NORMAL SLEEP

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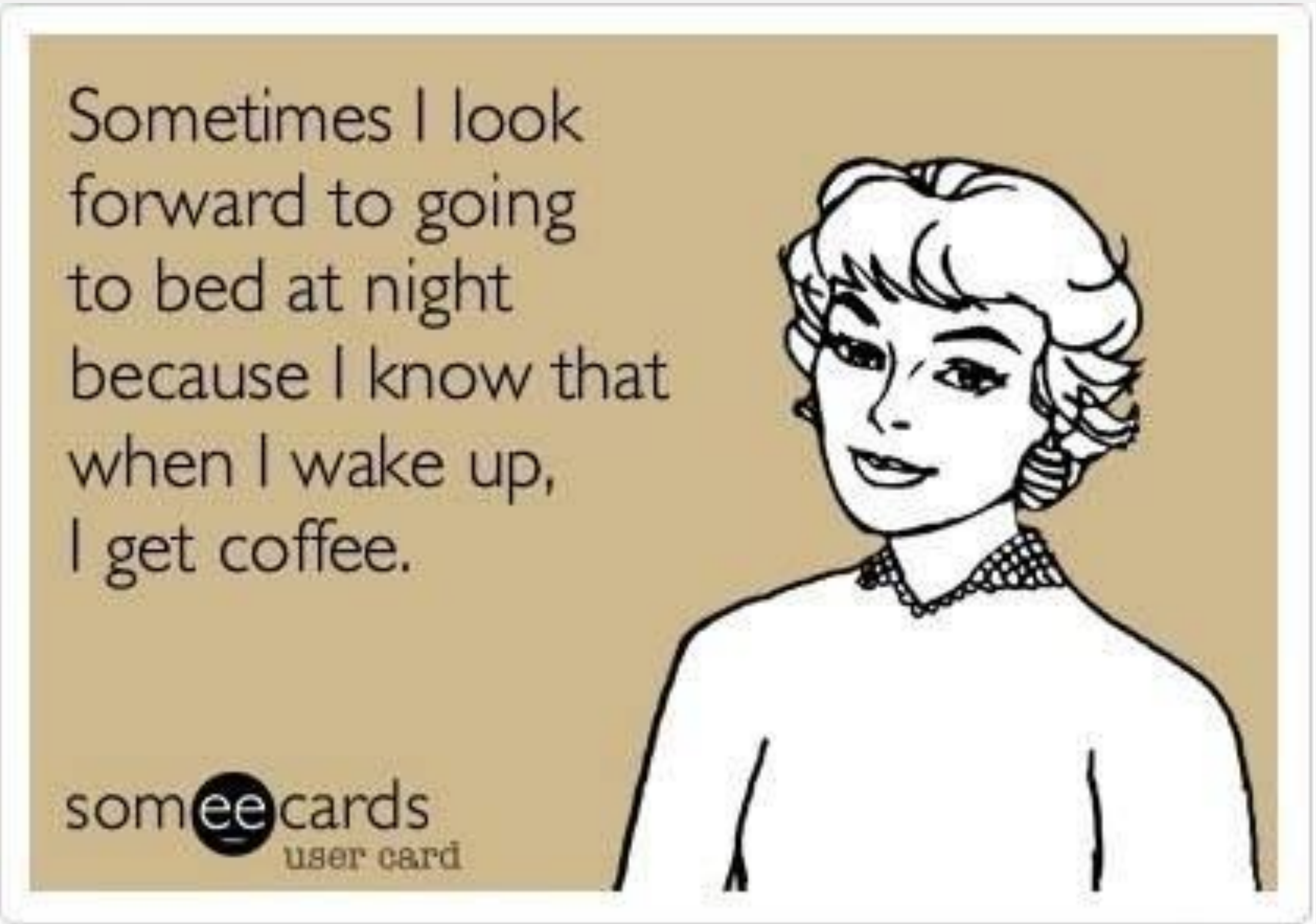
Sleep Medicine Fellow

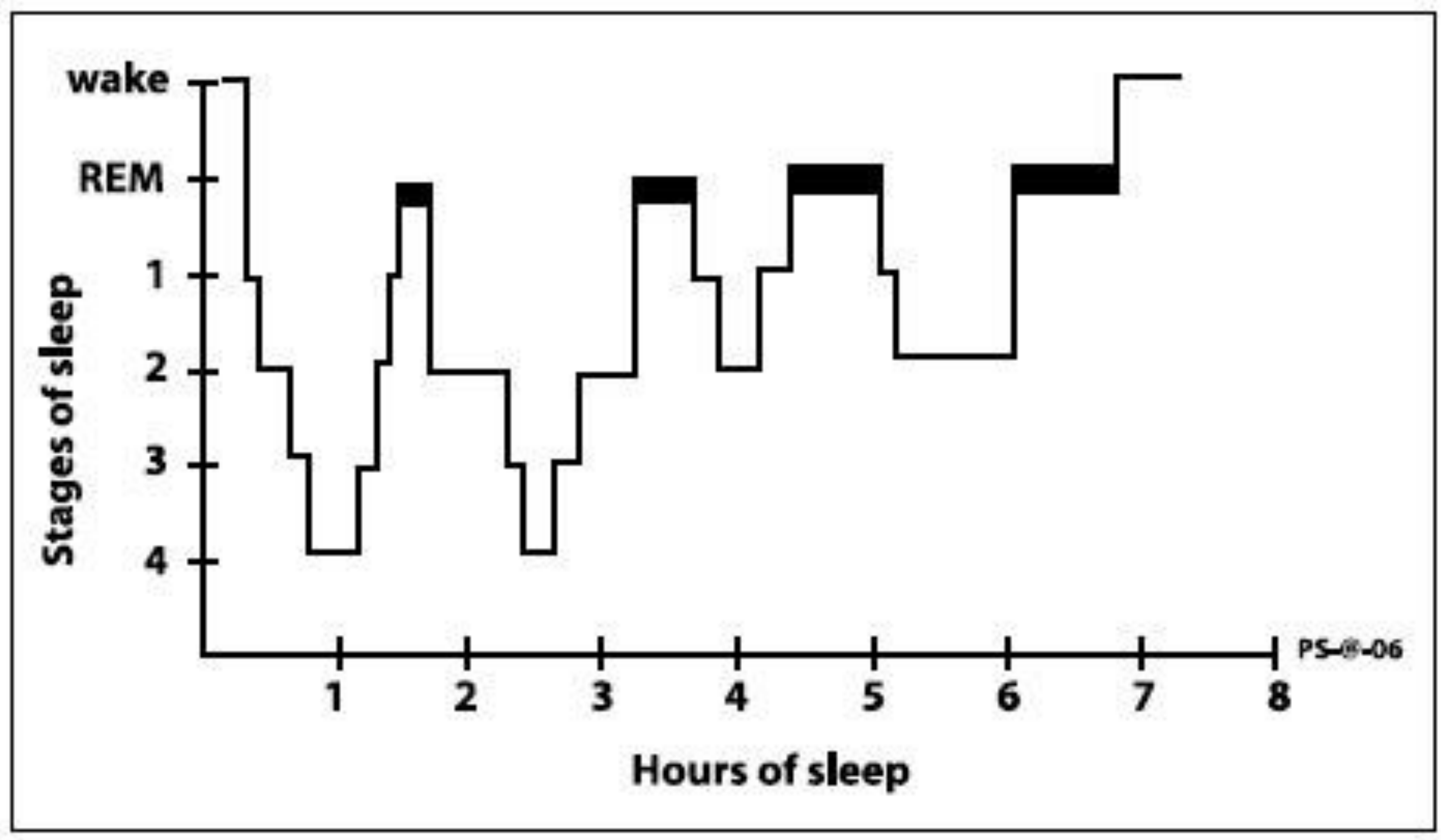
11/11/16


Sometimes I look
forward to going
to bed at night
because I know that
when I wake up,
I get coffee.
someecards
user card

WHAT IS SLEEP

- We spend ~ eight hours per day, 56 hours per week, 224 hours per month and 2688 hours per year sleeping
- 1/3 of our lives
- Sleep was defined by behavioral criteria before we had the tools to study it:
  - a reversible behavior state of perceptual disengagement and relative insensitivity to the environment
  - typically accompanied by a relaxed posture, both eyes closed, and decrease in motor activity

SLEEP HYPNOGRAM



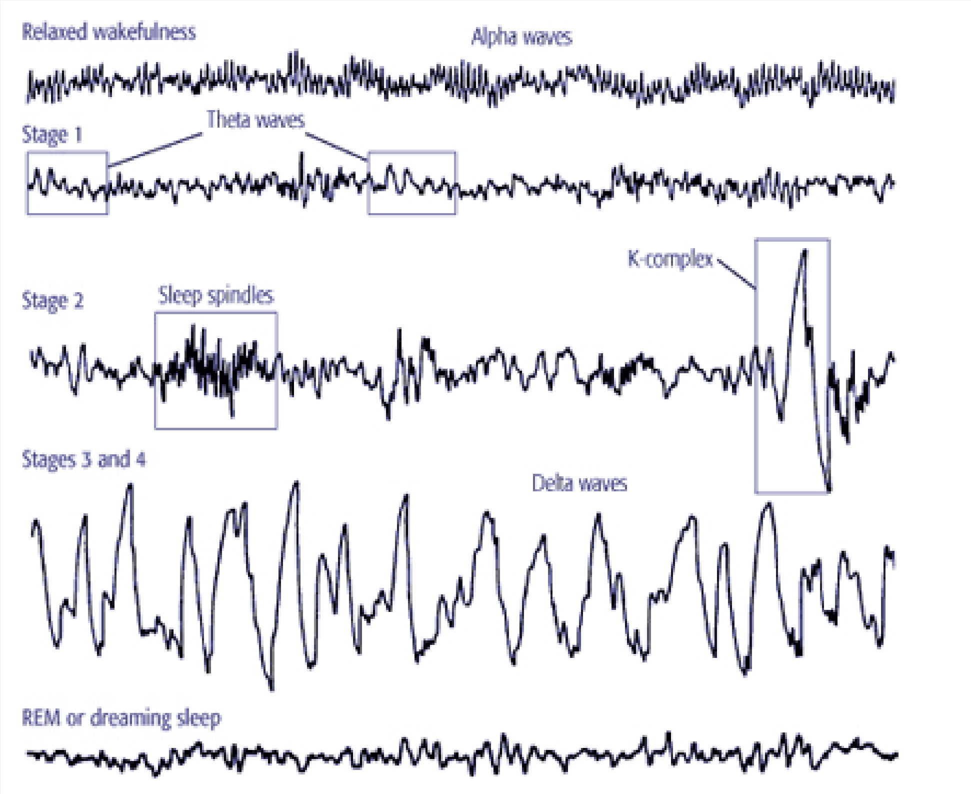
HISTORY OF SLEEP

SLEEP DESCRIBED THROUGHOUT HISTORY

- Hypnos, Greek god of sleep
- Concept of the "soul"
- Ancient Egyptians wrote dreams on papyrus
- Sleep & culture
- Father of Sleep Medicine, Dr. William Dement performs first polysomnogram in the 1950's

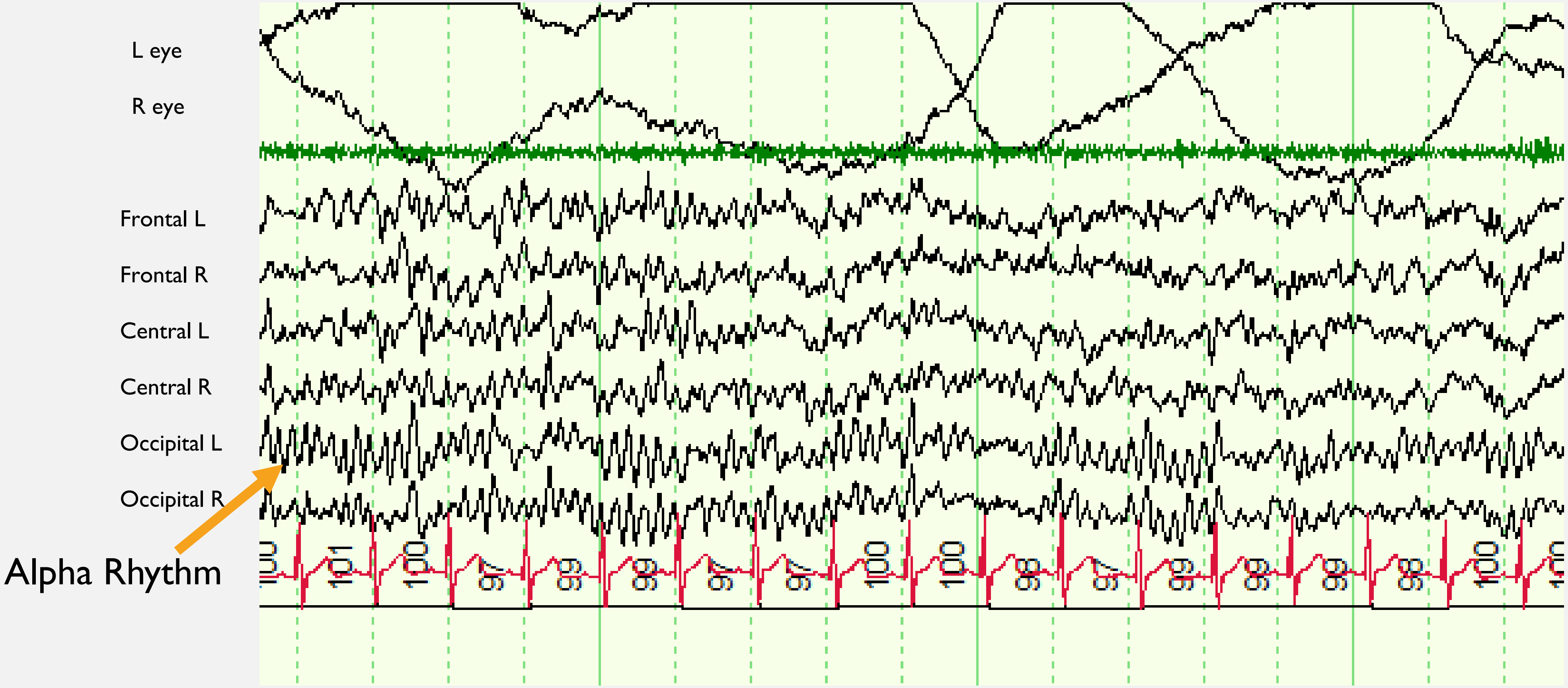
JOHN WILLIAM WATERHOUSE, 1874

SLEEP WAVES

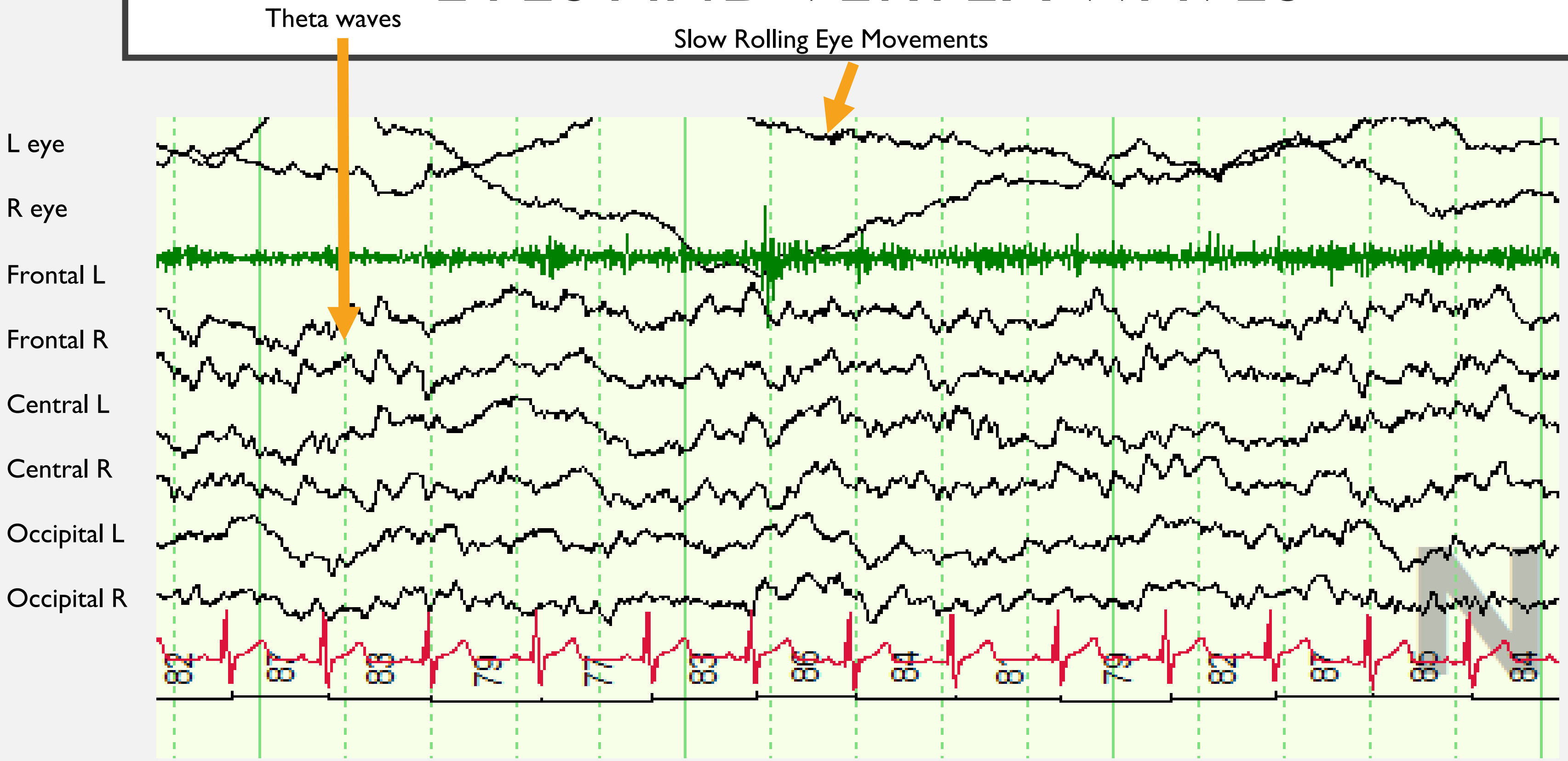


Relaxed wakefulness
Alpha waves
Stage 1
Theta waves
Stage 2
Sleep spindles
K-complex
Stages 3 and 4
Delta waves
REM or dreaming sleep

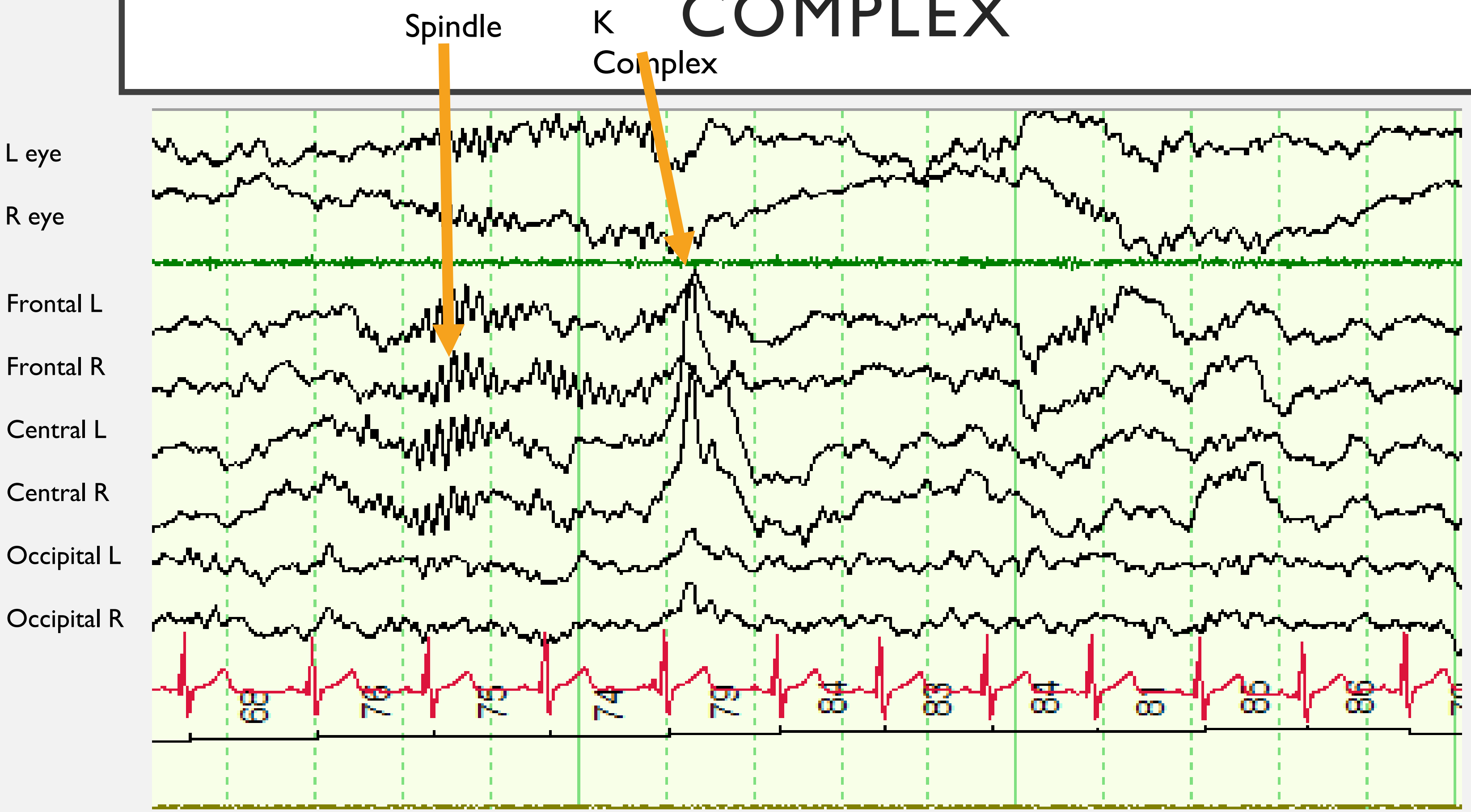
AWAKE AND RELAXED WITH EYES CLOSED



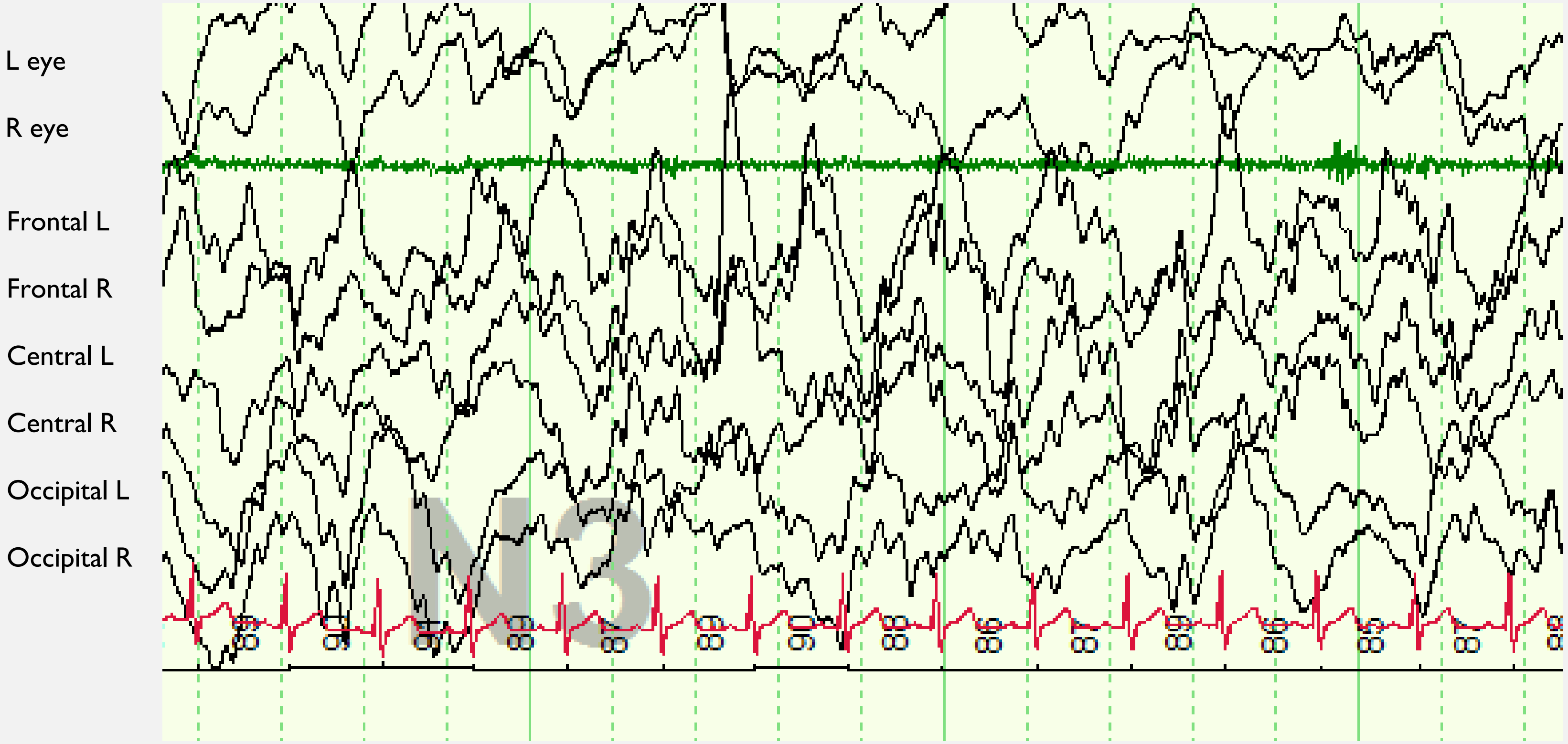
NON-REM 1 (N1) WITH SLOW ROLLING EYES AND VERTEX WAVES



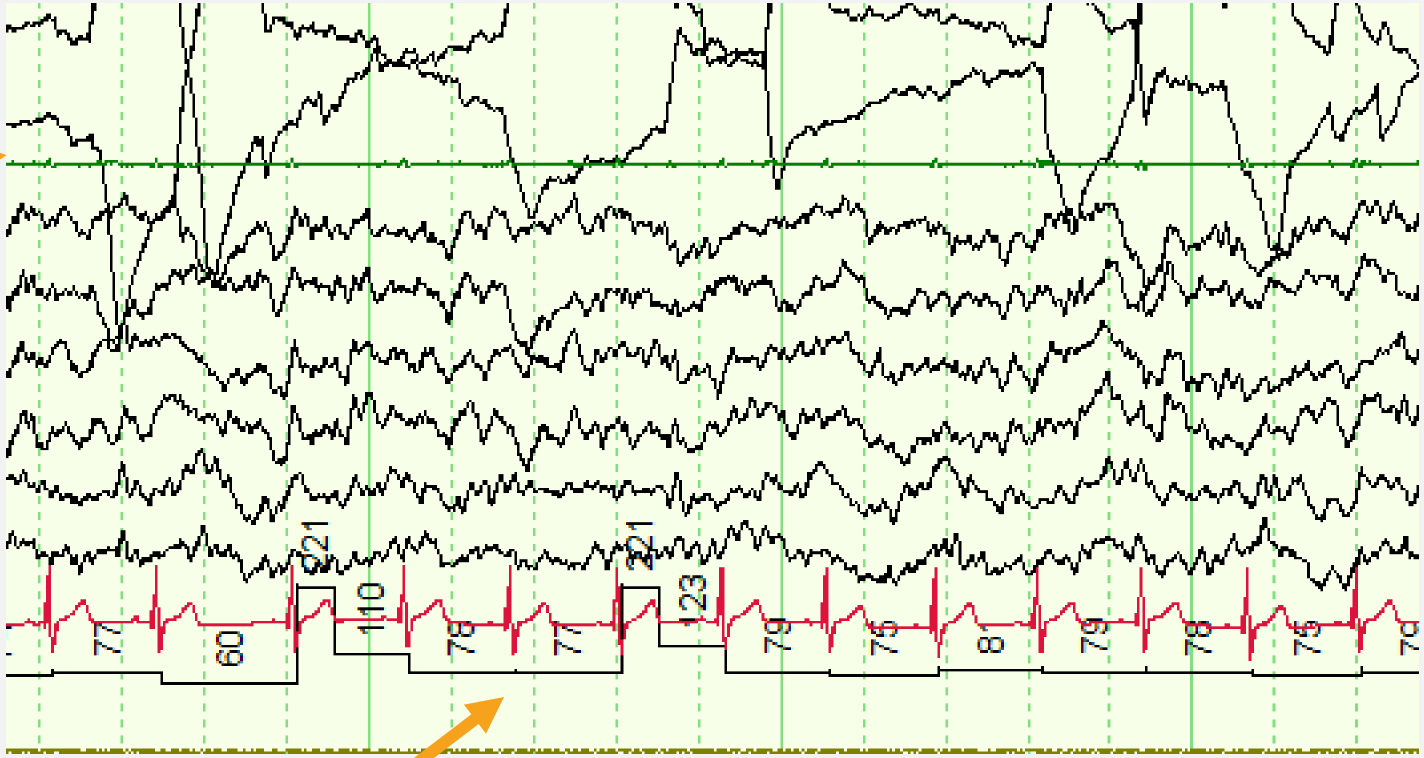
NON-REM 2 (N2) WITH SPINDLES AND K COMPLEX



SLOW WAVE SLEEP (N3)- DELTA WAVES



RAPID EYE MOVEMENT (REM) SLEEP



AWAKE AND ALERT LOOKS LIKE REM!

Rapid eye movements while awake

L eye

R eye

Chin tone is up

Frontal L

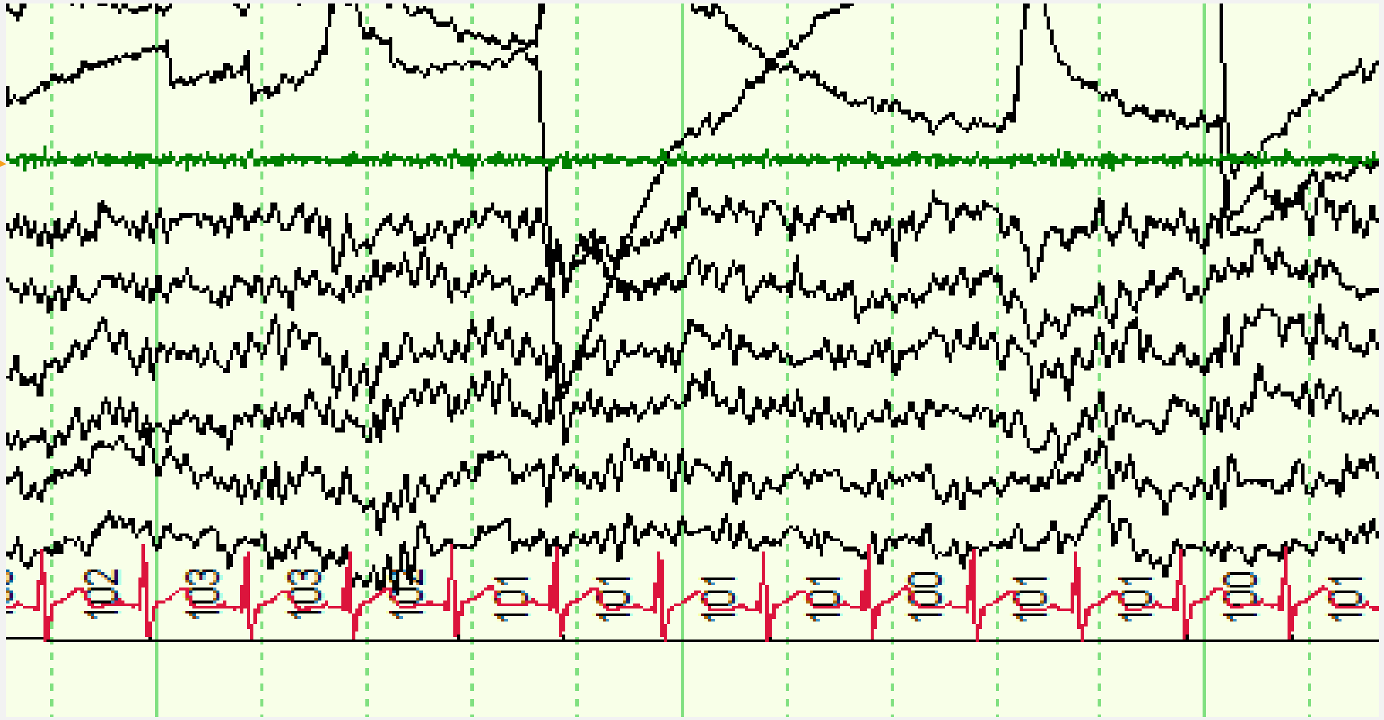
Frontal R

Central L

Central R

Occipital L

Occipital R



WHY WE SLEEP

- Sleep is crucial for:
  - Restoration and recovery for the body and brain
  - Sleep strengthens our immune defenses and insufficient sleep impairs them
    - induces a 24 hour oscillation between type one and type two cytokines
    - increases immune response efficacy
      - longer sleep and subjective reports of decreased fatigue the night before were associated with higher natural killer cell activities
  - Brain growth and development
  - Central nervous system repair
  - Maintaining normal body and hormonal functions
  - Learning and Consolidation of memory and daily experiences

WHY WE SLEEP (PART II)

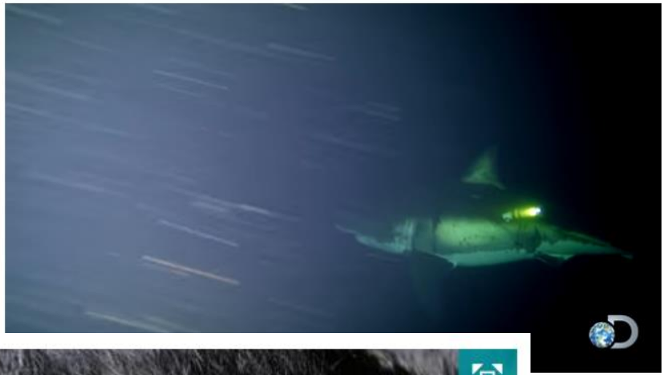
- Energy conservation
- Brain anabolism
  - Brain neurons depend on glycogen for energy
- Strategies for prey and predator
  - Animals match their sleep wake times to their needs for foraging and safety
  - Before electricity and shiftwork, we forged in hunted it when it was light and rested when night fell

Great white shark caught napping on camera for first time

Sharks get tired, too. A film crew delights in rare footage of a huge shark taking a snooze underwater.

Sci-Tech
June 29, 2016
8:55 AM PDT

by Amanda Kooser
@akooser



es and irrational hu
n other critters and
dramatically eating
annel filmed one m

Gorillas build new sleeping nests each night (RM Fauna/Alamy)

Apparently, Animals Dream of Learning, Too

By **Drake Baer**

Photo: Sandra Schmid/Getty Images

ANIMALS & SLEEP

- Some animals such as dolphins display unihemispheric sleep
- May be associated with unilateral or bilateral eye opening
- Birds had only one-thirds sleep time in migratory season
- Provides benefits of sleep and survival
- Provided first insight into human sleep behavior/biology

BRAIN PLASTICITY

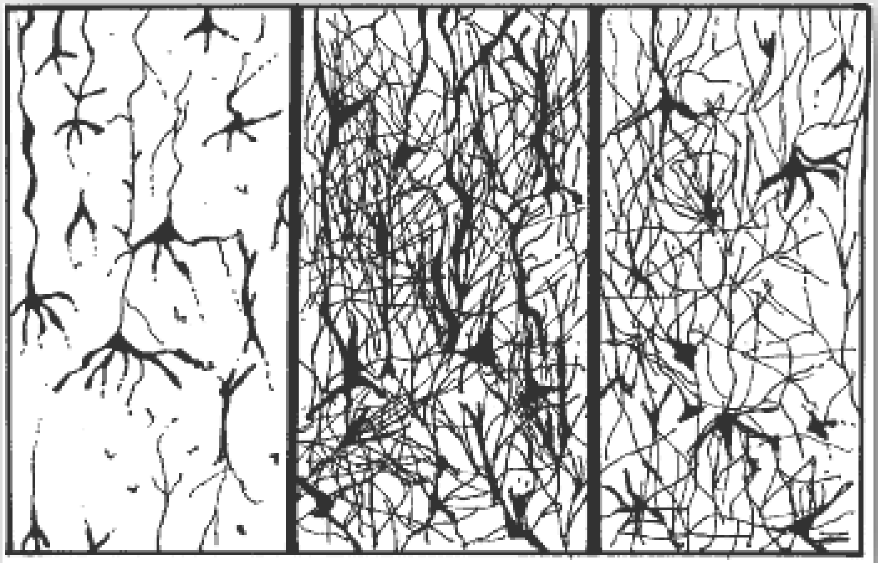
- Neurons communicate with each other by synaptic connections and networks
  - New neuronal firing patterns are made during sleep
  - Sleep allows time to maintain our functional synaptic circuit
    - Connections are made efficient and effective
      - Prune the ones you don't need
        - Reverse learning, or deleting unimportant memories so only the highly important memories are saved
      - Rejuvenate the ones you do need

BRAIN PLASTICITY PART II

- To learn a memory task or skill, we must first be trained, then encode and consolidate memories to retain them
  - Sufficient sleep the night before initial training is crucial for encoding new memories and learning
  - Memories are reviewed, refined, and consolidated during
    - REM sleep, NREM2, Slow wave sleep
  - During N2 sleep, different brain regions communicate with each other
    - Spindles arise from the thalamus to the cortex
    - The cortex sends K complexes back down
  - REM sleep enhances learning
- We learn best when we are in sync with our internal circadian clock
- Visual learning is enhanced by sleep and impaired by sleep loss

SYNAPTIC PRUNING

- Synapses are formed, strengthened and pruned at explosive rates during adolescence
- Restricted sleep then may lead to improper refinement of neural circuits.
- If chronic, may result in aberrant or mis-wiring (e.g. schizophrenia).



at a child's birth | at 7 years of age | at 15 years of age

NEUROBIOLOGY OF SLEEP

- Sleep prompting neurons and wake prompting neurons that inhibit each other→forms a "flip flop switch" circuit
  - results in rapid and complete transition in behavioral state also between REM and NREM sleep
- Allows for consolidated waking during the day and alternation between non-REM and REM sleep at night
- Break down of the circuitry results in and explains a variety of sleep disorders including:
  - Insomnia
  - Narcolepsy
  - REM sleep behavioral disorder

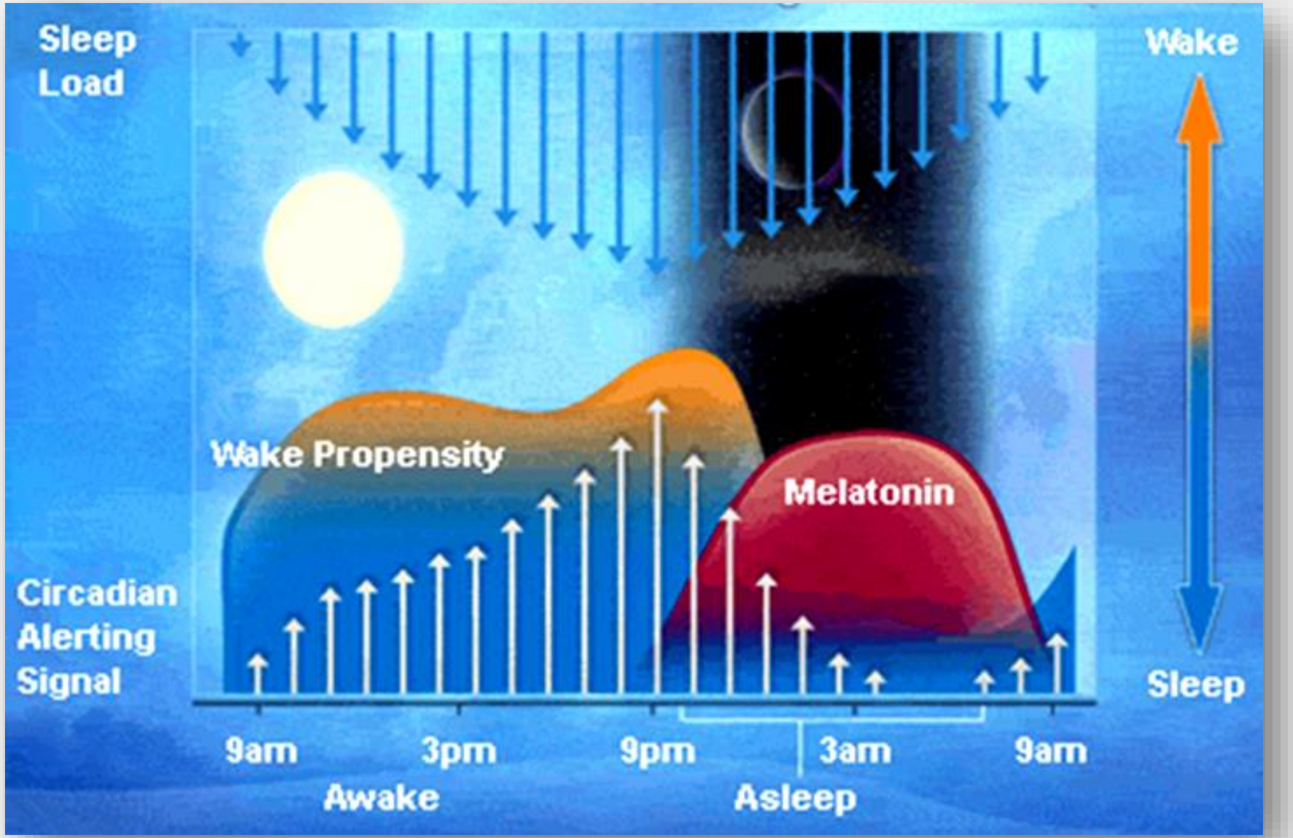
SUPRACHIASMATIC NUCLEUS (SCN)

- SCN=Circadian rhythm generator or "internal clock"
- Primary circadian pacemaker
  - Located in the anterior ventral hypothalamus
  - consists of only about 10,000 neurons
- Lesions of the SCN result in loss of the circadian rhythm of:
  - the sleep wake cycle to synchronize with the external light/dark cycle
  - melatonin secretion
  - cortisol secretion

MELATONIN

- Melatonin is secreted by the pineal gland
  - helps the suprachiasmatic nucleus sense the length of the night
  - bright light suppresses melatonin secretion
  - sleep occurs during the peak of melatonin secretion
  - levels rise about two hours before sleep onset
  - peak levels are a fivefold to tenfold rise compared with the low levels during the day
- Melatonin can reset our internal clock act as a chemical timekeeper and reset our internal clock
- Core body temperature rhythm can persist in the absence of SCN input

MELATONIN SECRETION AND LIGHT

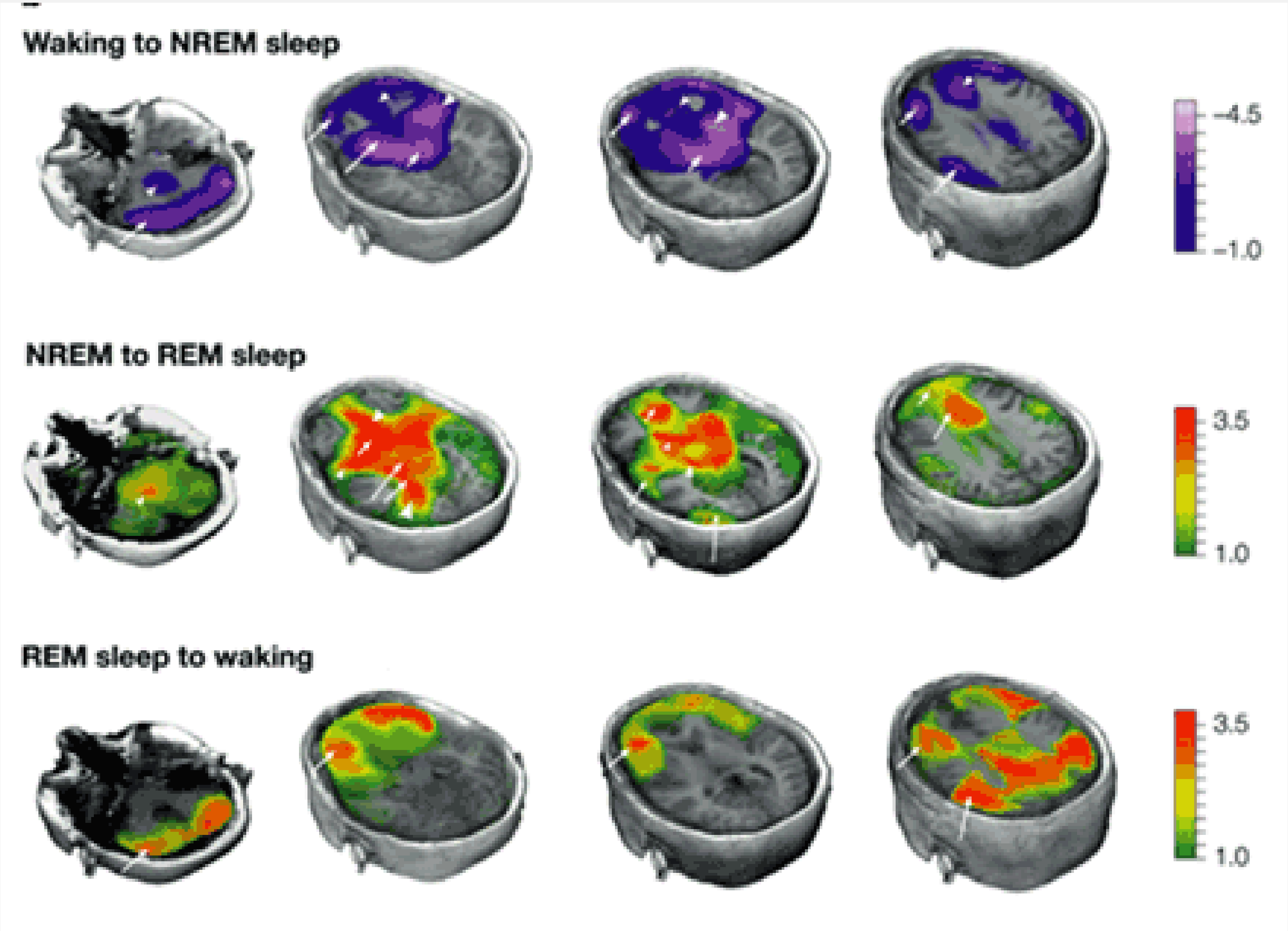


- In the absence of light, melatonin secretion in entrained individuals occurs almost exclusively during the nighttime hours starting between 9-11 pm, reaching peak serum levels 1-3 am, falling to low baseline values 7-9 am.

BRAIN ACTIVE IN PARTS DURING SLEEP

- Cerebral blood flow and cerebral metabolism are reduced during non-REM sleep:
  - wide portions of the frontal, parietal, temporal, and occipital cerebral & parts of the thalamus
    - the thalamus is in relay mode in wakefulness->allows incoming sensory information to reach the cerebral cortex
    - Changes to an oscillatory mode in sleep ->blocks transmission of sensory data
      - allows for restoration and rebuilding of selective portions of the brain during NREM sleep
- Parts that are selectively active include: hypothalamus and basal forebrain->generate and maintain the sleep state
- Regional glucose metabolism in REM sleep resembles that seen in wakefulness except for
  - selective the activation of higher order association
  - activation of visual association cortex areas

THE BRAIN IN DIFFERENT SLEEP STATES AND TRANSITIONS

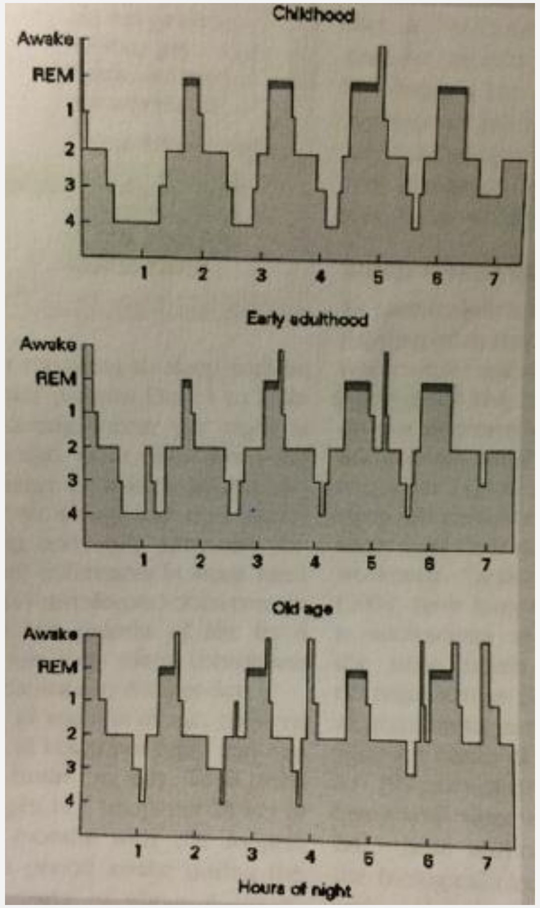


Hobson & Pace-Schott, Nature Reviews Neuroscience 2002;3:679-93.

SLEEP THROUGH THE AGES

- Age is the strongest and most consistent factor affecting the pattern of sleep stages across the night
- Sleep needs decline with age
- The biological clocks of teenagers change with puberty
  - tend to run later
  - By mid puberty, adolescents are sleepier mid morning and more alert mid afternoon
- A teen or adult who sleeps more than two hours more at night on the weekend compared with the weekday probably needs more sleep on weekdays

SLEEP NEEDS THROUGH THE AGES



Age	Sleep Needs (Hours per 24)
Normal full-term infant	16 to 18
4 months	14 to 15
6–8 months	13 to 14
Young children	9 to 10
Teenagers	8.5 to 9.25 (but they often do not get it so they get catch-up sleep on weekends)
Adults	7.0 to 8.5 per night
Older adults	5 to 6 per night; may compensate by taking 1-hour daytime naps

OTHER SLEEP CHANGES WITH AGE

- N1 sleep increases gradually across adult life
- Sleep efficiency (the percentage of time in bed and asleep) decreases with increasing age
- Sleep efficiency is relatively stable from childhood to age 30
  - declines in the fourth decade in men and fifth decade for women
- A gradual increase in the number of awakenings and arousals after sleep onset is observed across adulthood

OTHER FACTORS THAT MODIFY SLEEP STAGE DISTRIBUTION:

- Prior sleep history
- Drug effects
- Circadian processes and homeostatic processes impact→sleep amount
    - sleep needs are genetically determined
    - one cannot learn to sleep less
    - Timing: Sleep phase advance, Sleep phase delay
    - It is hard to delay or advance our circadian clock by more than two hours per day
  - Architecture
    - Core body temperature affects sleep architecture

IN SUMMARY

- Sleep is important for biological and behavioral needs
- Sleep in animals and humans based on environment
- Sleep can be assessed through sleep stages
- Brain remains active in sleep
- Sleep changes as a person develops
- Sleep can be modified by lifestyle, medications, disease processes

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- Lo JC, Loh KK, Zheng H, Sim SK, Chee MW. Sleep duration and age-related changes in brain structure and cognitive performance. Sleep. 2014 Jul 1;37(7):1171-8.
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QUESTIONS?

"Sleep is the best meditation."

~ Dalai Lama