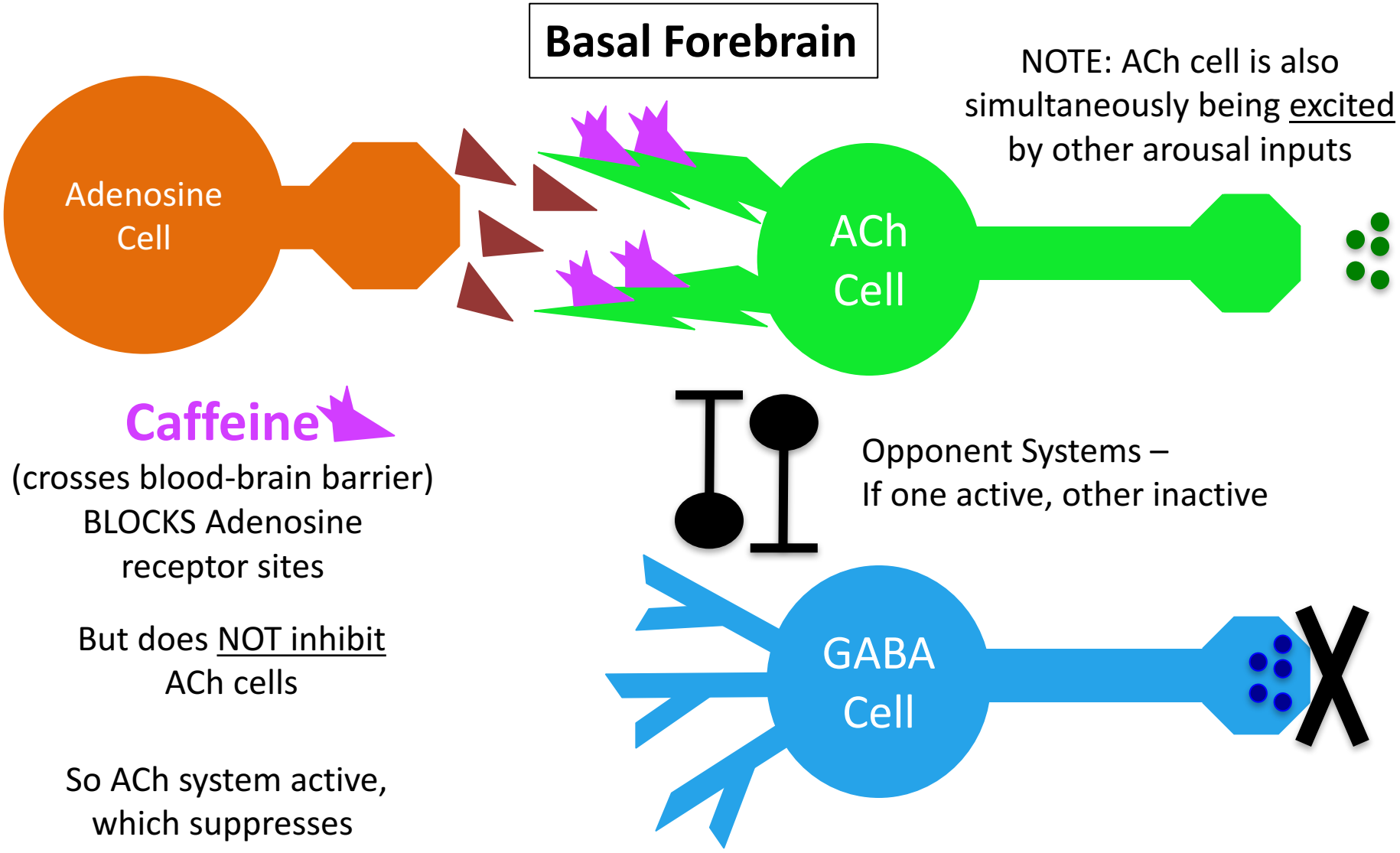
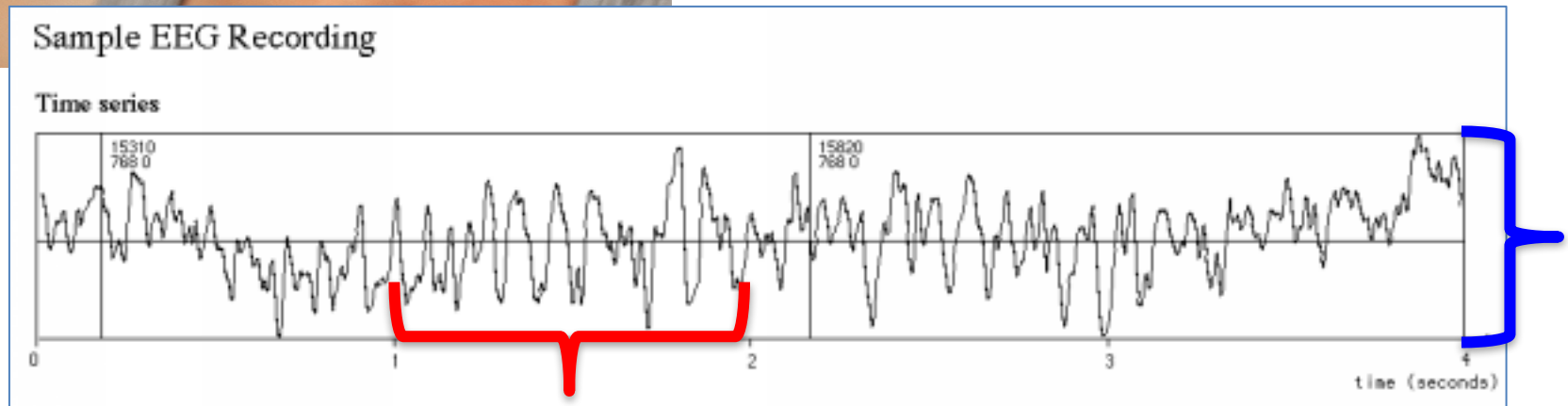


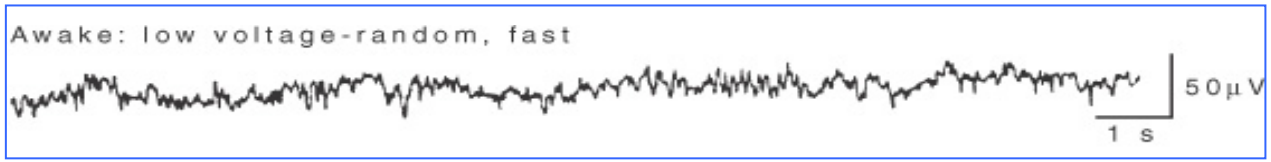
EEG - Electro-Encephalogram

Gross average change in
electrical potentials
in area under electrode

Amplitude = Voltage

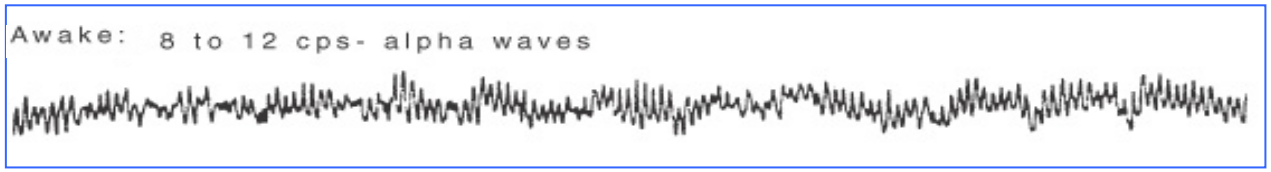
Frequency = Cycles per second (Hz)





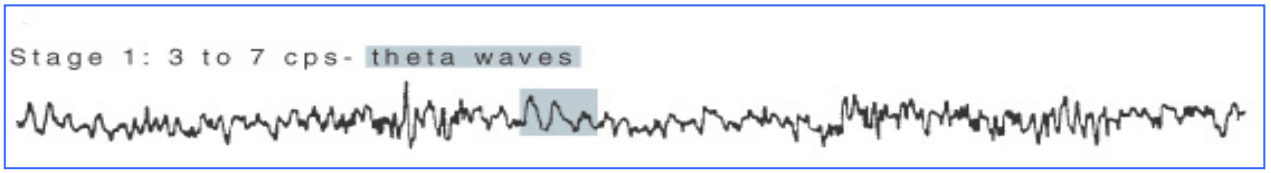
Awake

Beta (18-24 Hz)



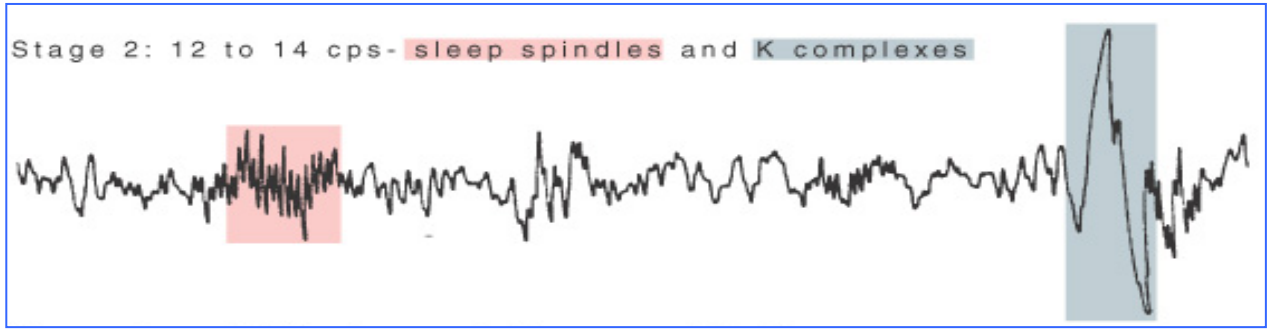
Alert & Relaxed

Alpha (8 -12 Hz)



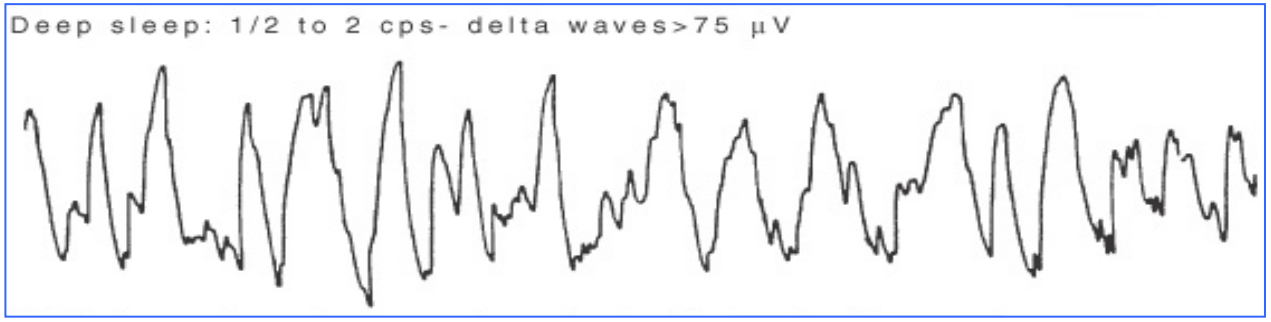
Stage 1

Theta (4-7 Hz)



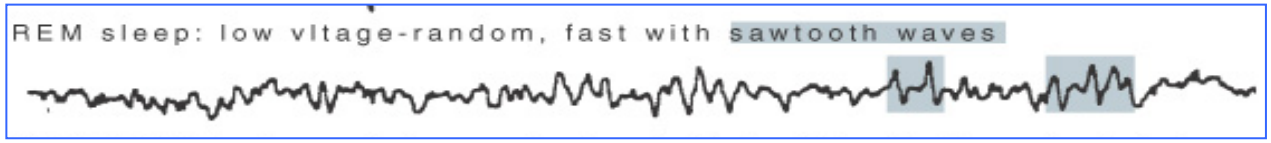
Stage 2:

Theta w/Spindles
and K-Complexes



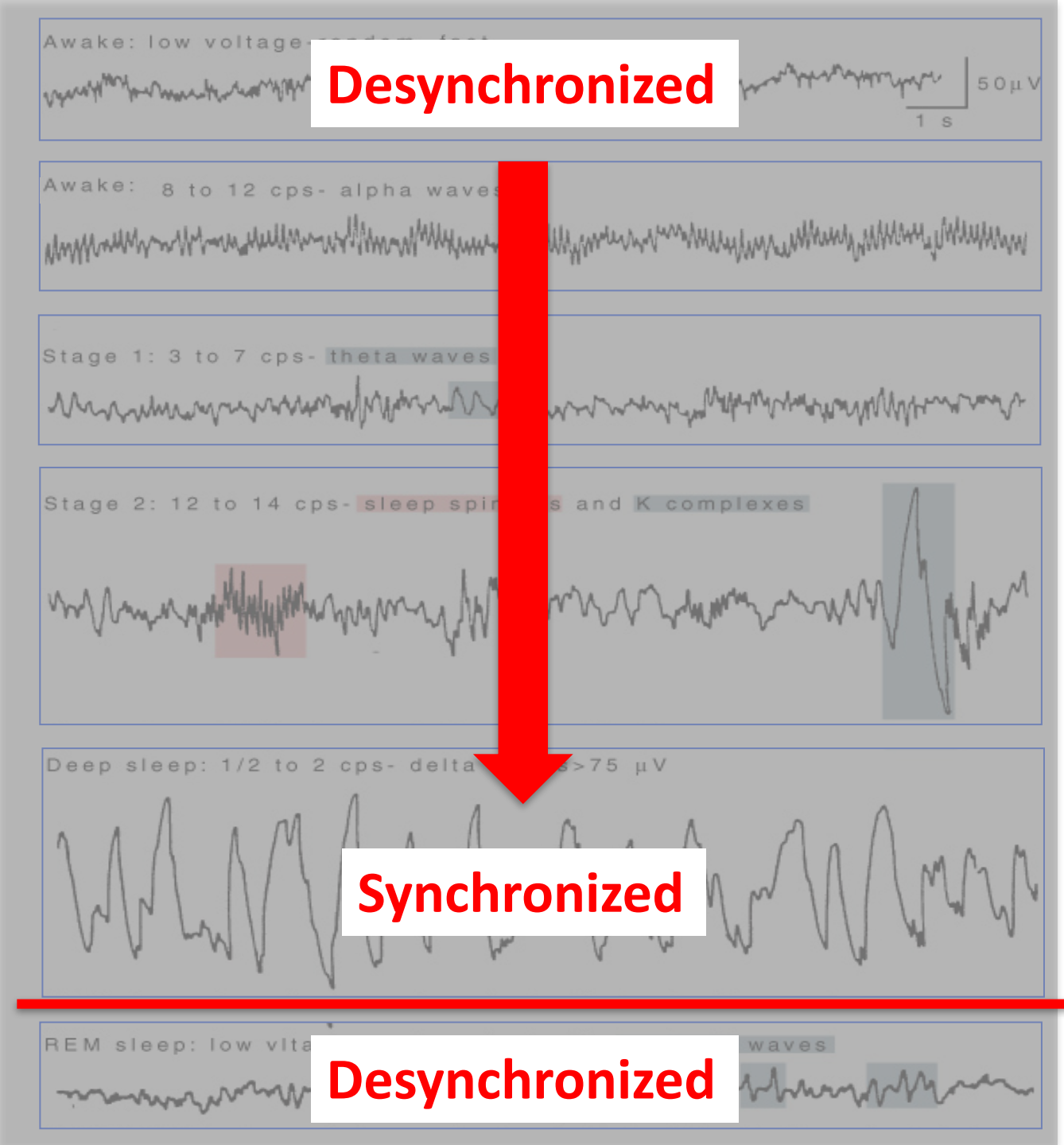
Stage 3 & 4
"Slow Wave Sleep"

Delta (< 4 Hz)
3=<50% 4=>50%



REM

Variable EEG: 12-28 Hz



Awake

Beta (18-24 Hz)

Alert & Relaxed

Alpha (8 -12 Hz)

Stage 1

Theta (4-7 Hz)

Stage 2:

Theta w/Spindles
and K-Complexes

Stage 3 & 4

"Slow Wave Sleep"

Delta (< 4 Hz)

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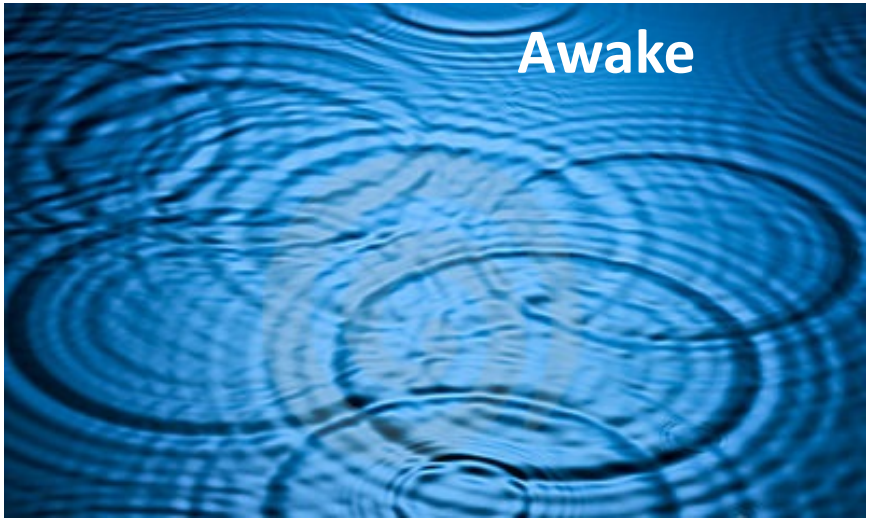
REM

Variable EEG: 12-28 Hz

Desynchronized

Lob many stones into a pond…



Lob one stone into a pond…

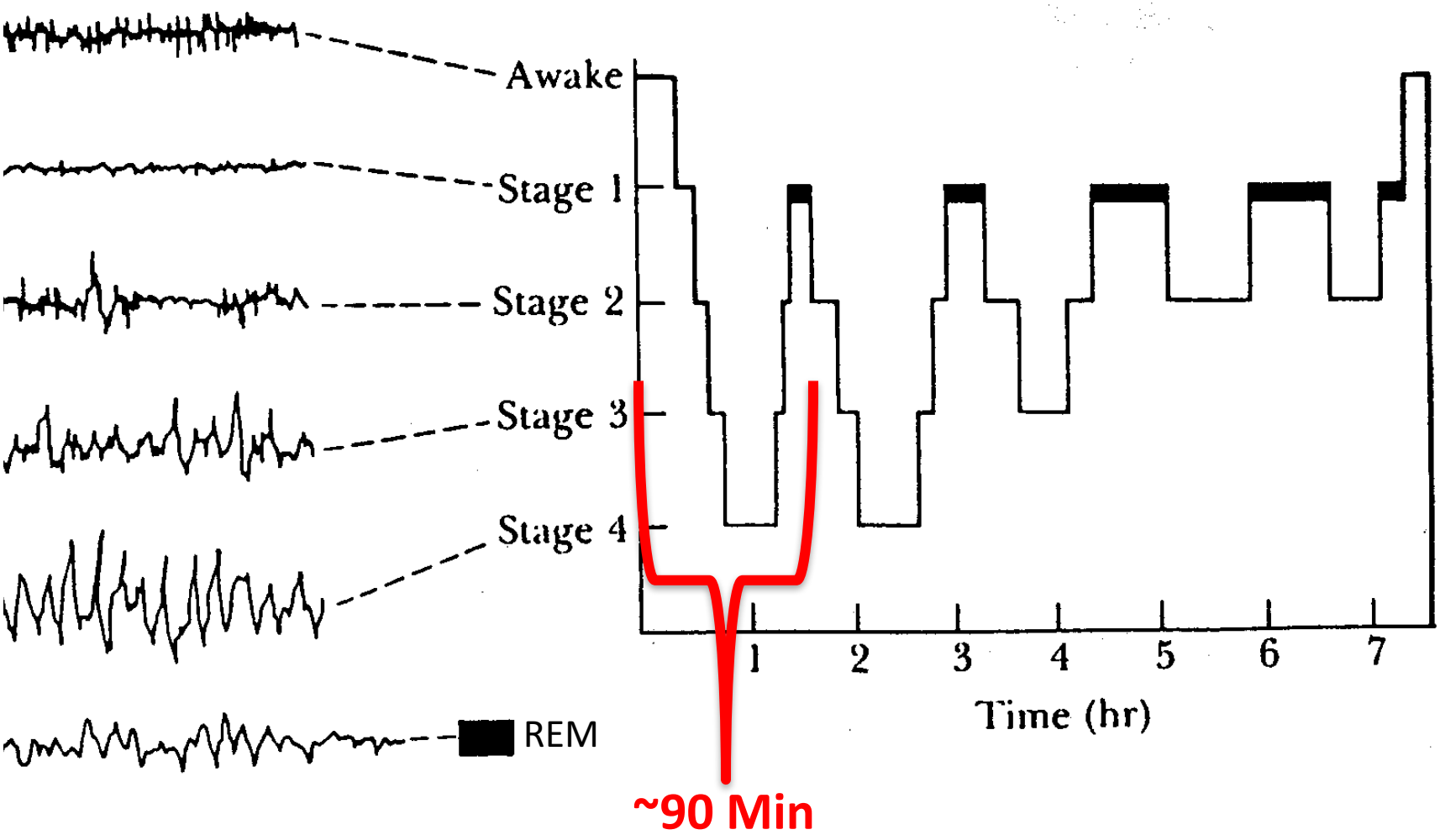
Synchronized

Lob *imaginary* stones into a pond…

Desynchronized

Sleep Cycle

~ 90 Minute Cycle: Stage 1, 2, 3, 4, 3, 2, REM



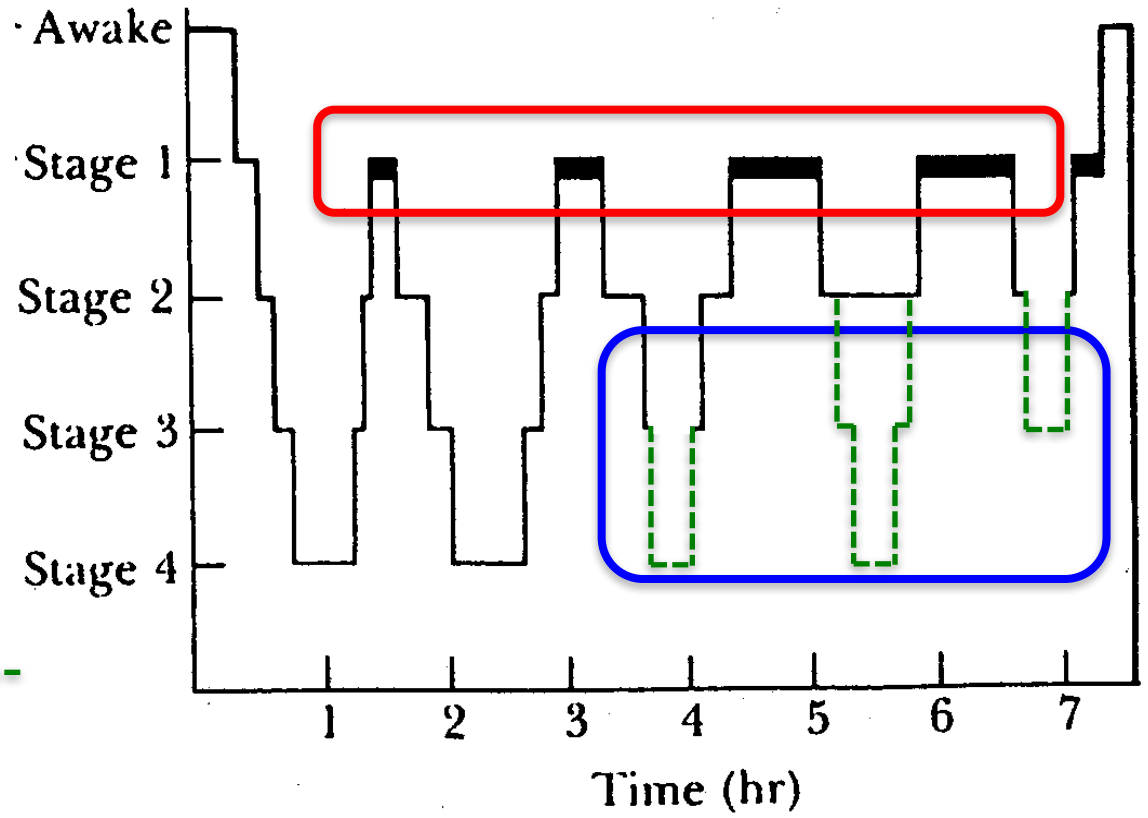
Sleep Cycle

~ 90 Minute Cycle: Stage 1, 2, 3, 4, 3, 2, REM

As night progresses,
less Slow Wave sleep

Duration of REM increases

Deprived of sleep >>
show **more Slow Wave**



Sleep Deprivation >> Lethargy, poor concentration, irritability;
Decreased resistance to infection

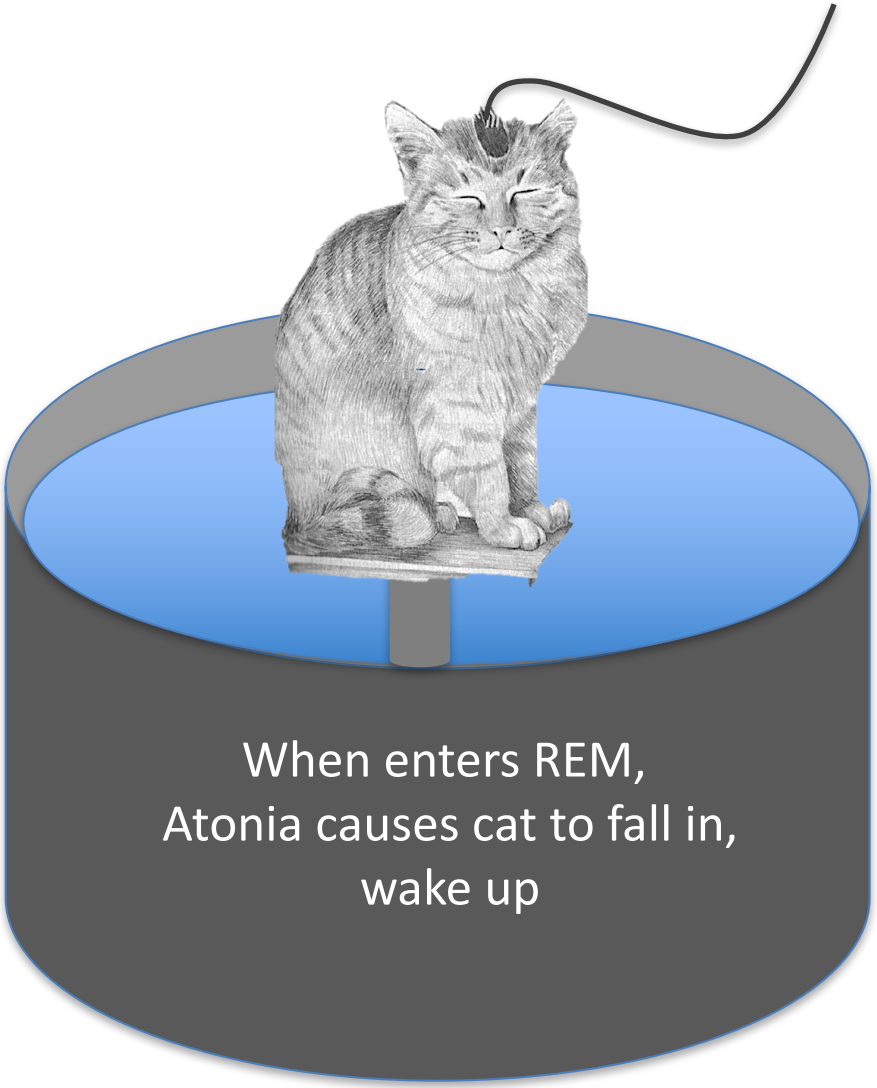
REM (Rapid Eye Movement) Sleep

Also called "Paradoxical" Sleep

- EEG Desynchronized
  high freq, low voltage
- Heart & breathing rates
  highly variable
- Eyes move, genitals active
  but muscles paralyzed
  "ATONIA"
- Highly correlated with
  DREAMING

REM Deprivation

Cat on pedestal in tank – recording EEG



So, selectively deprive it of REM sleep

REM-deprived cat displays….

- Irritability
- Poor concentration
- Hallucinations
- Death!

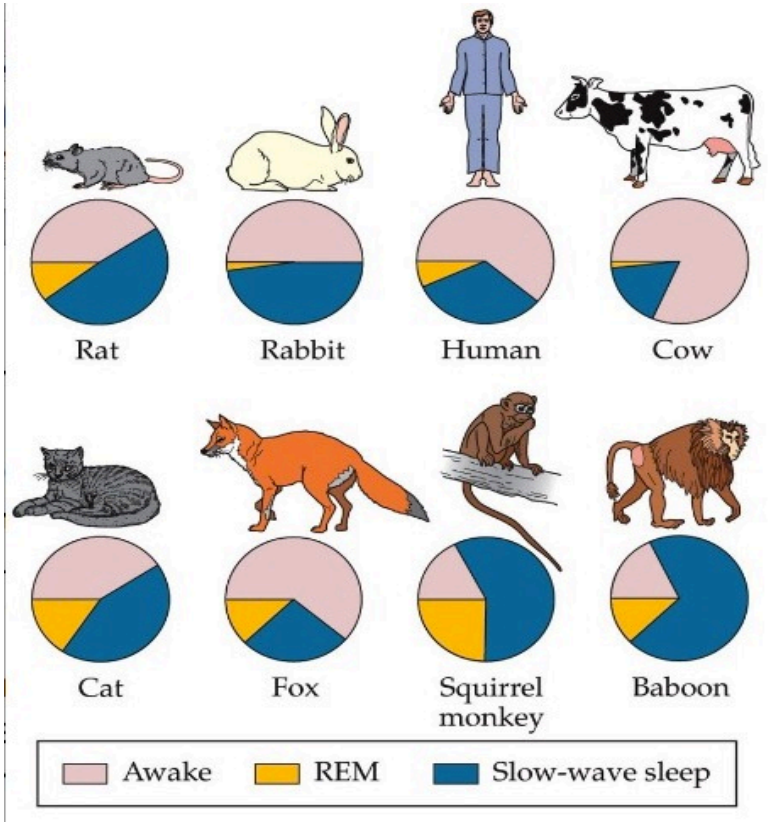
If REM deprived, will show

REM rebound

- <u>REM periods lengthen</u>

Functions of Sleep & REM ???

- Controversial!
- Sleep IS restorative
  - Engage in critical metabolic processes, process waste, etc
  - But, then why do some animals (e.g. prey) sleep only a few hours while others require so much more (e.g. predators) ?



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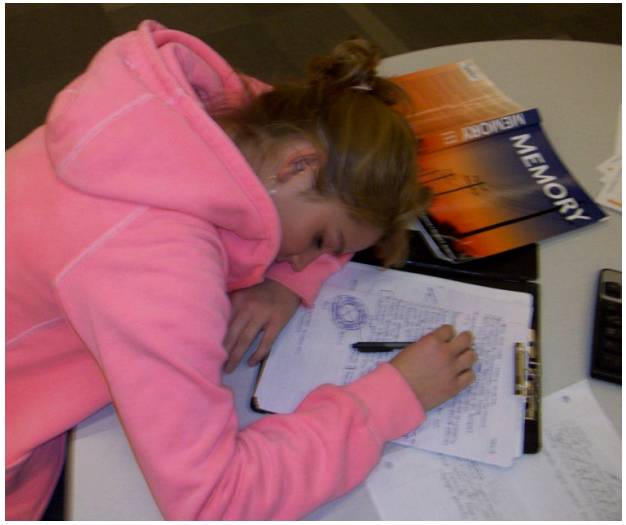
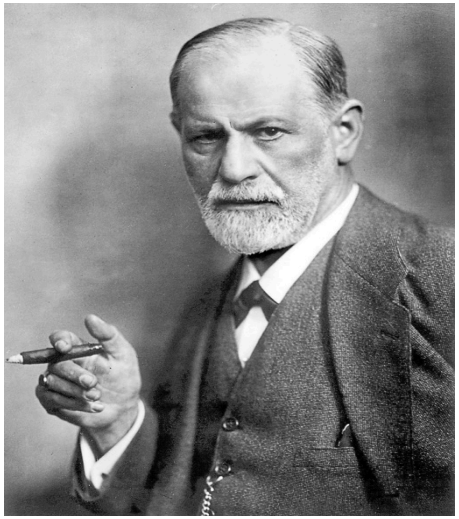
  - REM-deprived have poorer memory for previous day's learning
  - Dreams may be involved in helping to resolve psychological conflicts





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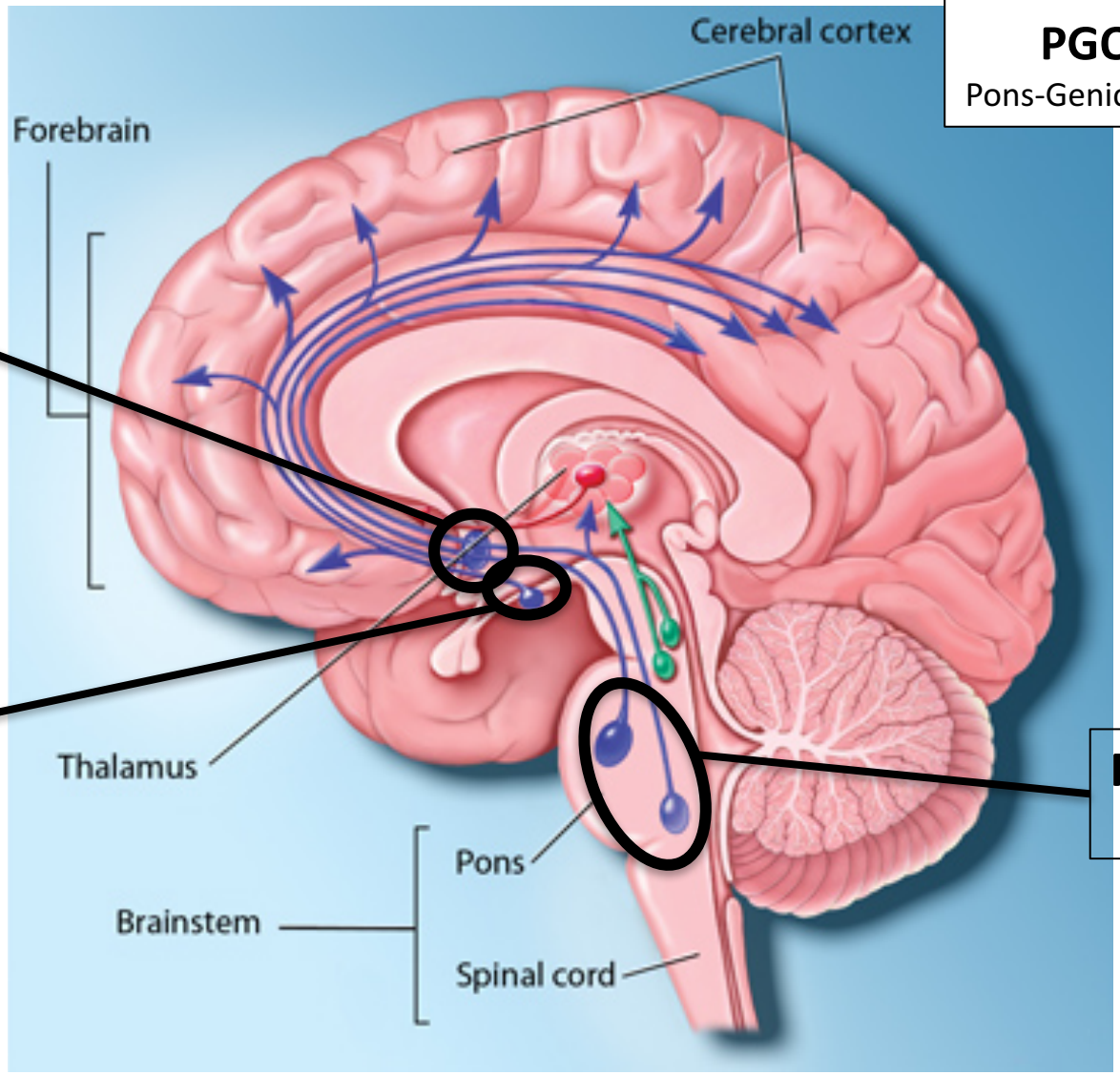
- Slow-Wave/REM cycle may also involve temperature regulation
  - Brain operates within a very narrow range of temperatures
  - Brain cools down during Slow-Wave sleep
  - REM warms brain (Poss why Hypothalamus triggers PGO wave?)

Regulating the Sleep Cycle

Plus
PGO Wave
Pons-Geniculate-Occipital

Hypohalamus:
VLPOA
(Ventro-Lateral
Pre-Optic Area)
>>**Basal Forebrain**

Hypothalamus:
Tubero-Mammilary



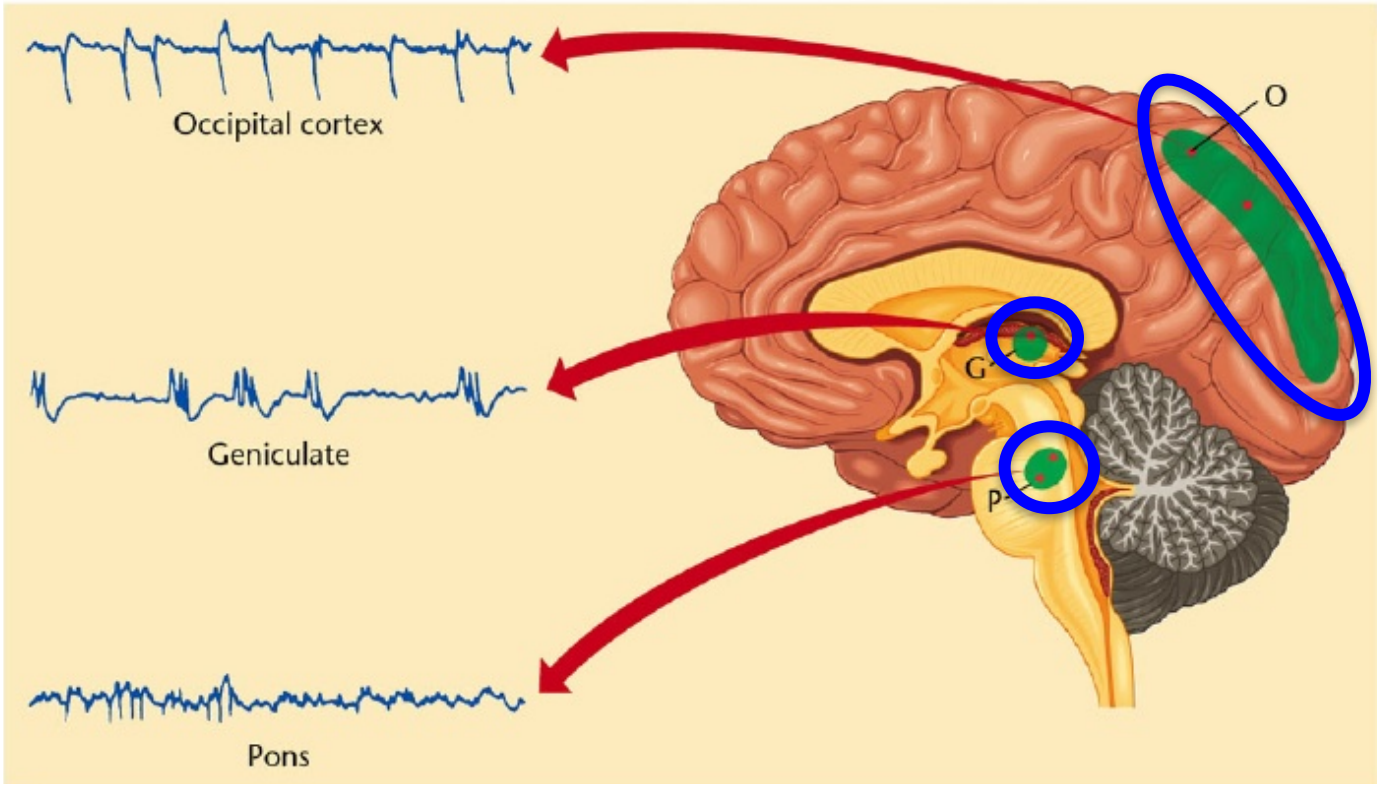
Raphe Nuclei
in medial Pons

REM – Initiated by PGO Waves

Then to
OCCIPITAL
(Visual) Cortex

Then to
Lateral Geniculate
of THALAMUS

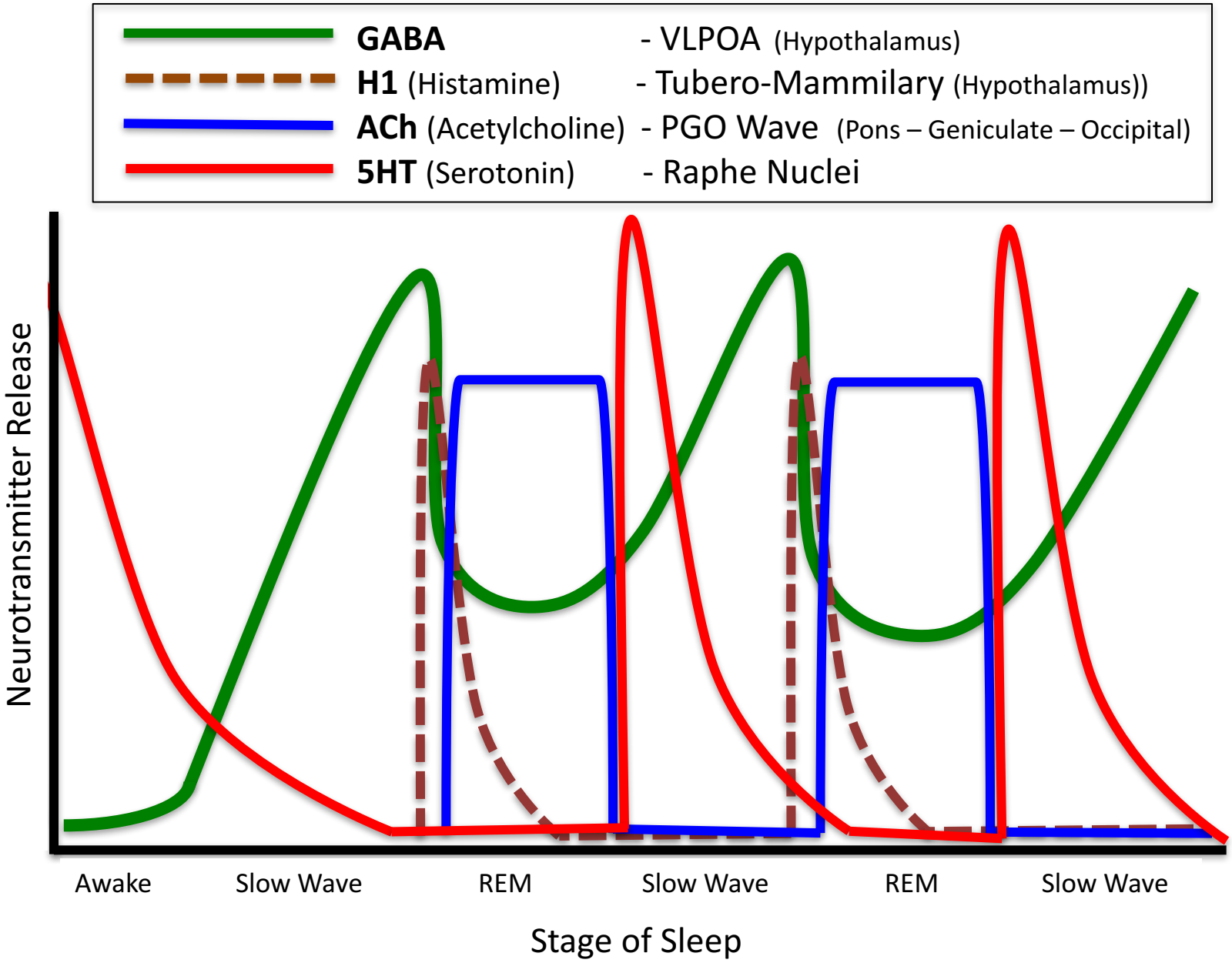
Activity begins in
PONS



REM

P → G → O

(Some) Neurotransmitters regulating Sleep Cycle



Circadium Rhythm

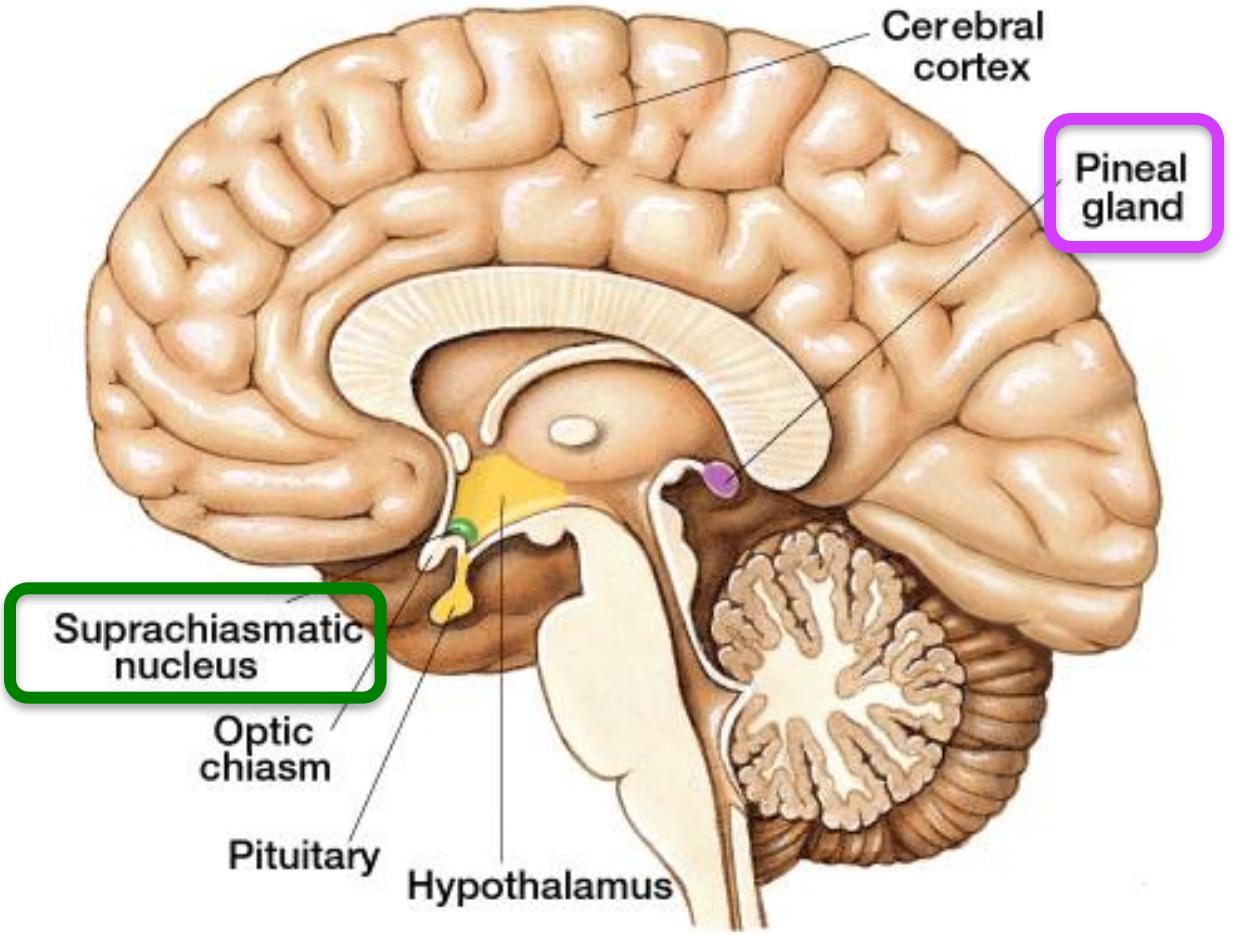
SCN

Suprachiasmic Nucleus of Hypothalamus

"Clock" maintains a 24 +/- 1 hour rhythm of activity

Virtually impossible to disrupt this rhythm in living cells

Apparently genetically controlled



Interacts with **Pineal Gland** – see more below

Circadium Rhythm

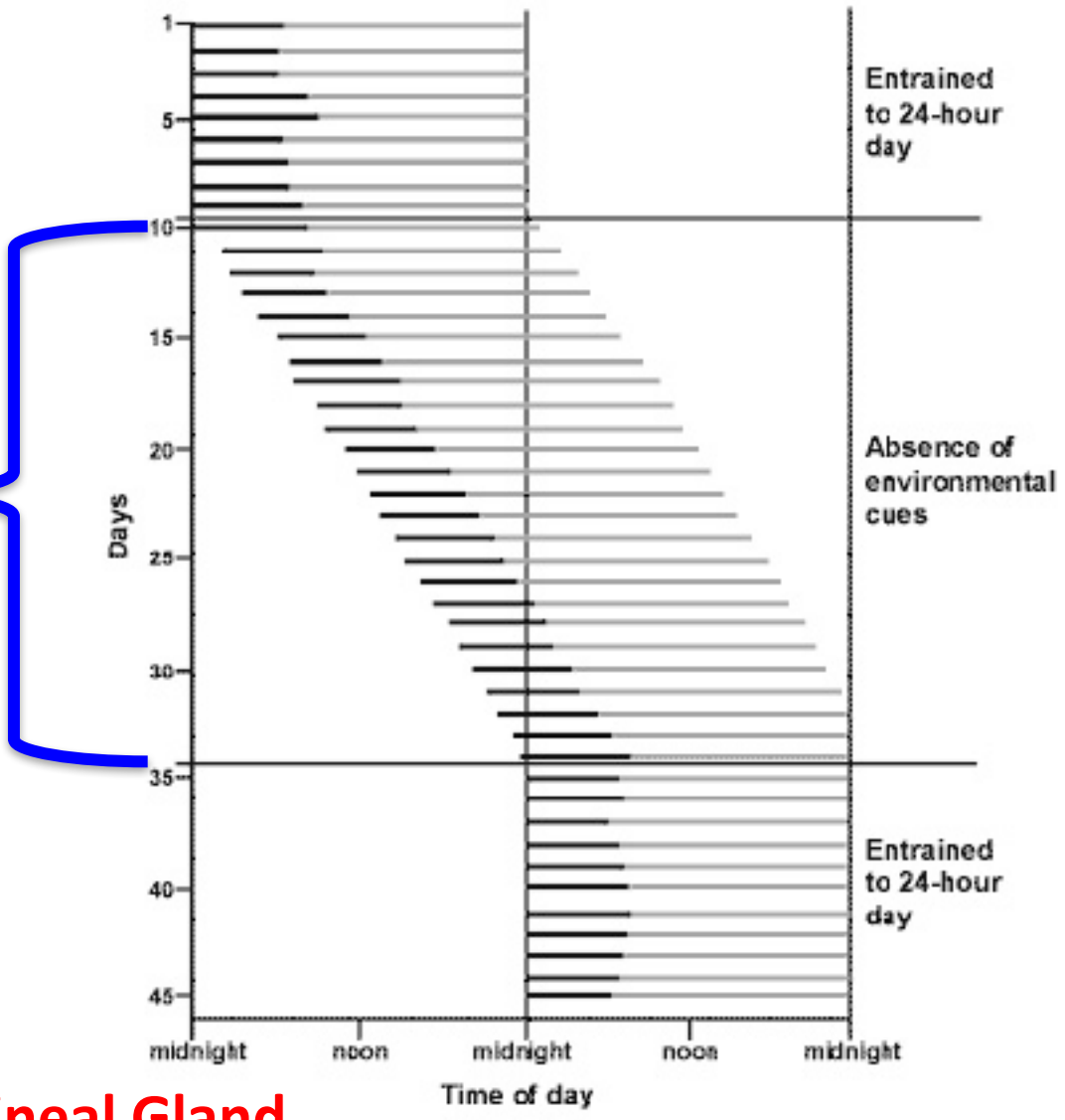
Subject asleep

Subject awake

In the absence of Day/Night cues…

…subject maintains 24=+/-1 hour rhythm…

…but cycle tends to **drift**



This flexibility allows creature to adapt to seasonal changes.

So, in addition to **SCN** clock, need a way to link it to time of day

"Zeitgeber" (Time Giver) = **Pineal Gland**

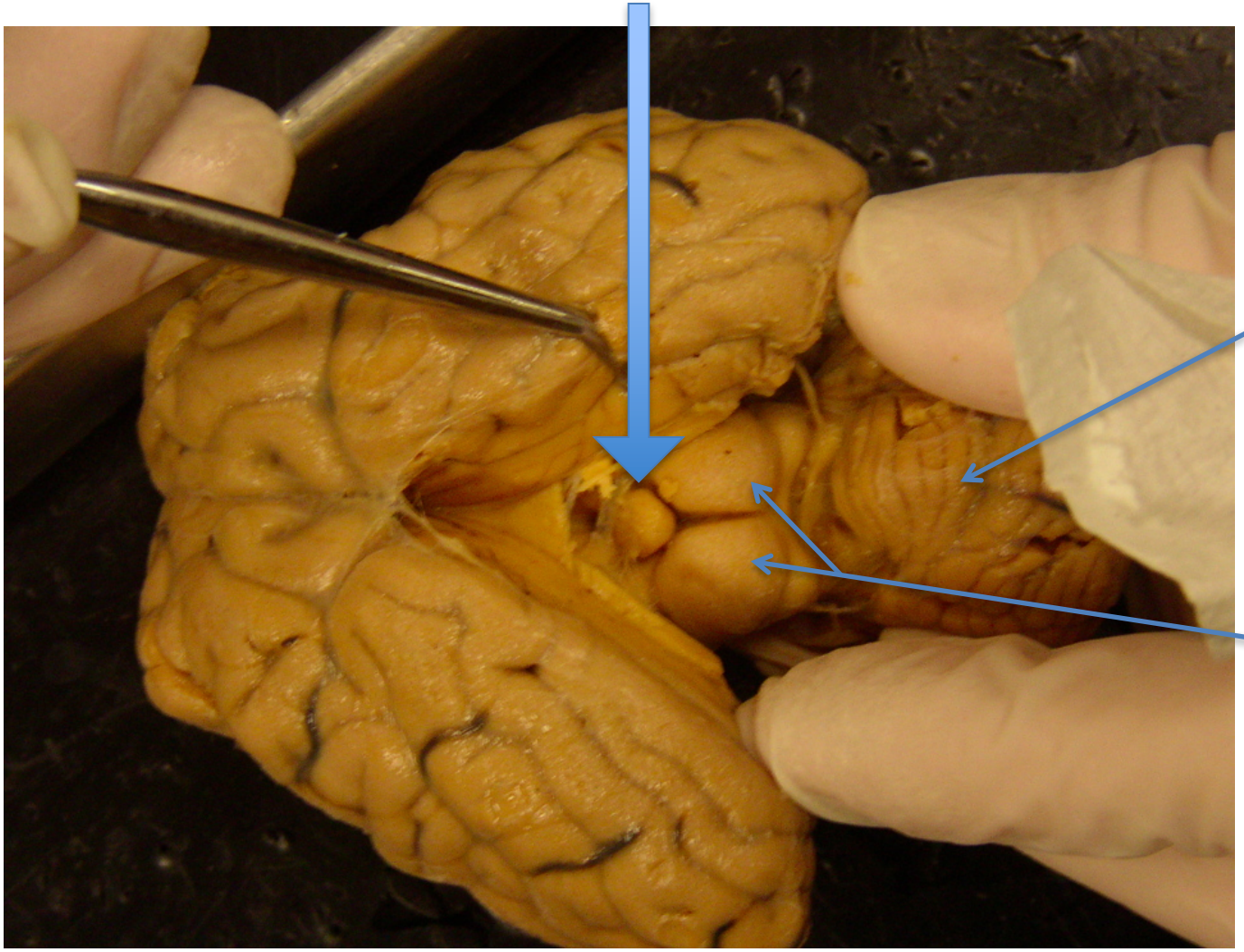
The Pineal Gland

"The Third Eye"

In some lizards & birds,
the **Pinal Gland**
(or specialized visual receptors to the Pineal Gland)
is a third eye!

While not exposed to the outside in humans,
it serves much the same function . . .

The Pineal Gland



Pineal gland releases **Melatonin** – promotes Sleep

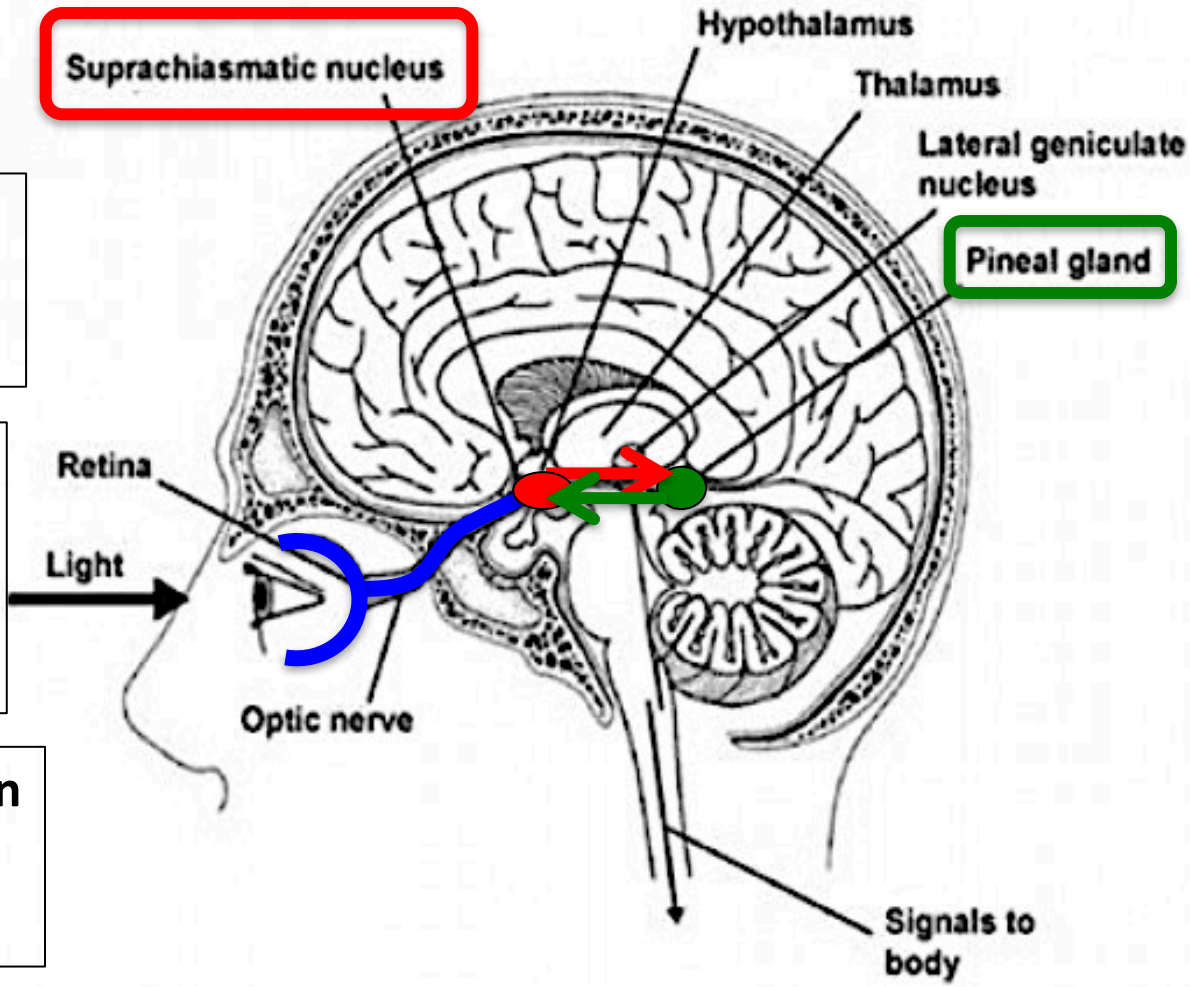
Retino-Hypothalamic Path

Specialized visual receptors
(ancient **Ganglion** cells,
with photopigment Melanopsin)
react to ambient light levels

These Ganglions send their axons
not to LGN, but to **SCN**
of Hypothalamus

SCN informs **Pineal Gland**,
so daylight decreases/
nightfall increases its release of
Melatonin

Pineal Gland releases **Melatonin**
inhibiting **SCN**
regulating its active/inactive cycle



NOTE – You can take Melatonin for jet-lag

Fly east, take about 1 hour before bed, promotes Pineal production of Melatonin, resets "clock"