# Sleep! For your Body and your Brain

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# Contents


- Sleep Definitions and ‘Normal’ Sleep
- The Organization of Sleep Networks
- Common Sleep Disorders
- Sleep and General Health

# Sleep

Sleep is a reversible behavioral state of perception disengagement from and unresponsiveness to the environment

Sleep is dynamic

Sleep both reflects the state of, and contributes to, the health of your body and brain

# Why is Sleep Important?

- Key to our health, performance, safety and quality of life
- As essential a component as good nutrition and exercise to optimal health
- As necessary as the water we drink, the air we breathe and the food we eat to function and live at our best.

# The Function of Sleep

Facilitation of **memory** retention

Restoration of synthesis of macromolecules/ **Recovery**

Synaptic homeostasis hypothesis/ **Energy Conservation**

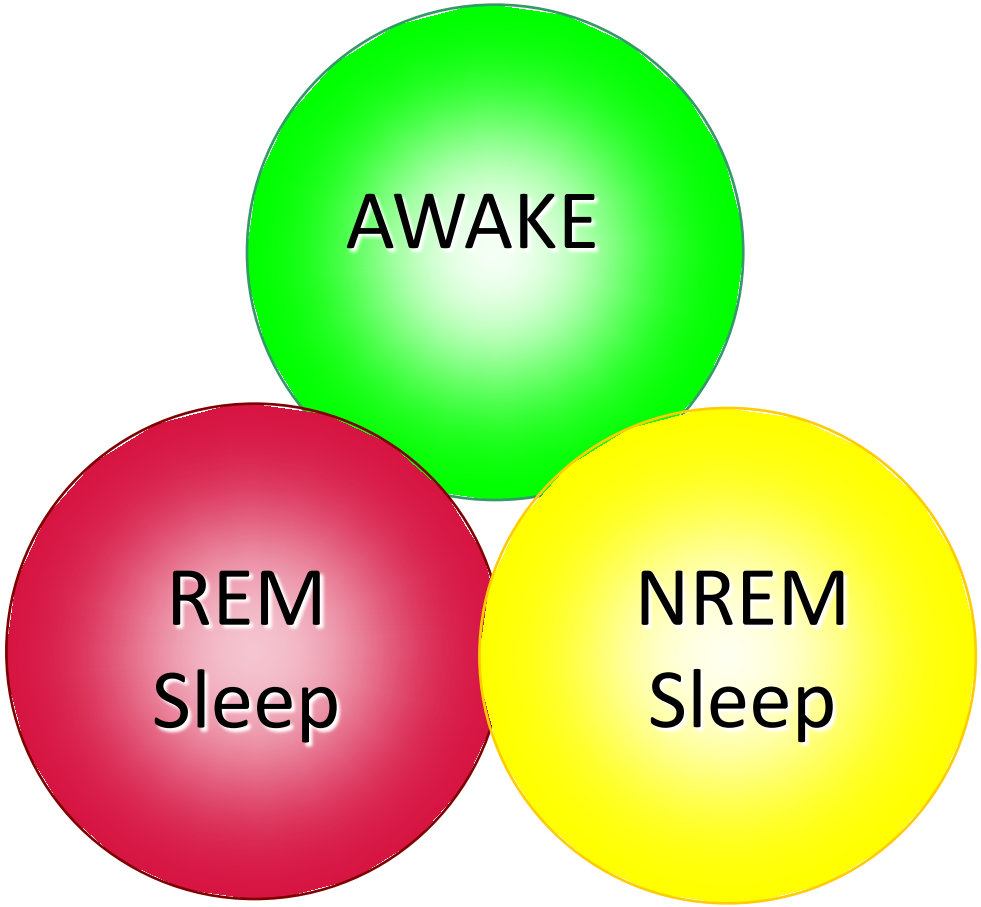
# Sleep States

Sleep in general involves a number of complex behavioral and physiologic changes

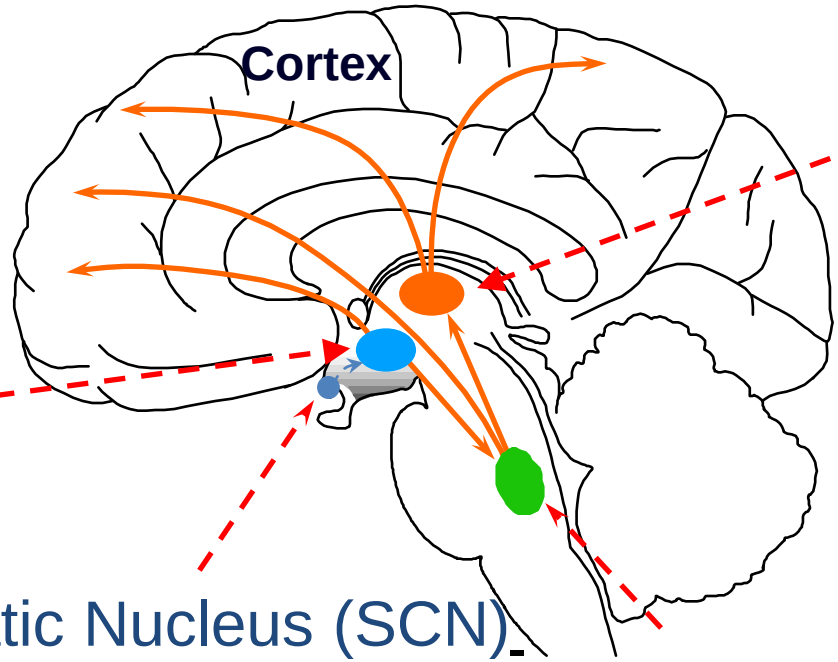
Neurophysiological monitoring of the sleeping brain and body defines states

2 general stages (defined by EEG, EMG, EOG): Non-REM and REM

# States of Being



# Neurobiology of Sleep and Wake




**Thalamus**

**Cortical Activation**
**Sleep Spindles**
**EEG Synchronization**

**Hypothalamus**

**Sleep/Wake Switch**

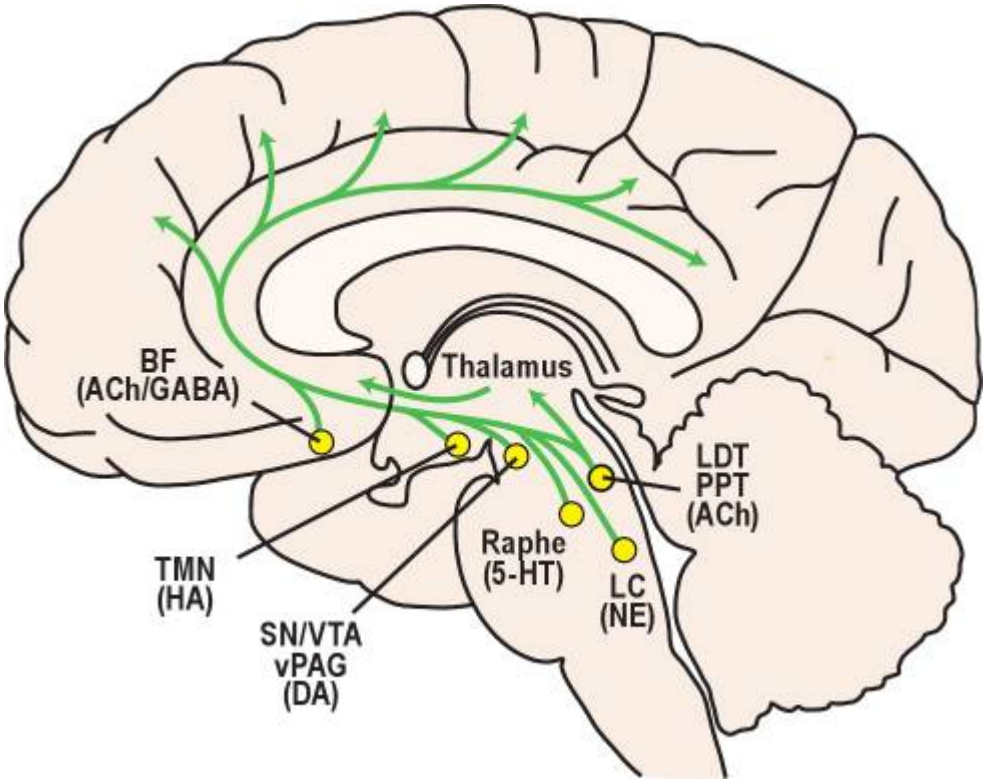
**Suprachiasmatic Nucleus (SCN)**

**Circadian Clock**

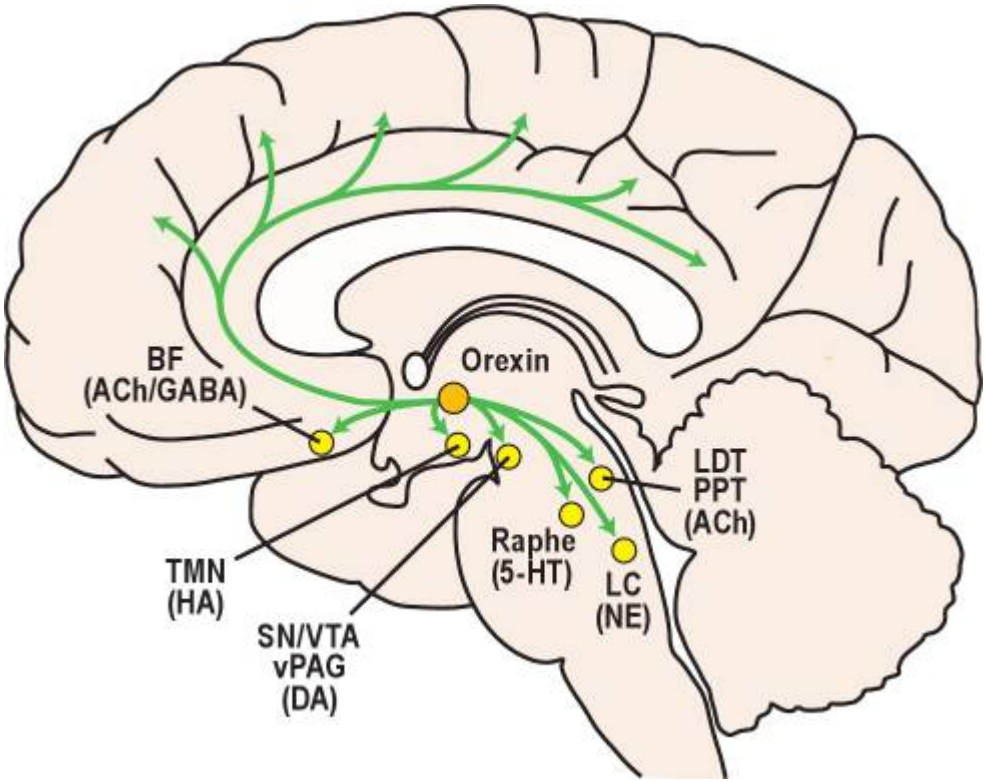
**Brainstem**

**Ascending Cortical Activation**
**REM/SWS Switch**

SWS = slow-wave sleep




Sleep. 2011 Jul 1; 34(7): 845–858.

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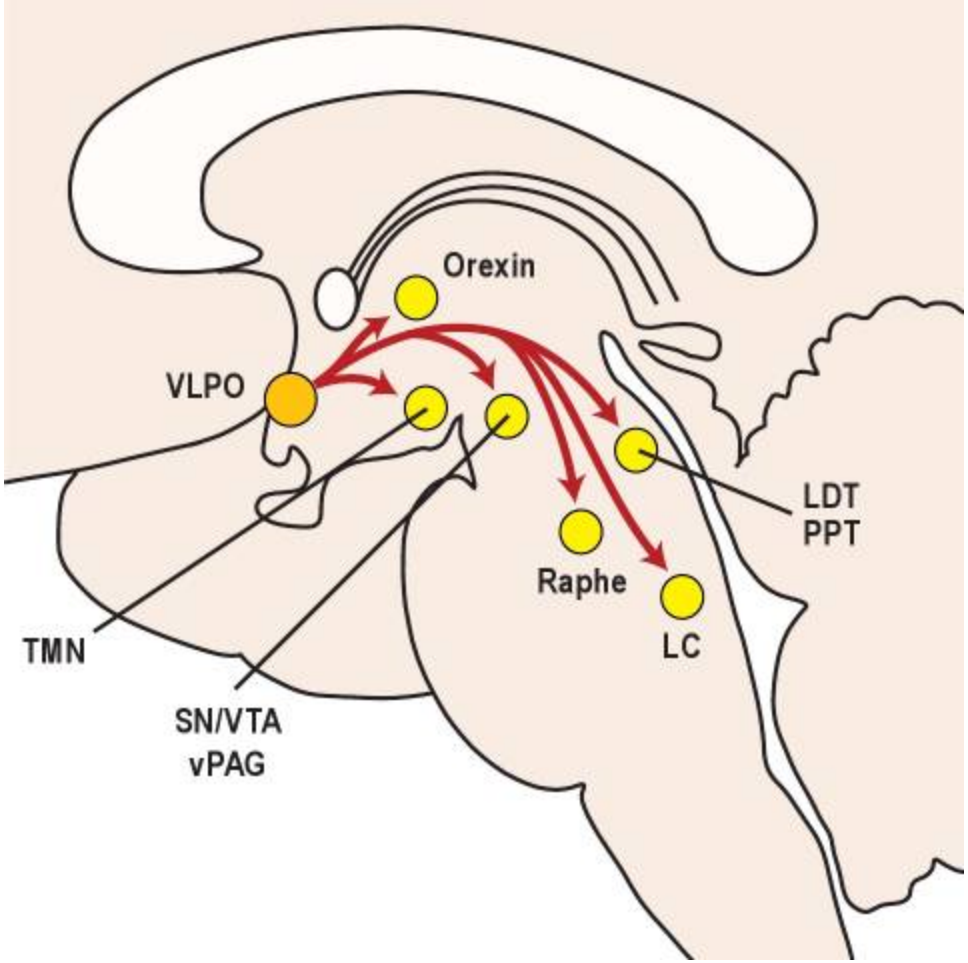
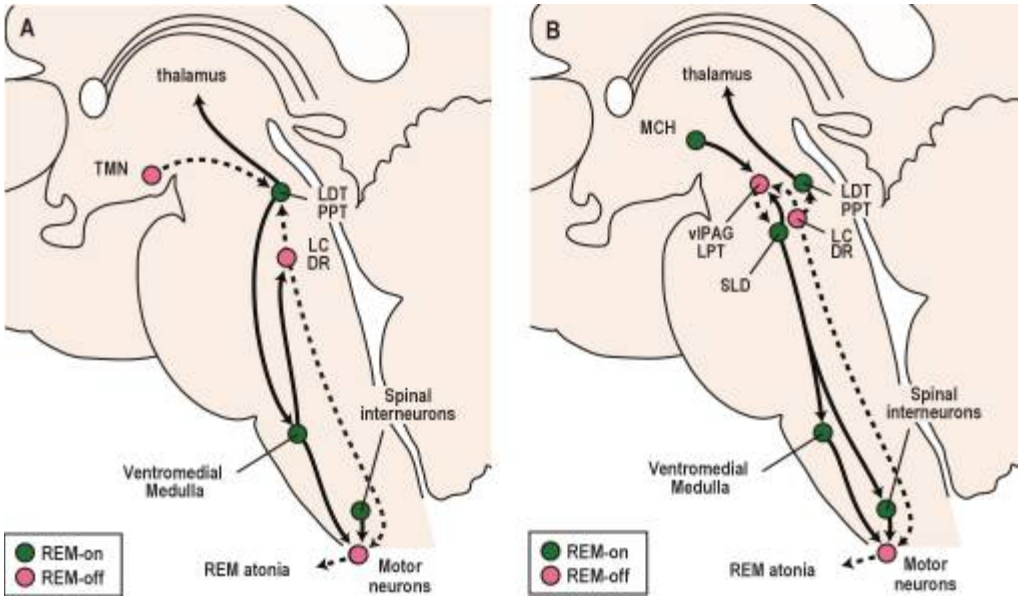



Sleep. 2011 Jul 1; 34(7): 845–858.

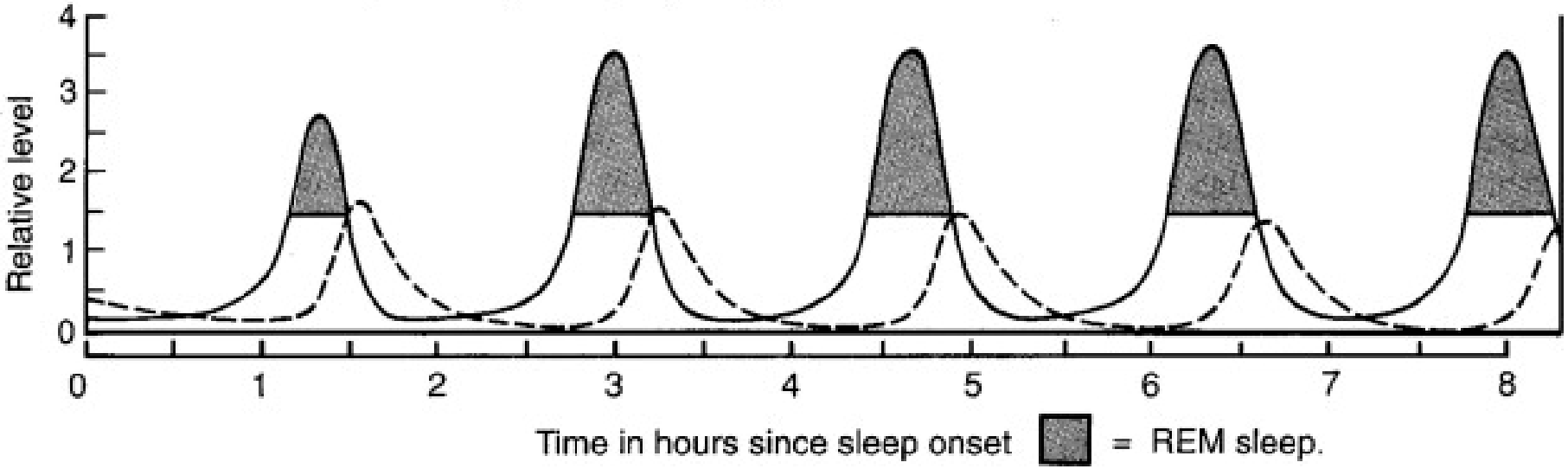



Sleep. 2011 Jul 1; 34(7): 845–858.

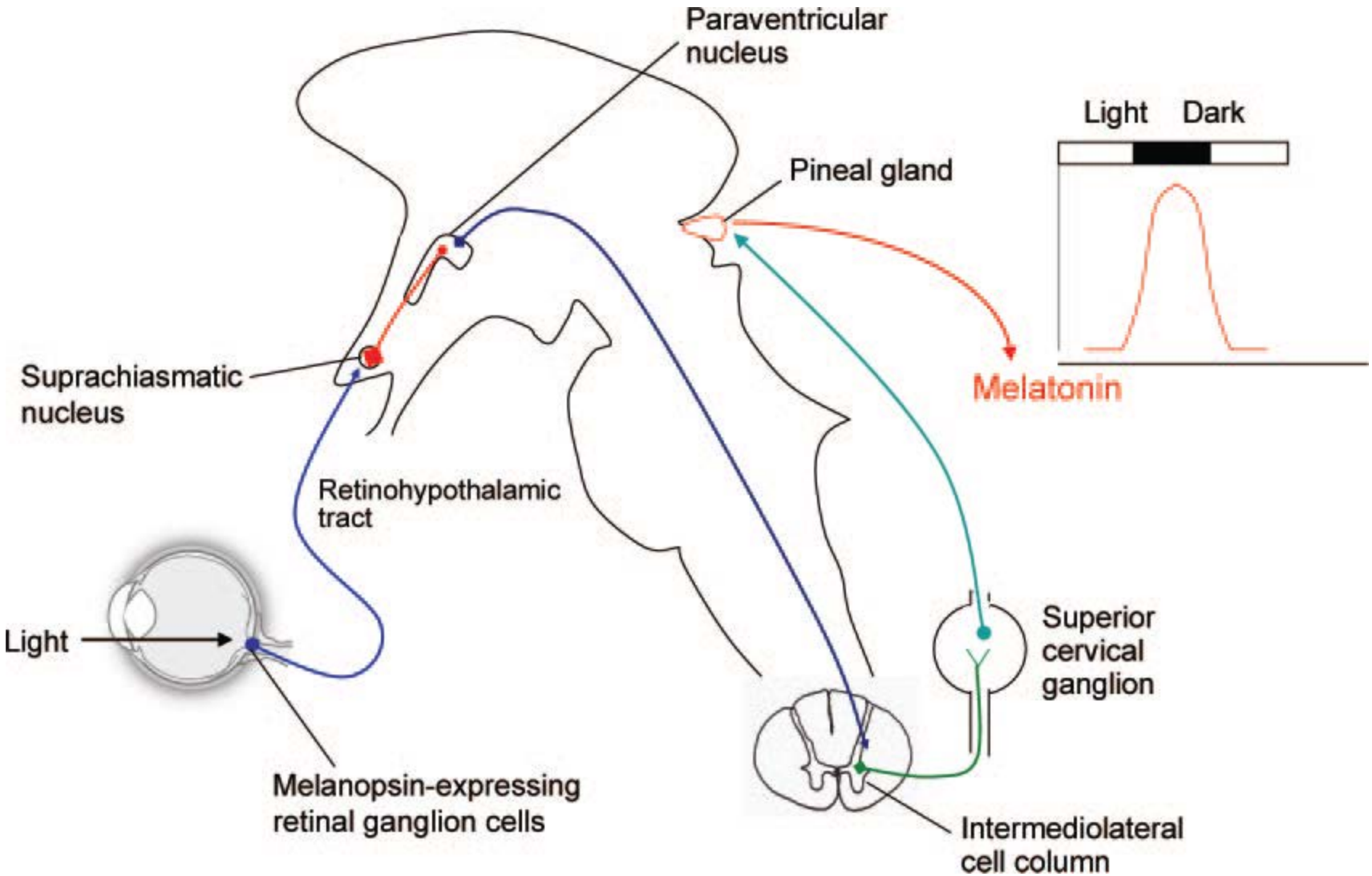
Activity profiles of neurotransmitter systems across sleep/wakefulness

| Neurotransmitter | Wakefulness | NREM sleep | REM sleep |
|---|---|---|---|
| Acetylcholine | ↑↑ | — | ↑↑ |
| Monoamines | ↑↑ | ↑ | — |
| Orexin/Hypocretin | ↑↑ | — | — |
| MCH | — | — | ↑↑ |
| VLPO/MNPO | — | ↑↑ | ↑↑ |

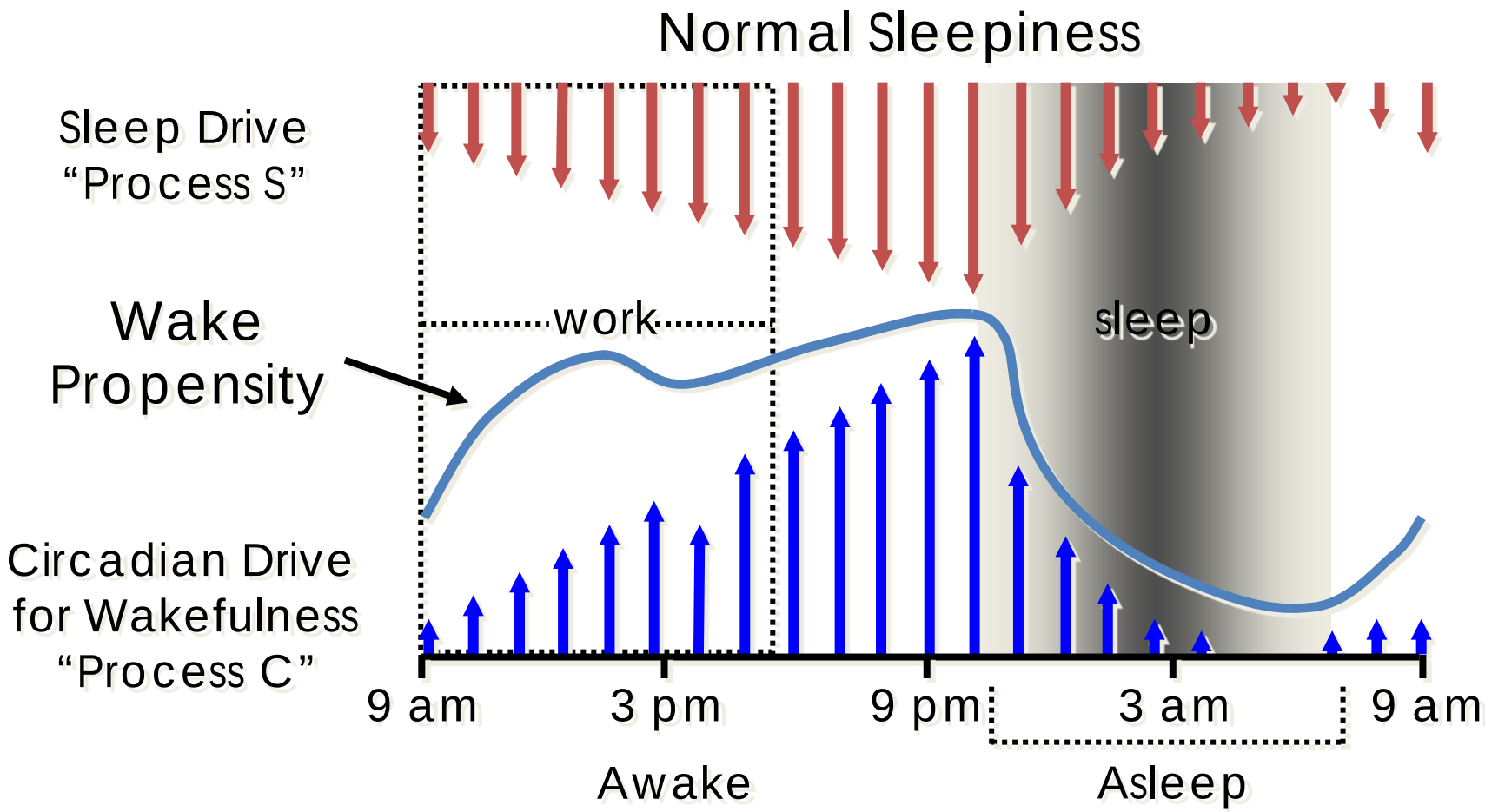
Time course of REM sleep and sleep neurotransmitter rhythms:
REM-on neurons, _____, acetylcholine
REM-off neurons, ----------, norepinephrine, serotonin




McCarley and Massaquoi


Paraventricular nucleus
Light
Dark
Pineal gland
Melatonin
Suprachiasmatic nucleus
Retinohypothalamic tract
Light
Superior cervical ganglion
Melanopsin-expressing retinal ganglion cells
Intermediolateral cell column

# “Two Process” Model of Sleep Regulation



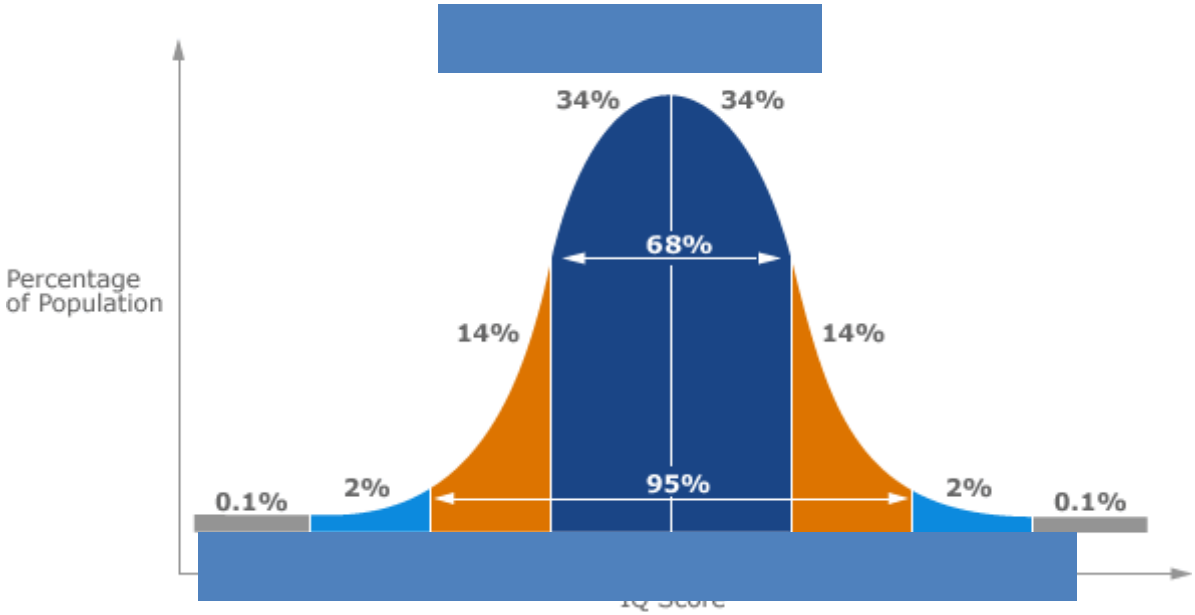

**Adapted from: Kryger MH, et al. *Principles and Practices of Sleep Medicine*. 2000.**

# Sleep Needs Vary Over the Life Cycle

| | | |
|---|---|---|
| Newborns/Infants | 0 - 3 months:<br>4 - 11 months: | **14-17 hours**<br>**12-15 hours** |
| Toddlers/Children | 12 mo - 24 mo:<br>3 - 5 years:<br>6 - 13 years: | **11-14 hours**<br>**10-13 hours**<br>**9-11 hours** |
| Adolescents<br>Young Adults | 14-17 years:<br>18-25 years: | **7-9 hours** |
| Adults<br>Older Adults | 26-64 years:<br>> 64 years: | **7-9 hours**<br>**7-8 hours** |

National Sleep Foundation Recommendations, 2015

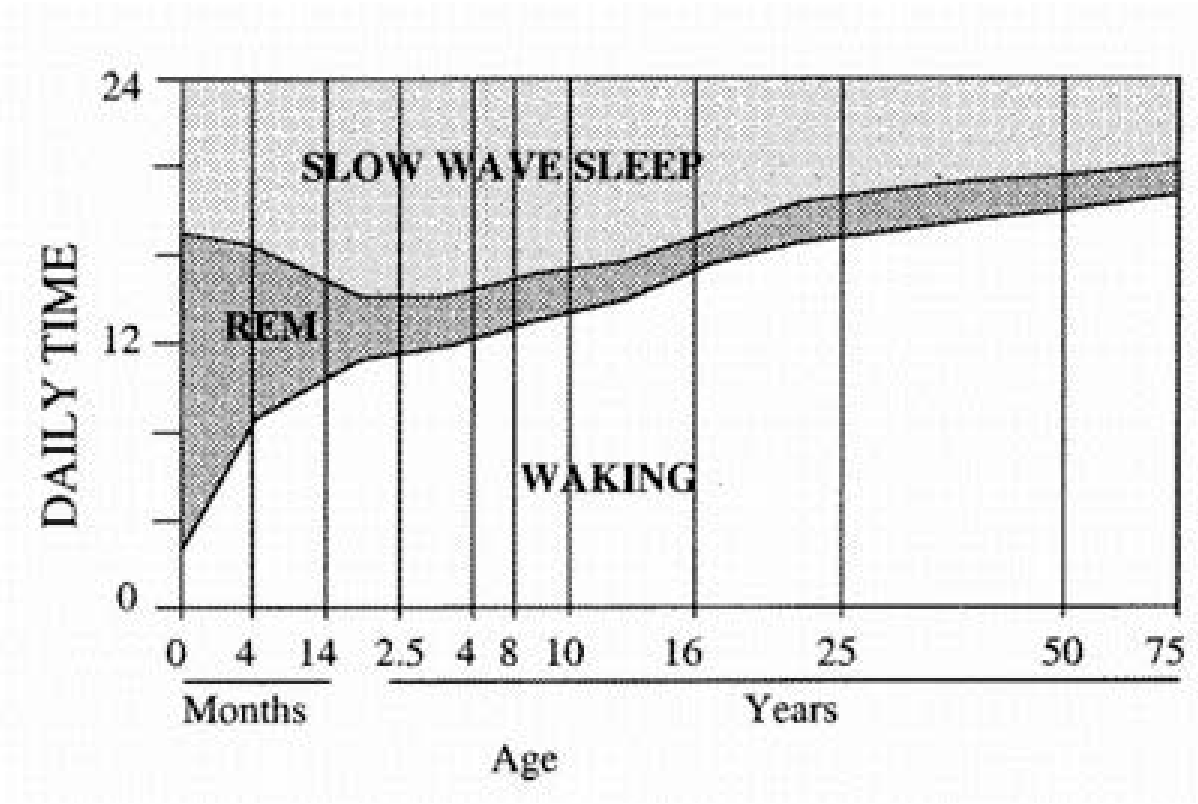
# Sleep Needs




SOME individual variation BUT…

- Bell-shaped curve
- 10-15% of the population may have increased (or decreased tolerance to inadequate sleep)
- Self-judgment of sleepiness is poor
- Signs of daytime sleepiness may be subtle
- “Adequate” vs “optimal”
- Don’t assume you need less

# States and the Lifespan



# Sleep Patterns and Characteristics Change Over the Life Cycle

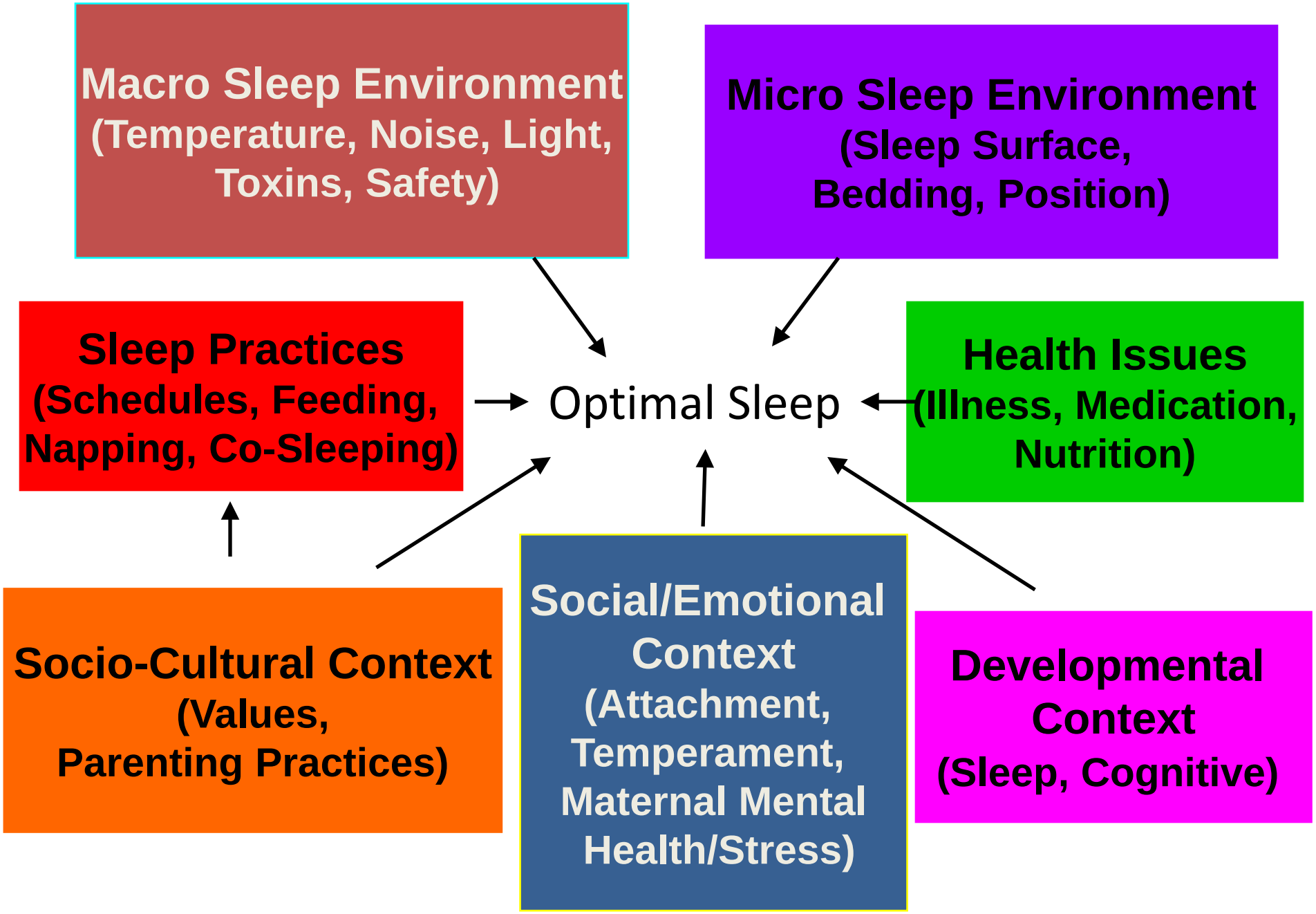
| | |
|---|---|
| Newborns/Infants | **More active in sleep; 50% REM; several periods of sleep; need naps** |
| Toddlers | **Sleep begins to resemble adult patterns** |
| Children | **Experience more deep sleep** |
| Adolescents | **Shift to later sleep-wake cycle; experience daytime sleepiness** |
| Adults | **Need regular sleep schedule to obtain sufficient, quality sleep** |
| Older Adults | **More likely to have medical problems; sleep disrupters & disorders; sleep less efficiently** |

# Sleep in Childhood

- **Newborns spend 16-17/24h asleep- 50% SWS/50% REM (by age 60y, SWS is 3-5% of sleep)**
- **By age 2y, average child has spent 9500h (~13mths) asleep vs 8000h awake**
- **Between 2-5y, time asleep = time awake**
- **In school-age children, sleep occupies 40% of the 24h day**
- **Sleep is *the* primary activity of the brain during early development**

# Sleep Changes in Adulthood

- Sleep *amounts* decrease but not sleep *needs*; remain 7.5 to 8 hrs/night
- Sleep phase advances
- Sleep architecture changes with increased awakenings and arousals and decreased SWS
- Sleep disorders increase with insomnia and sleep apnea most common

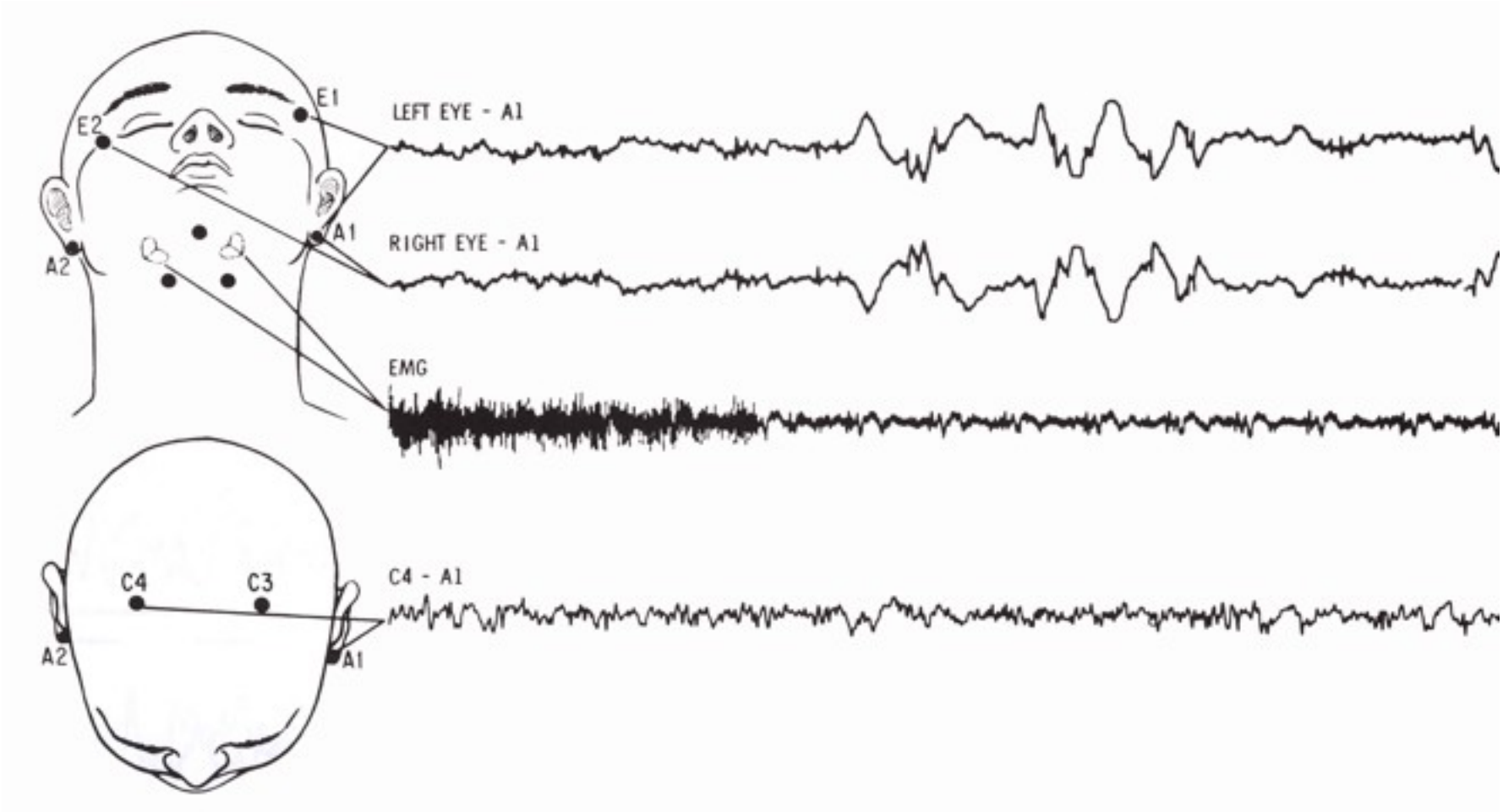

Macro Sleep Environment
(Temperature, Noise, Light, Toxins, Safety)
Micro Sleep Environment
(Sleep Surface, Bedding, Position)
Sleep Practices
(Schedules, Feeding, Napping, Co-Sleeping)
Optimal Sleep
Health Issues
(Illness, Medication, Nutrition)
Socio-Cultural Context
(Values, Parenting Practices)
Social/Emotional Context
(Attachment, Temperament, Maternal Mental Health/Stress)
Developmental Context
(Sleep, Cognitive)

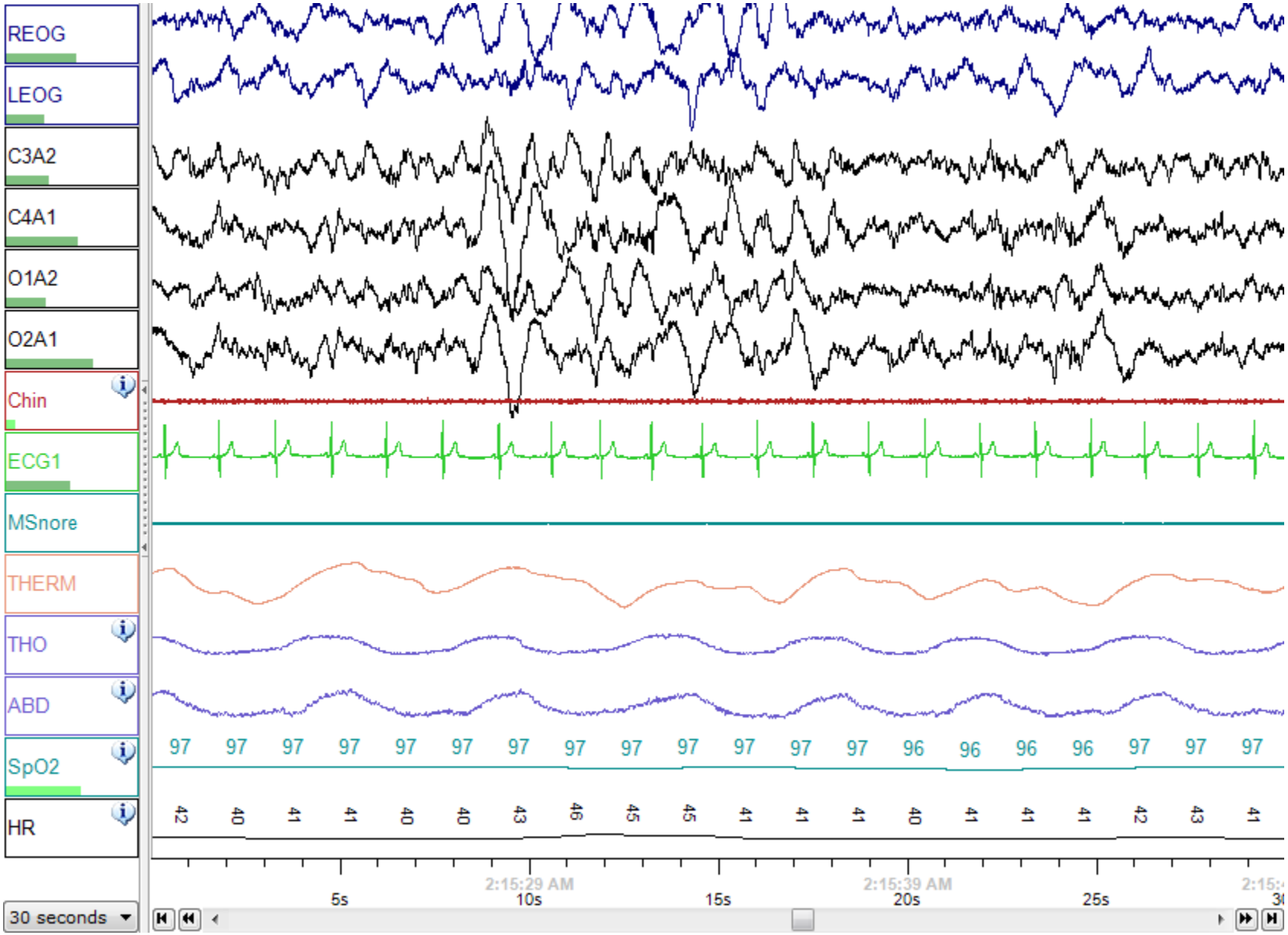
# Objective Sleep Measurement

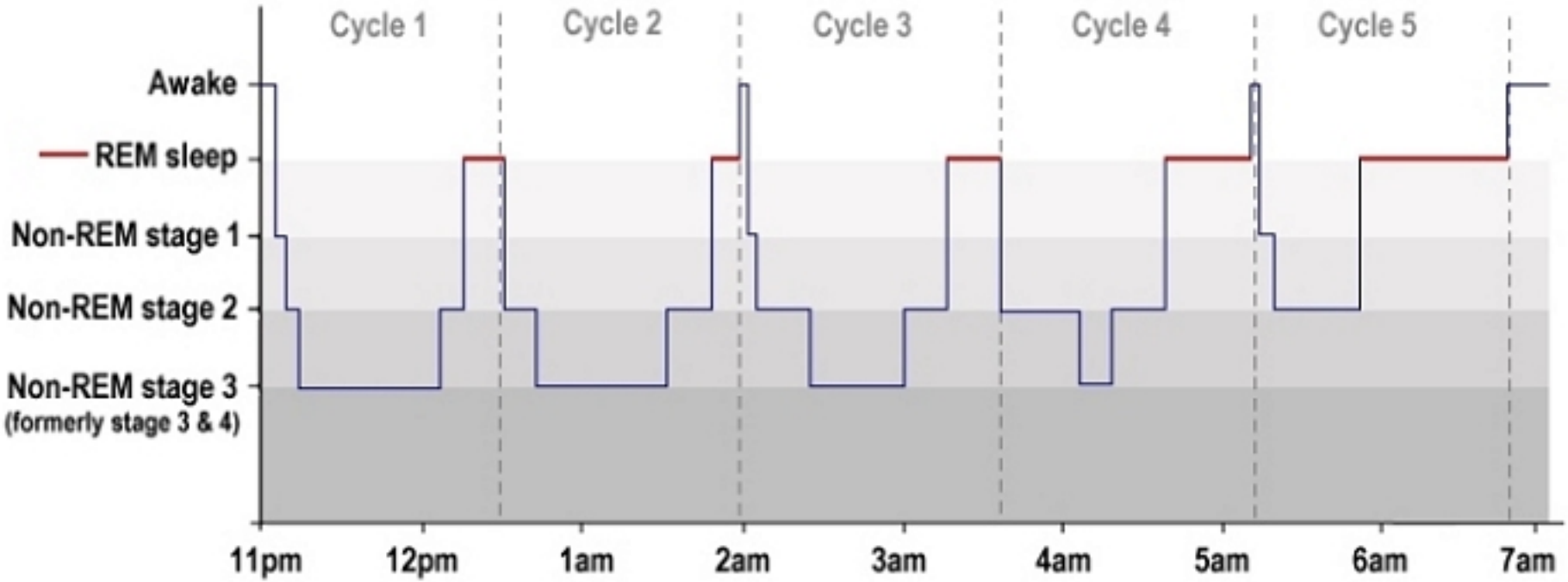
**Polysomnography (PSG) is a noninvasive tool that incorporates measurements by the EEG, EOG and the EMG**

**Stages are scored by the frequency, morphology and amplitude of the EEG in relation to the other parameters (Rachtschaffen and Kales, 1968, 2007, AASM, 2013)**

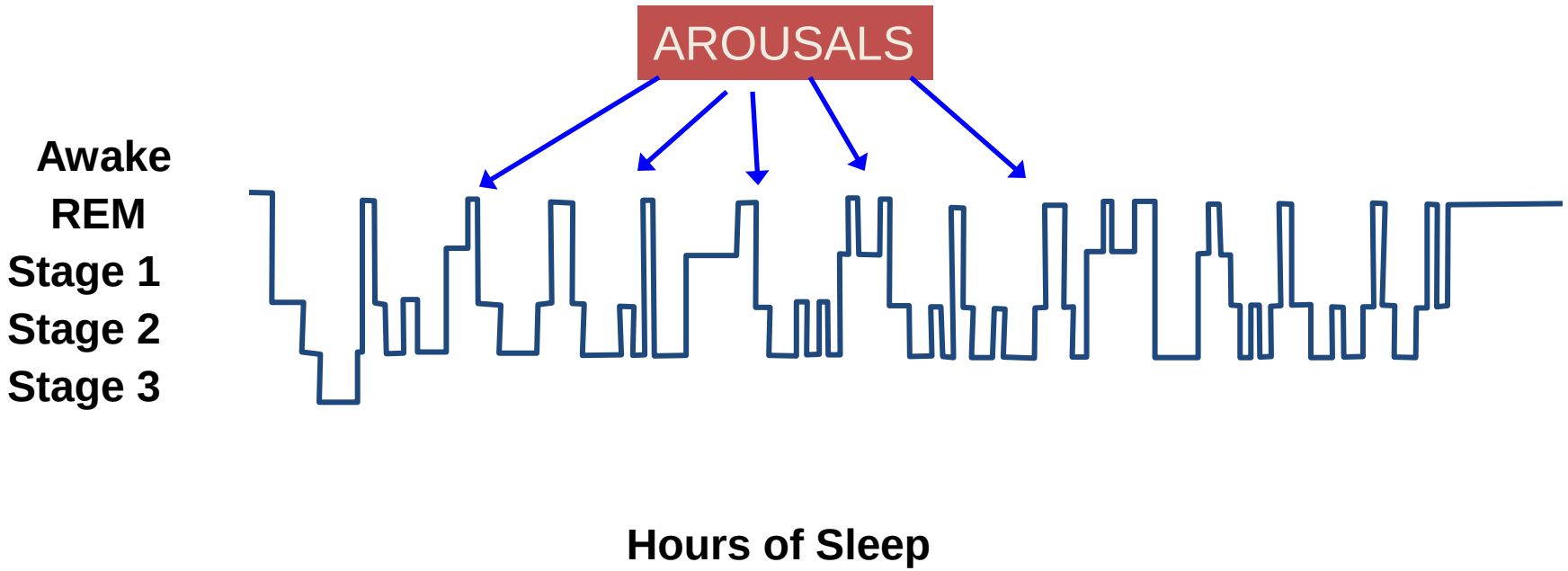
**Actigraphy**


E1
E2
A1
A2
LEFT EYE - A1
RIGHT EYE - A1
EMG
C4
C3
A2
A1
C4 - A1


REOG
LEOG
C3A2
C4A1
O1A2
O2A1
Chin
ECG1
MSnore
THERM
THO
ABD
SpO2
HR
97 97 97 97 97 97 97 97 97 97 97 97 97 96 96 96 96 97 97 97
42 40 41 41 40 40 43 46 45 45 41 41 41 40 41 41 41 42 43 41
2:15:29 AM
2:15:39 AM
5s
10s
15s
20s
25s
30 seconds


Cycle 1
Cycle 2
Cycle 3
Cycle 4
Cycle 5
Awake
REM sleep
Non-REM stage 1
Non-REM stage 2
Non-REM stage 3
(formerly stage 3 & 4)
11pm
12pm
1am
2am
3am
4am
5am
6am
7am

# Disrupted Sleep Architecture




When sleep is fragmented by frequent arousals, the amounts of both deep sleep and REM sleep are severely compromised

# Classification of Sleep Disorders

- Insomnia
- Sleep Related Breathing Disorders
- Central Disorders of Hypersomnolence
- Circadian Rhythm Sleep-Wake Disorders
- Parasomnias
- Sleep Related  Movement Disorders

# Insomnia

Insomnia is defined as a **persistent difficulty with sleep initiation**, duration, consolidation or quality that occurs despite **adequate opportunity** and circumstances for sleep and results in some form of **daytime impairment**

# Sleep Related Breathing Disorders

Characterized by abnormalities of respiration during sleep.

Grouped into obstructive events (**OSA**), central sleep apnea disorders, sleep related hypoventilation disorders and sleep related hypoxemia disorders.

# Daytime Sleepiness

The primary mechanism of impairment in sleep deprivation and restriction is believed to be in prefrontal cortex and associated integrative functions

# Effects of Sleep Loss

- Sleep deprivation/prolonged wakefulness affects the brain
  - Neuronal functions
  - Neuronal “plasticity”: ability of the brain to change structure/function in response to the environment
  - Gene activation/expression
  - Neurogenesis
  - Brain cell protection/repair from stress
  - Neurotransmitter release and function (serotonin, dopamine, etc)
  - Melatonin production/circadian biology
    - Cellular metabolism, neurogenesis, brain/eye development
  - Highest susceptibility during critical developmental period
- Sleep deprivation/prolonged wakefulness affects the body
  - -increases the stress response and stress hormones
  - -disrupts normal hormonal rhythms essential to optimal functioning

# Impact of Sleep Problems

**Growth**: disruption of normal growth hormone release

**Immune function**: impairment of host defenses

**Endocrine** system regulation

**Metabolic regulation**: diabetes and inadequate sleep

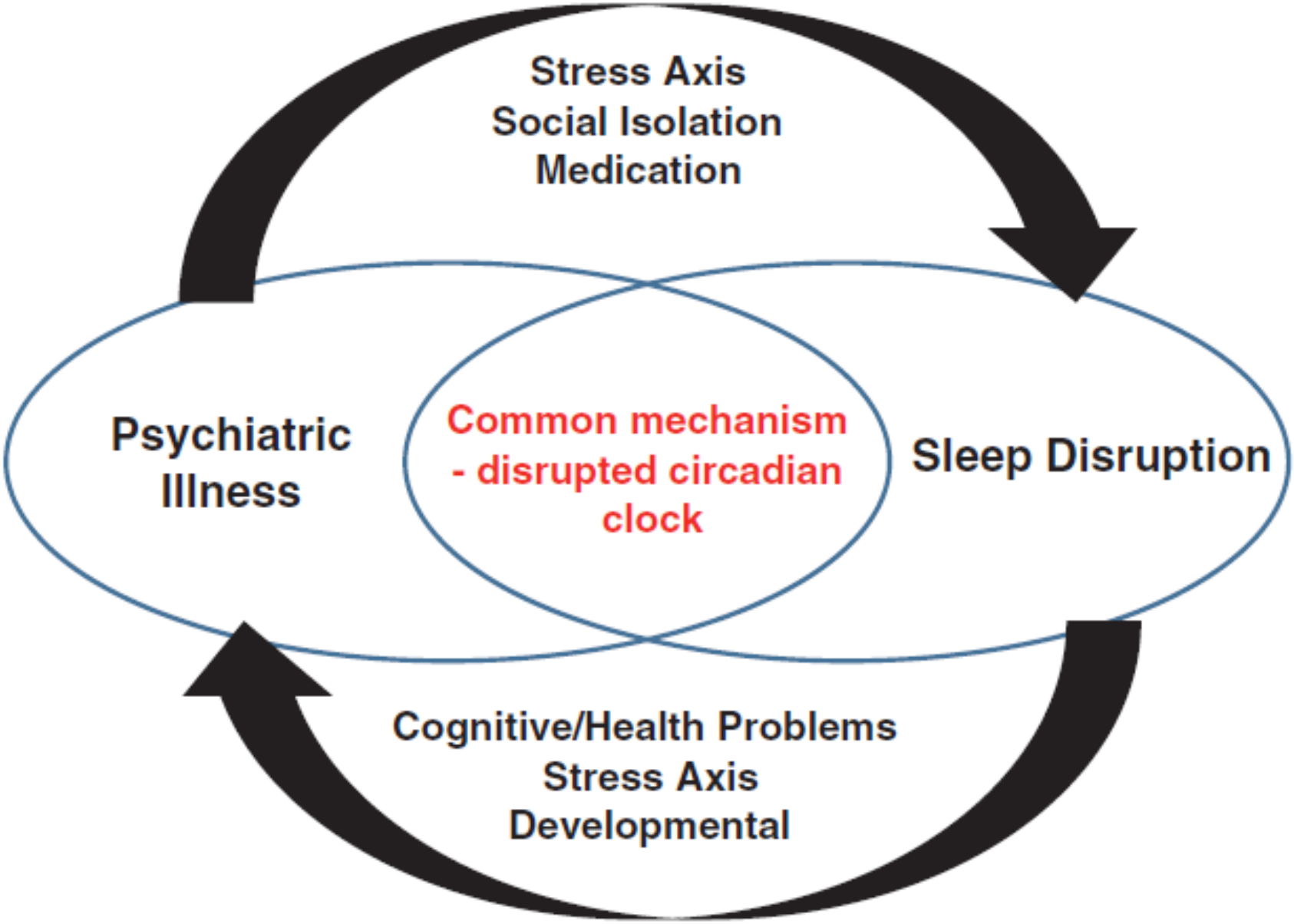
**Mental Health and Wellness**

# Sleep and Neuropsychiatric Illness

Most psychiatric disorders are associated with sleep disturbance

-(Part of diagnostic criteria for MDD, BD, GAD, PTSD)

Psychiatric Illness is the most common comorbidity associated with chronic insomnia




Current Opinion in Neurobiology

2013

# Other Health Consequences of Inadequate Sleep

Drowsy driving crashes

Workplace errors and accidents

# Sleep and Work Safety

- 21 mil people work alternate shifts
- USBLS , 2012,  25% worked greater than 40 hr/week
- CDC reports 40.6 mil report 6hrs or less

Workplace Health and Safety, 2014

TABLE 1

## Current Work Hour Regulations and Recommendations

| *Worker Population* | *Regulation/Recommendation* | *Agency* |
|---|---|---|
| Airline Pilots | Limits domestic flight time to 8 hours within a 24-hour period with at least 8 hours' rest in 24-hour period. | Federal Aviation Administration (2010) |
| Maritime Watch Officers | Rest period no less than 10 hours in any 24-hour period and 77 hours in any 7-day period. | International Maritime Organization (2010) |
| Medical Residents | Limits duty hours to 80 hours per week inclusive of in-house call and moonlighting. | Accreditation Council for Graduate Medical Education (2011) |
| Nuclear Power | Limits work hours to 16 hours in any 24-hour period, 26 hours in any 48-hour period, and 72 in any 7-day period. | United States Nuclear Regulatory Commission (2012) |
| Nurses | States with identified mandatory overtime restrictions in law: AK, CT, IL, MD, MN, NJ, NH, NY, OR, PA, RI, TX, WA, WV. States with mandatory overtime provisions in regulations: CA, MO. | American Nurses Association (2012) |
| Nurses | Prevents work hours by nurses providing direct patient care in excess of 12 consecutive hours or in excess of 60 hours in any 7-day period. | United States Department of Veterans Affairs (2004) |
| Railroad | Duty period not to exceed 12 hours or must have 10 consecutive hours off duty during prior 24 hours. | United States Department of Transportation (2011a) |
| Truck Drivers | Limits driving from 11 to 14 hours per day depending on timing of mandatory half-hour break. | United States Department of Transportation (2011b) |

Workplace Health Safety, 2014

# Key Learning Points

Sleep is regulated by complex interactions between homeostatic (sleep “drive”) and circadian clock systems

Sleep patterns and behaviors are the result of multiple biological, environmental, psychological, cultural and developmental factors

Unhealthy Sleep has far reaching consequences on every aspect of your health