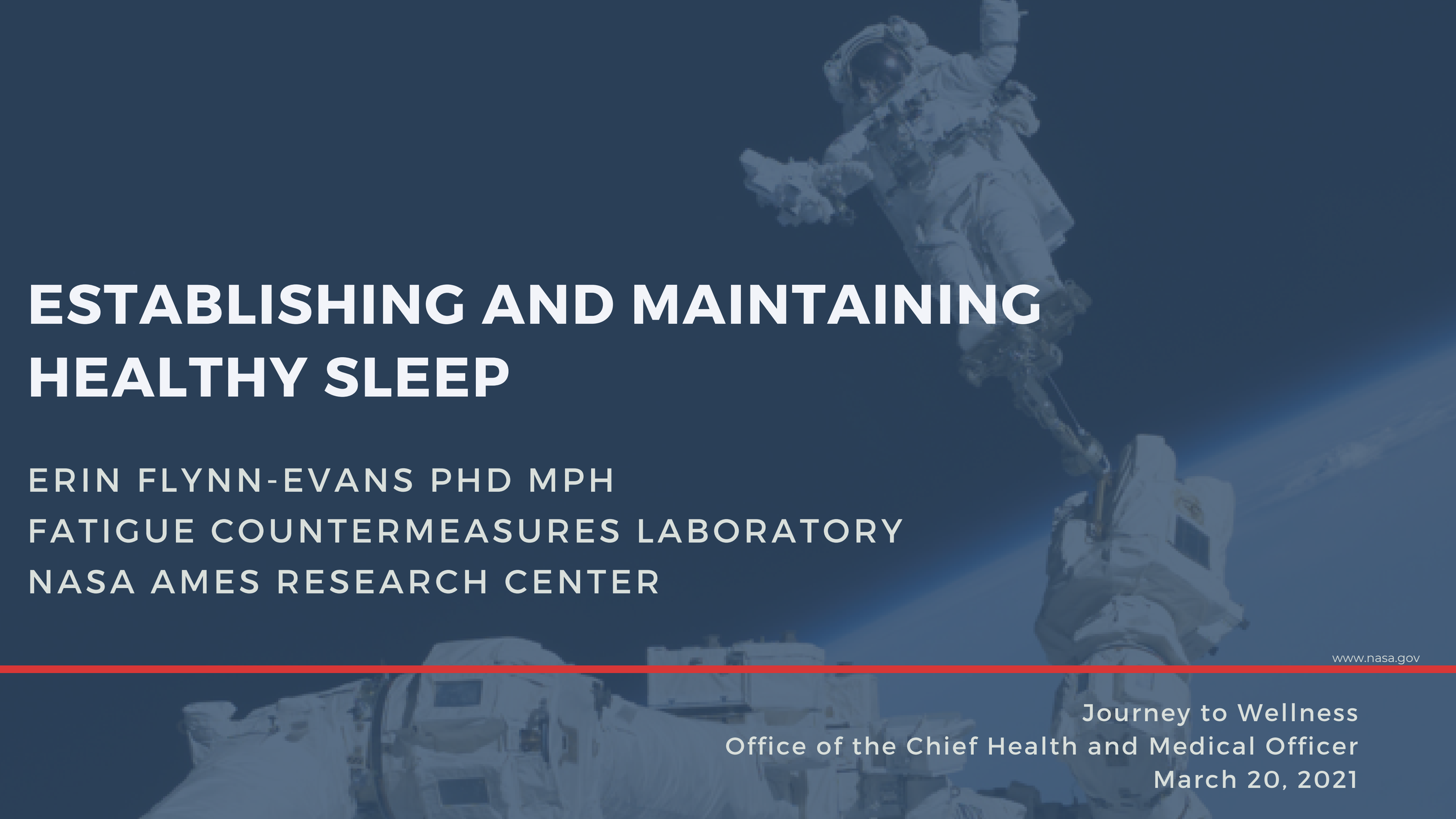


ESTABLISHING AND MAINTAINING HEALTHY SLEEP

ERIN FLYNN-EVANS PHD MPH
FATIGUE COUNTERMEASURES LABORATORY
NASA AMES RESEARCH CENTER

Journey to Wellness
Office of the Chief Health and Medical Officer
March 20, 2021

Learning Objectives

Understanding how sleep works will help you improve your sleep

Why do we need sleep?

How much sleep do we need?

How do we measure sleep?

What happens when we sleep?

What makes us sleep?

- Homeostatic sleep pressure
- Circadian rhythms

What happens when we don’t sleep enough or sleep at the wrong time?

- Short term consequences
- Long term consequences

How can you improve your sleep?

What do we do in the Fatigue Countermeasures Laboratory?

SPACEFLIGHT RESEARCH



AERONAUTICS RESEARCH



MISSION OPERATIONS



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Three Research Areas



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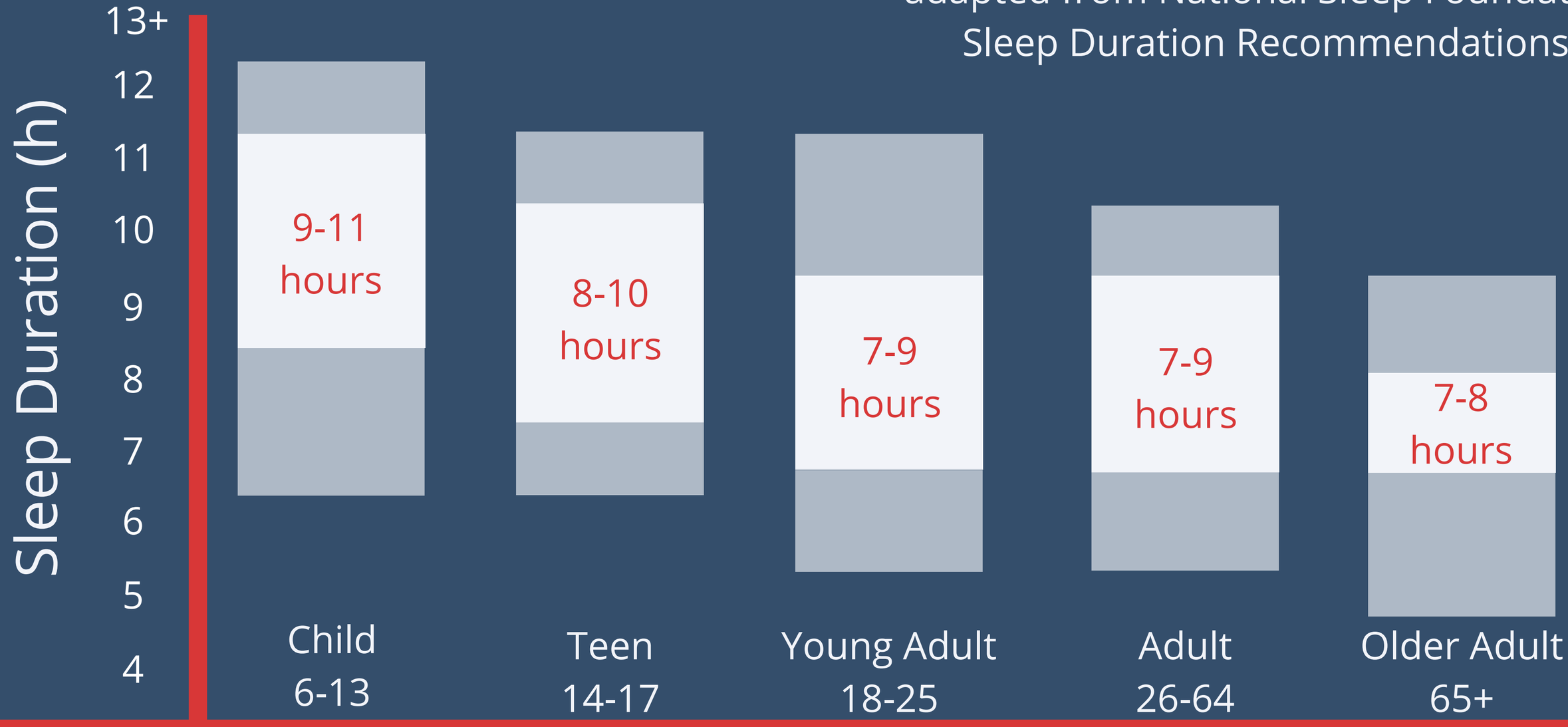
Why do we sleep?



www.nasa.gov

Why do we sleep?

adapted from National Sleep Foundation
Sleep Duration Recommendations



How much sleep do we need?

IT IS NORMAL TO TAKE UP TO 20 MINUTES TO FALL ASLEEP

Falling asleep in less than 5 minutes is a sign of insufficient sleep

YOU SHOULD BE ABLE TO SLEEP FOR 7-8 HOURS IN A ROW

Brief waking is normal
Waking to use the bathroom is normal for older adults

YOU SHOULD FEEL RESTED THROUGHOUT THE DAY WITHOUT STIMULANTS

It's normal to have modest sleepiness after lunchtime
If you are getting enough sleep you should not feel fatigued throughout the day

BED/WAKE TIME DRIVEN BY CHRONOTYPE

Morning types prefer an early bed/wake schedule
Evening types prefer a later bed/wake schedule



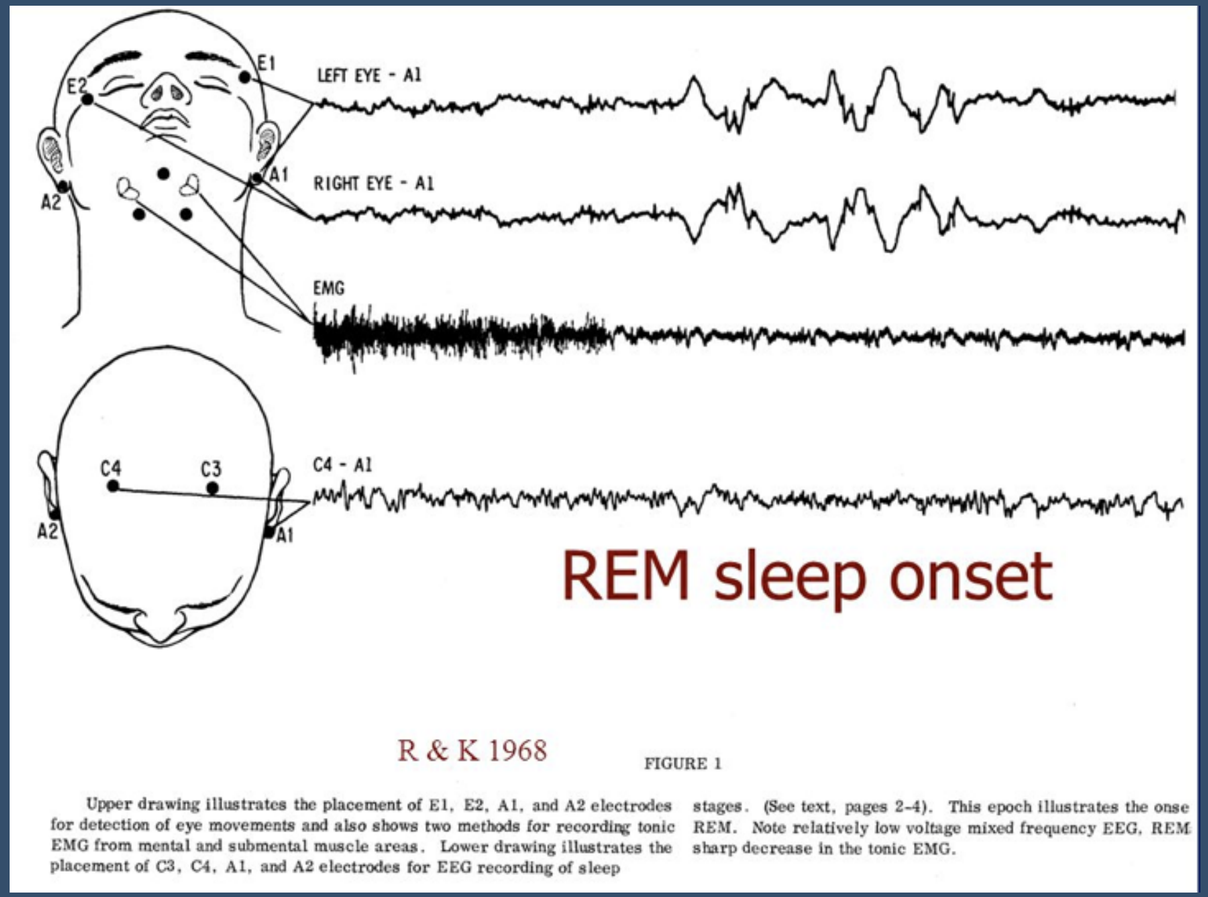
What is normal sleep anyway?

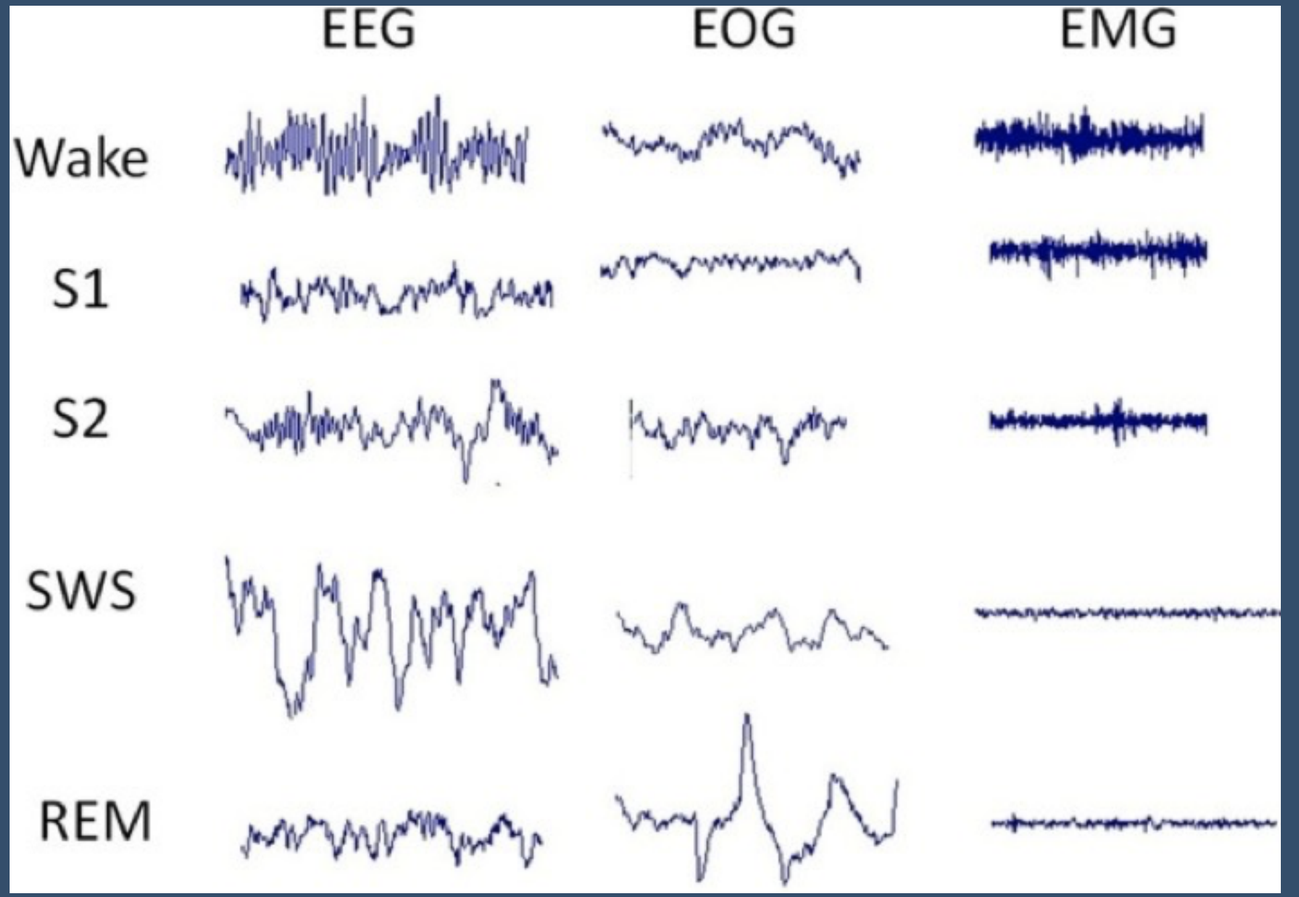


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What happens when we sleep?

Normal sleep architecture

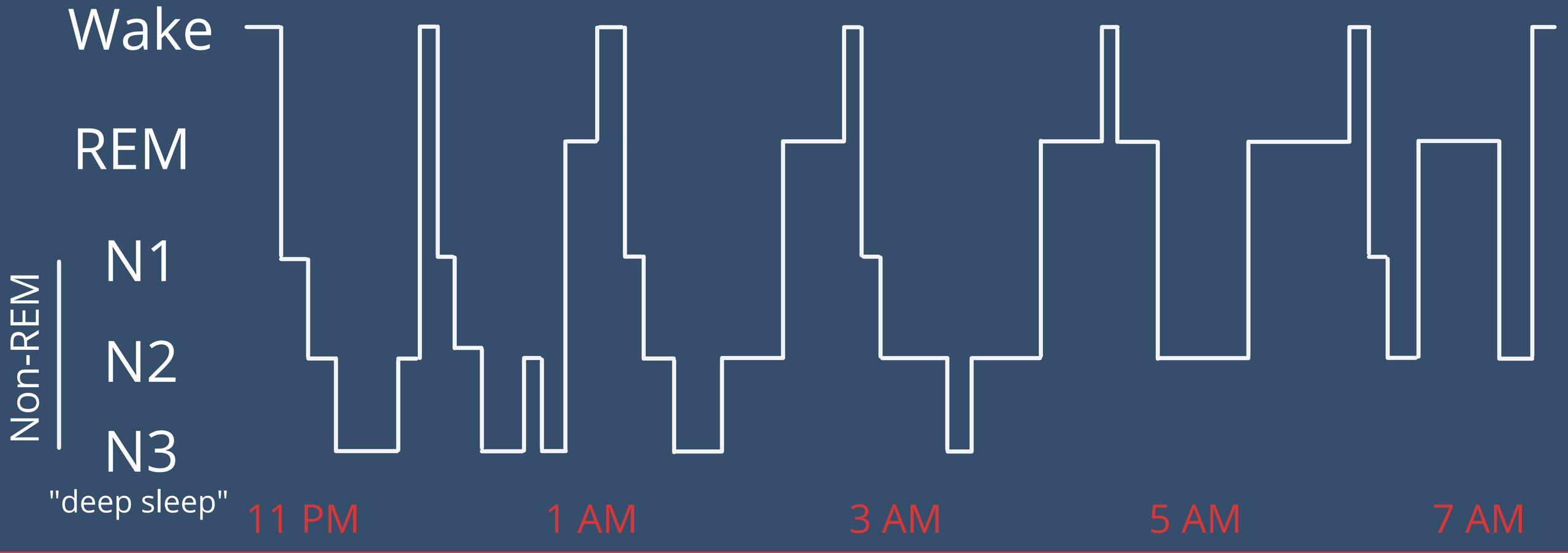




Rechtschaffen and Kales 1968

What happens in the brain during sleep?

Normal Sleep Architecture



How does sleep change during the night?

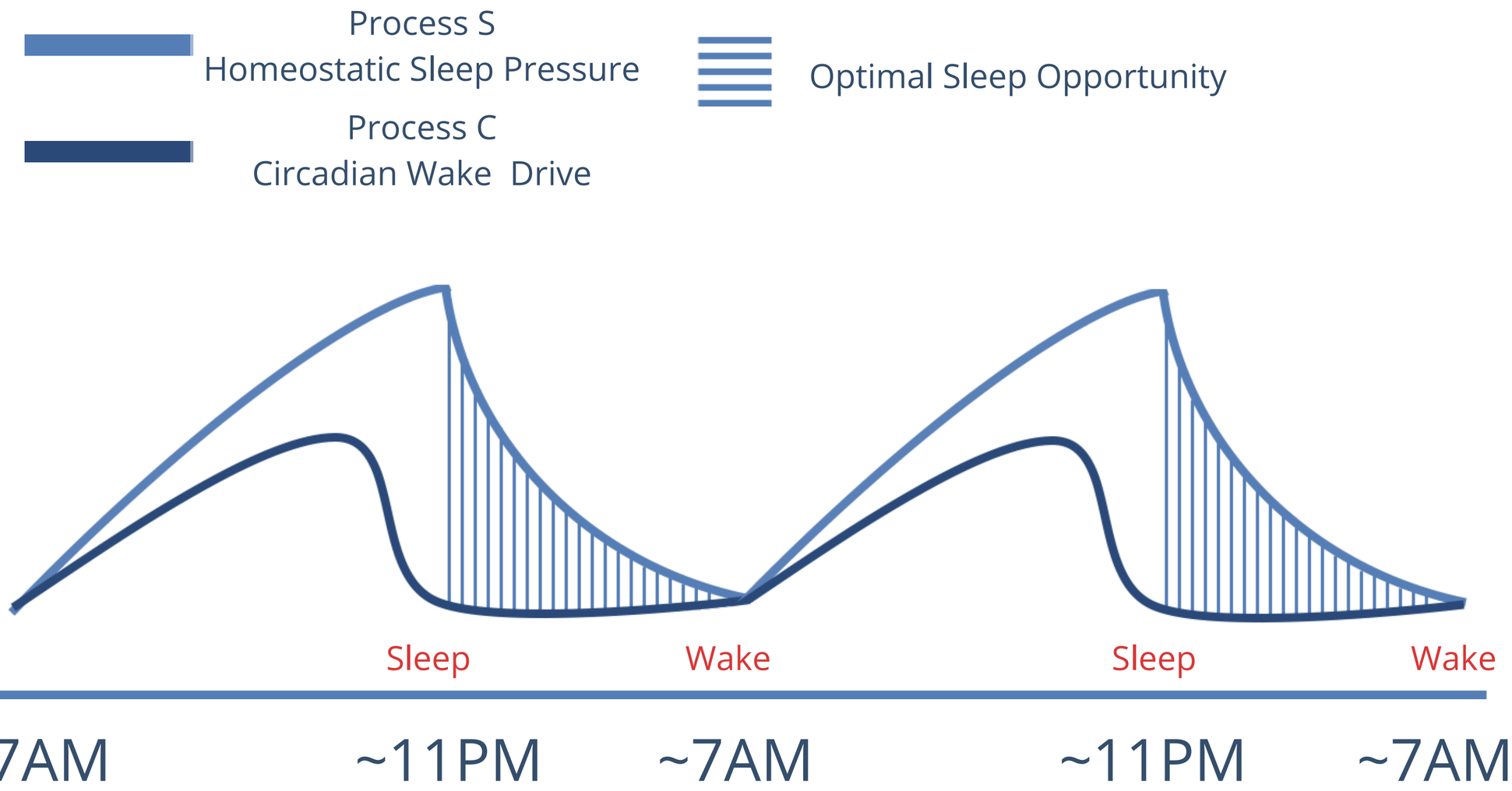


Sleep-Wake Regulation

What makes us sleep?

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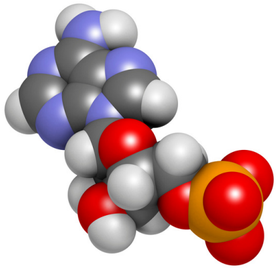
Two-Process Model of Sleep Regulation



adapted from Borbely *Hum Neurobiol* 1982

Sleep-Wake Regulation

Process S (Homeostatic) Sleep Regulation





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Sleep-Wake Regulation

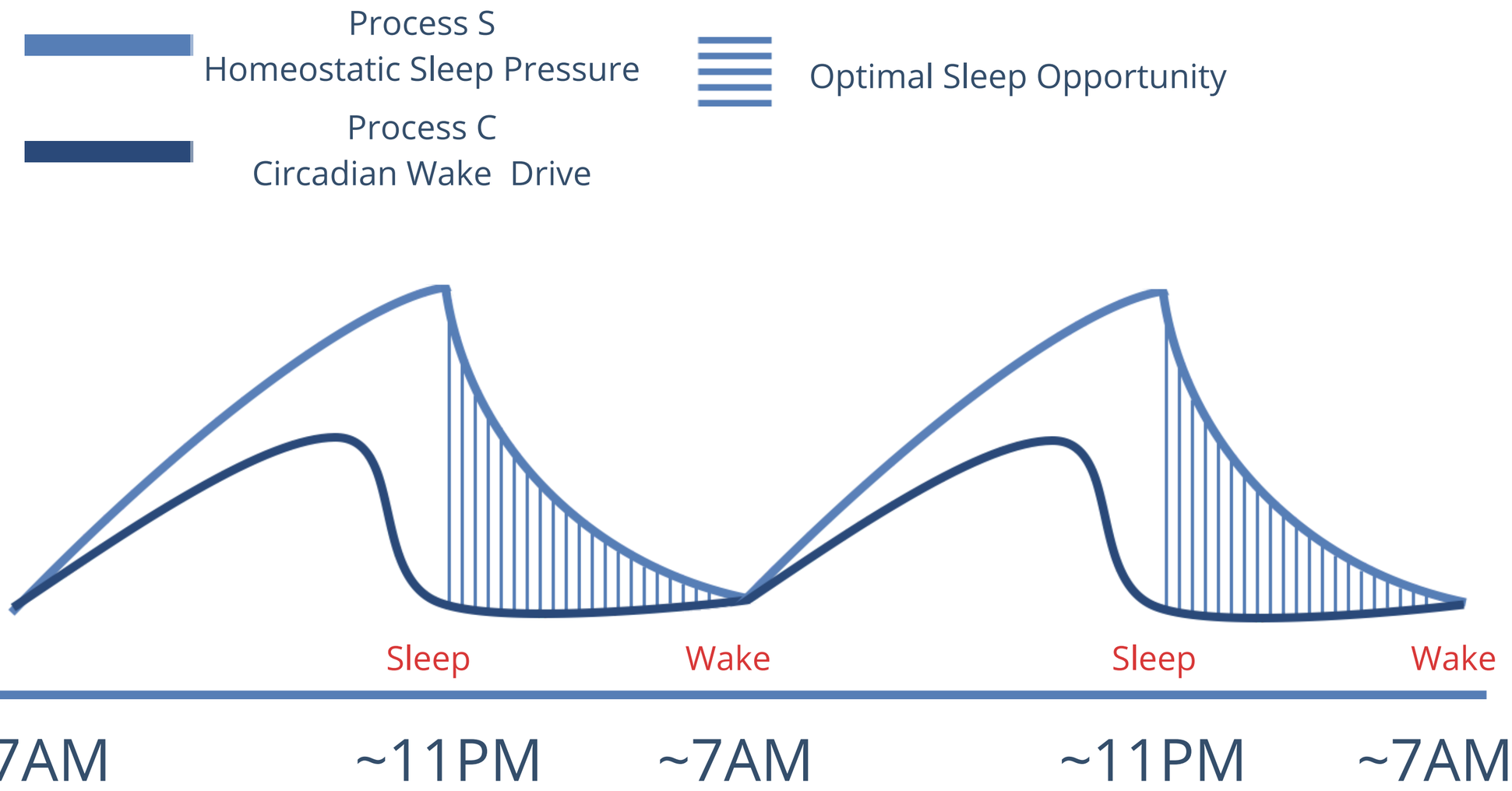
Process S (Homeostatic) Sleep Regulation



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Sleep-Wake Regulation

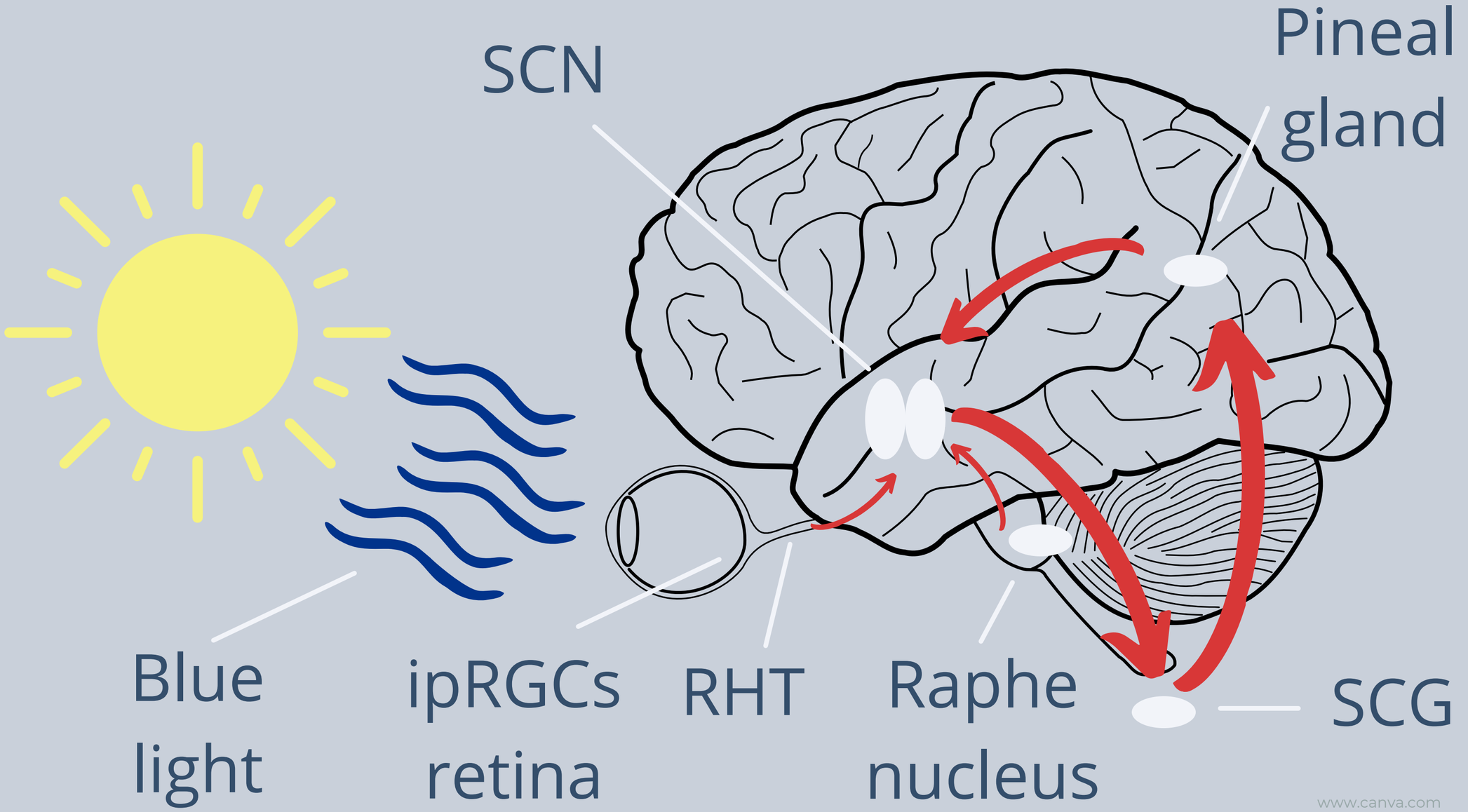
Two-Process Model of Sleep Regulation



adapted from Borbely *Hum Neurobiol* 1982

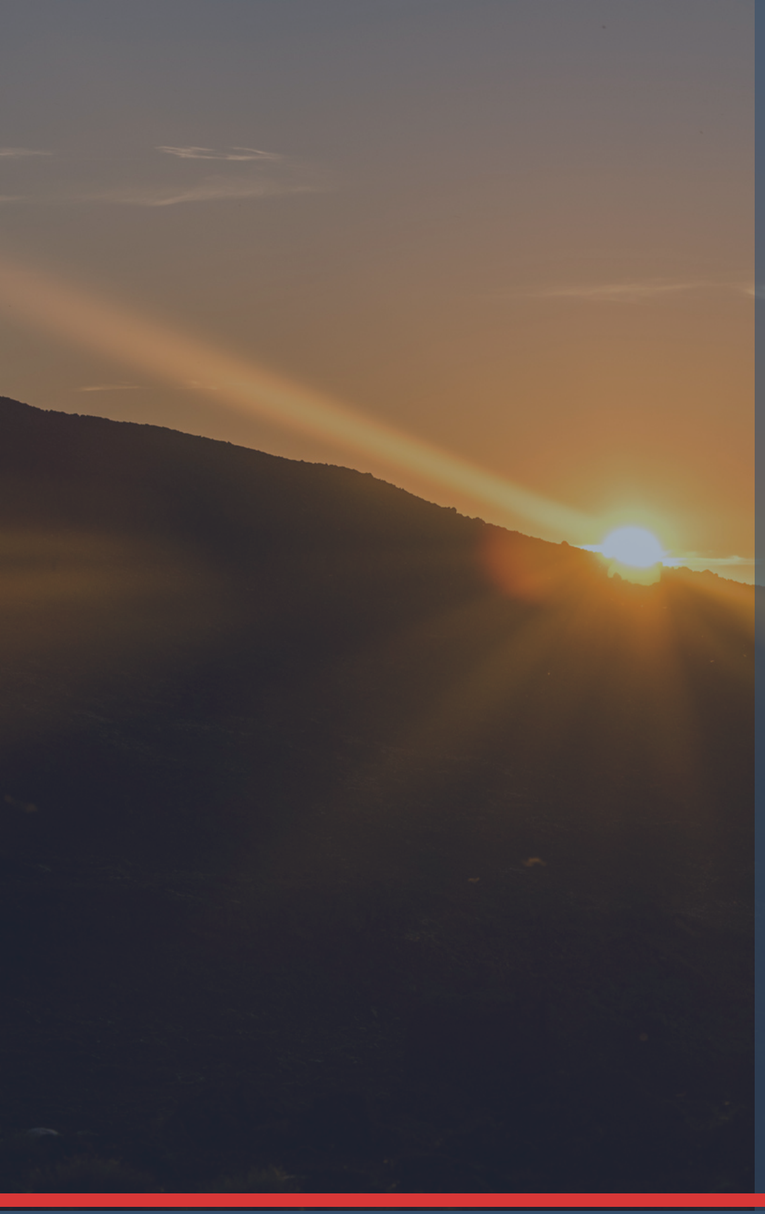
Sleep-Wake Regulation

Process C (Circadian)
Wake Regulation



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Circadian Rhythm Resetting



Influence of light on circadian rhythms

Dependent on:

- Wavelength
  - Blue light ~480 nm = range strongest
    - Suppresses melatonin
  - Red light ~700 nm = weak effect
- Pattern
- Duration
- Intensity

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Light in the morning shifts the drive to sleep and wake EARLIER

Light in the evening shifts the drive to sleep and wake LATER



Light exposure at different times does different things



What happens when sleep is too short or mis-timed?

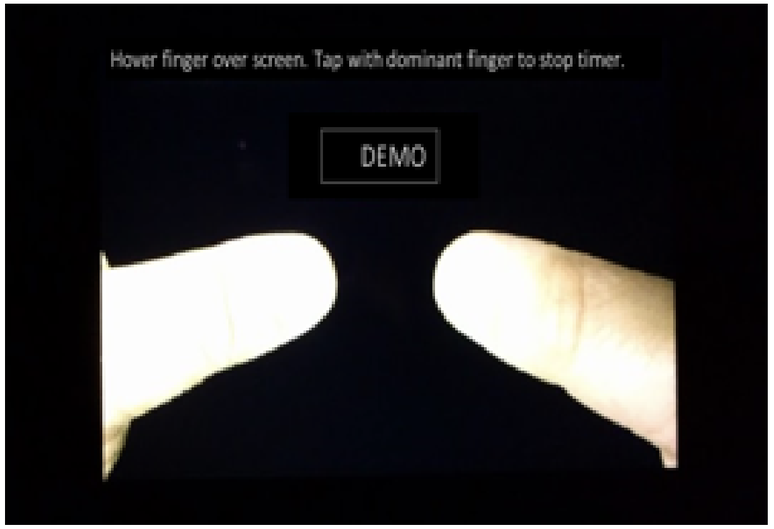
Causes and consequences of circadian misalignment



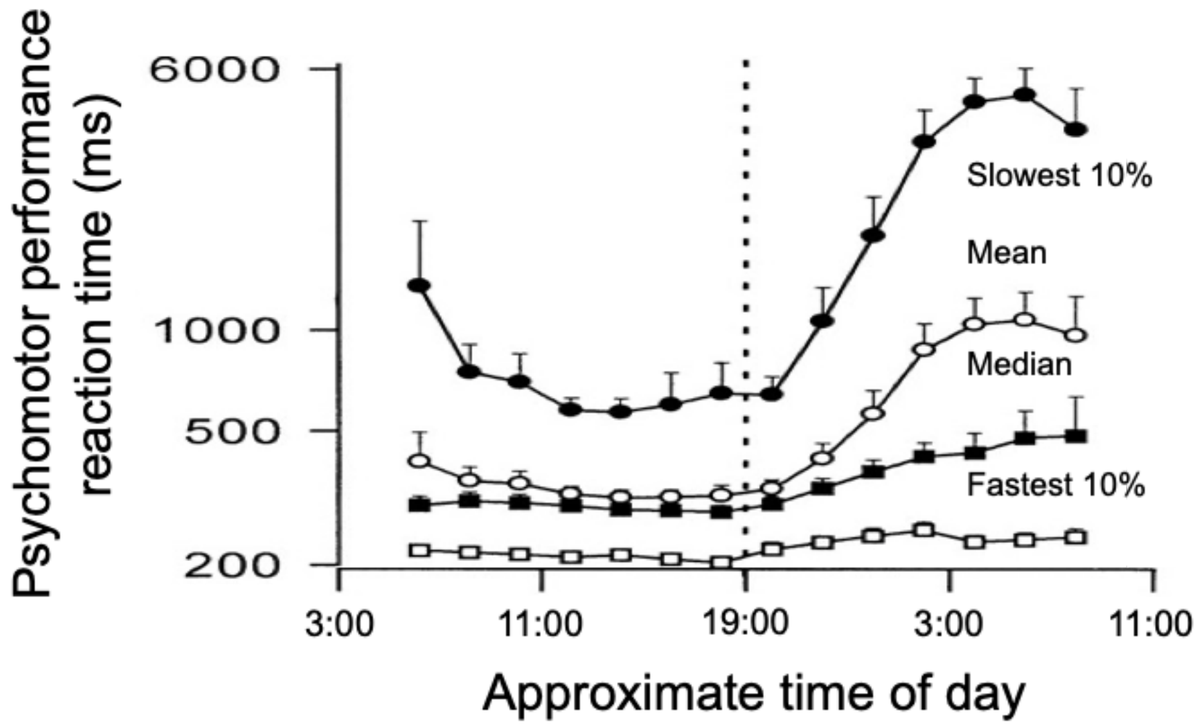


Circadian Misalignment

Performance Impairment



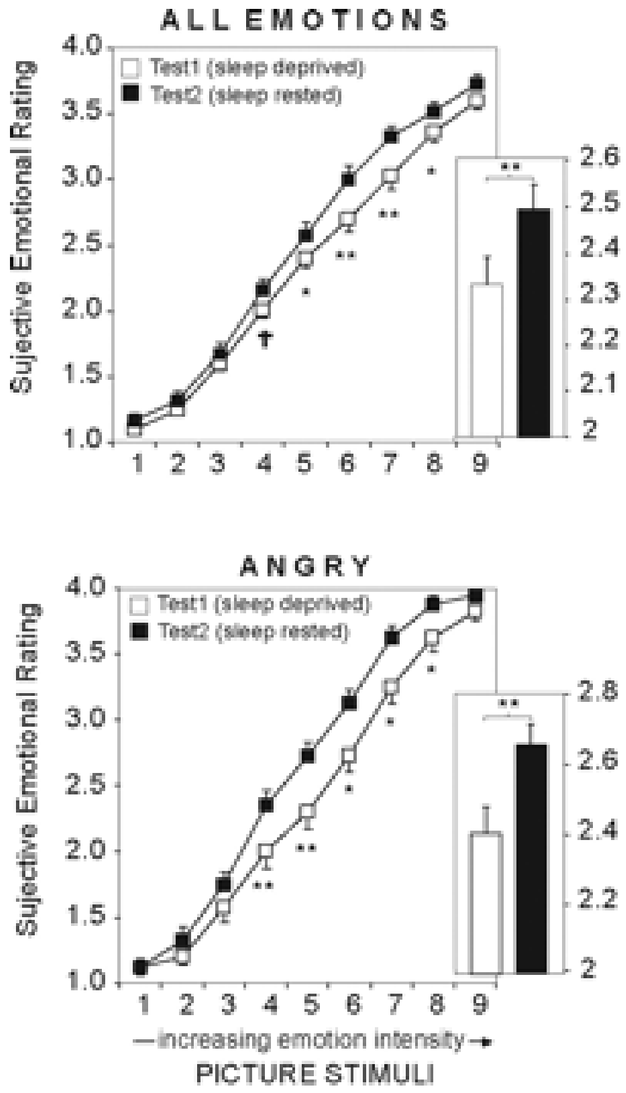


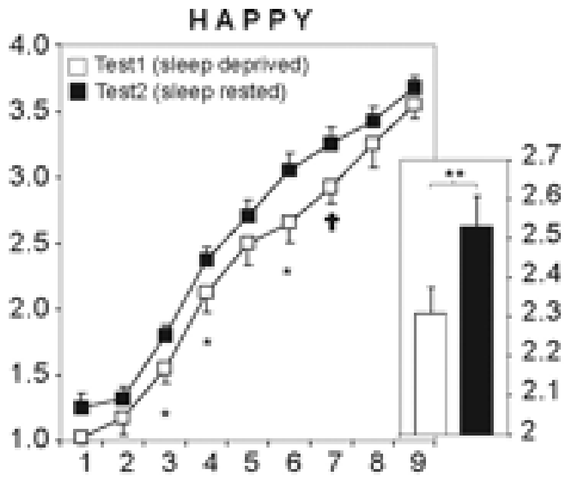


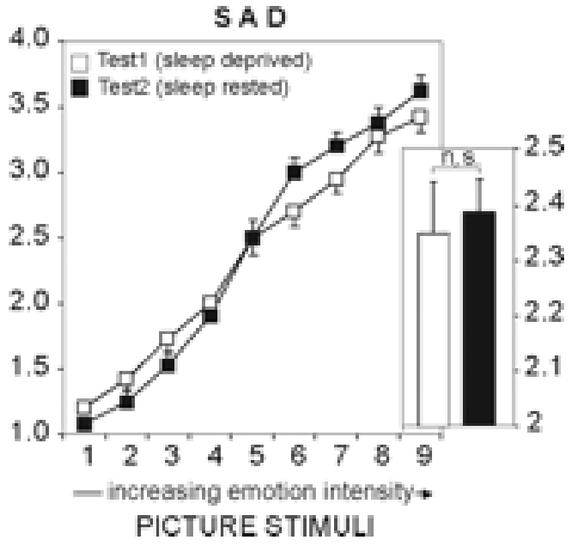
Johnson *et al.* 1995

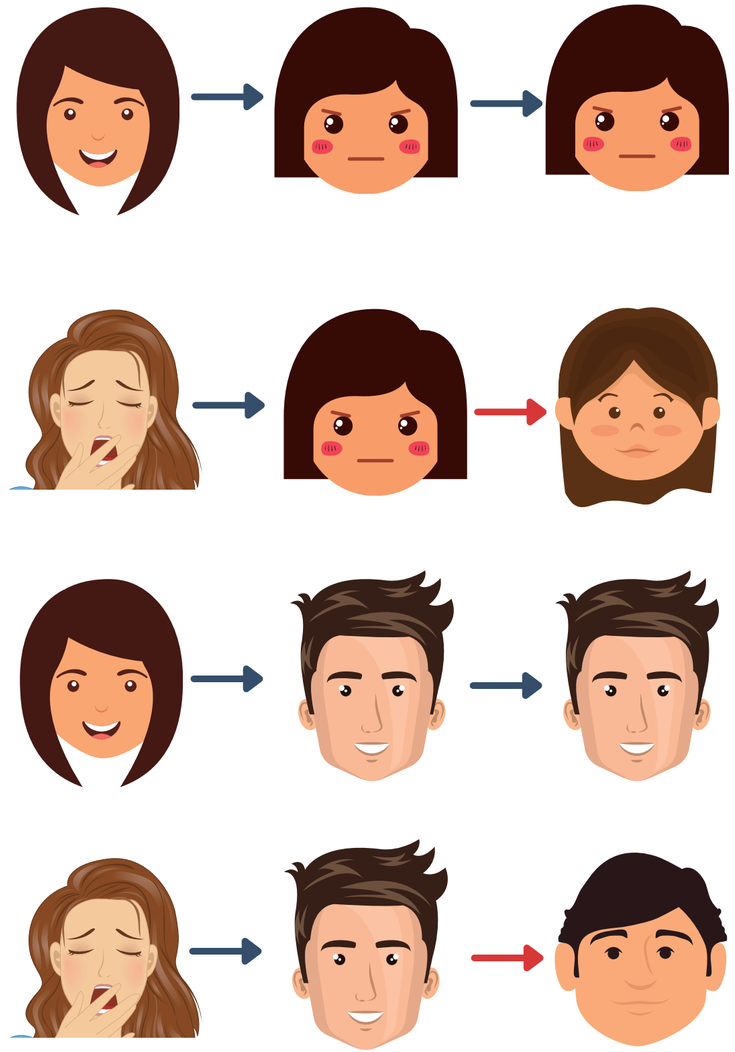
Consequences of Sleep Loss and Circadian Misalignment

Impaired Emotion Recognition







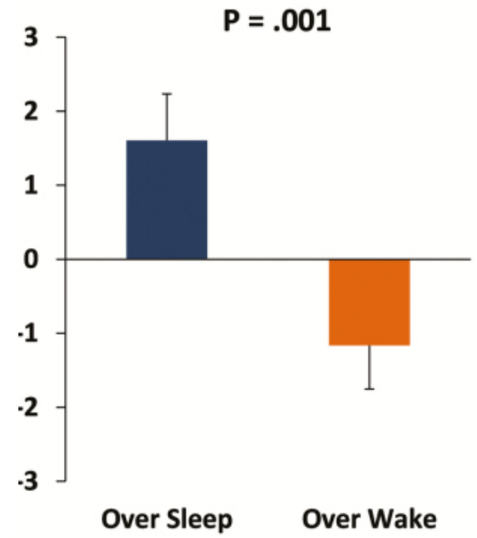


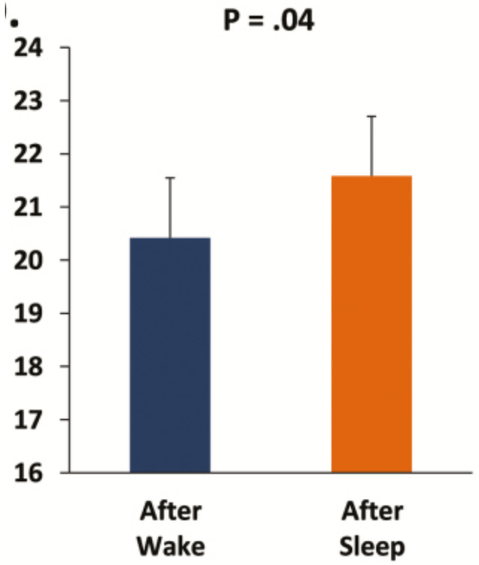
van der Helm 2010 *Sleep*

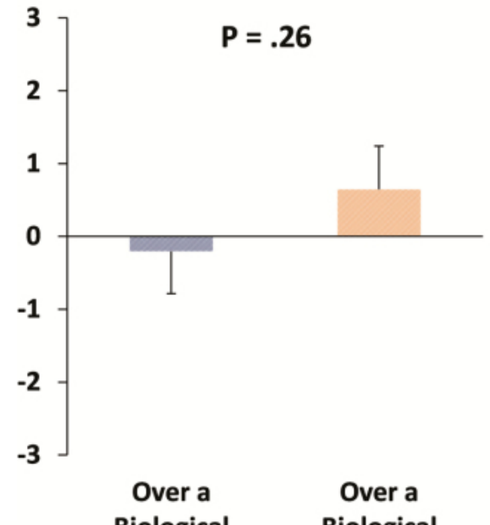
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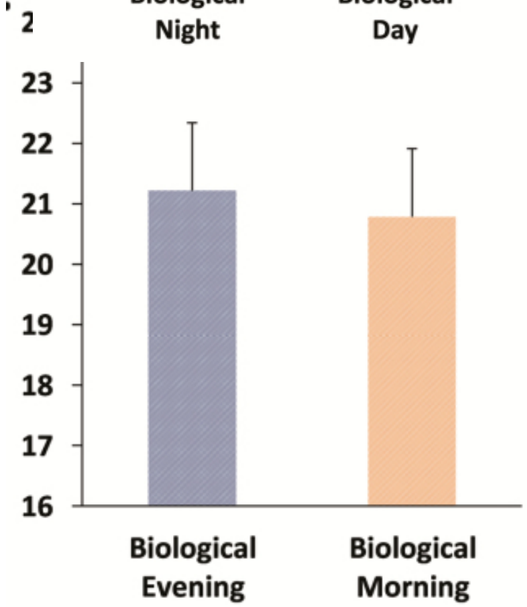
Consequences of Sleep Loss and Circadian Misalignment

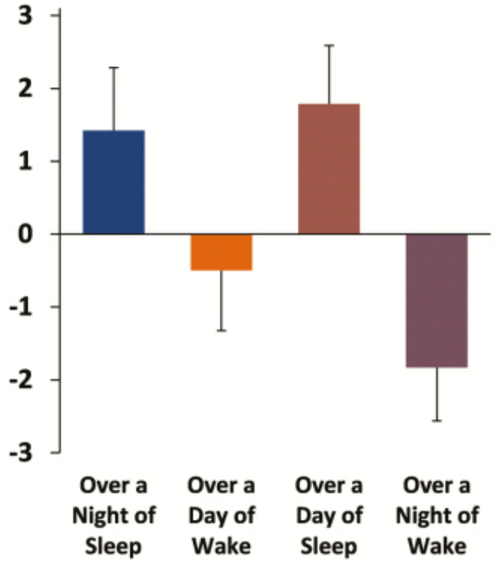
Impaired Learning and Memory Consolidation

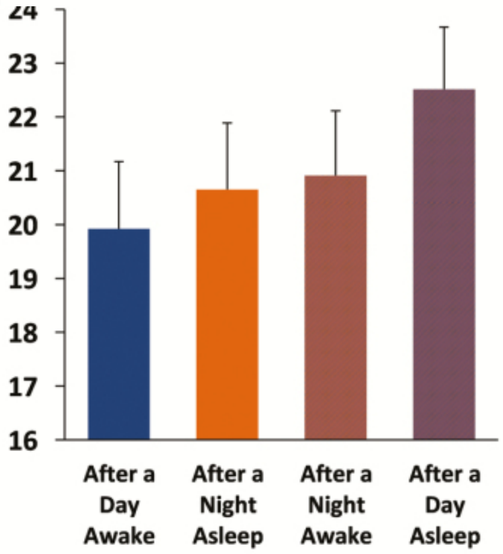








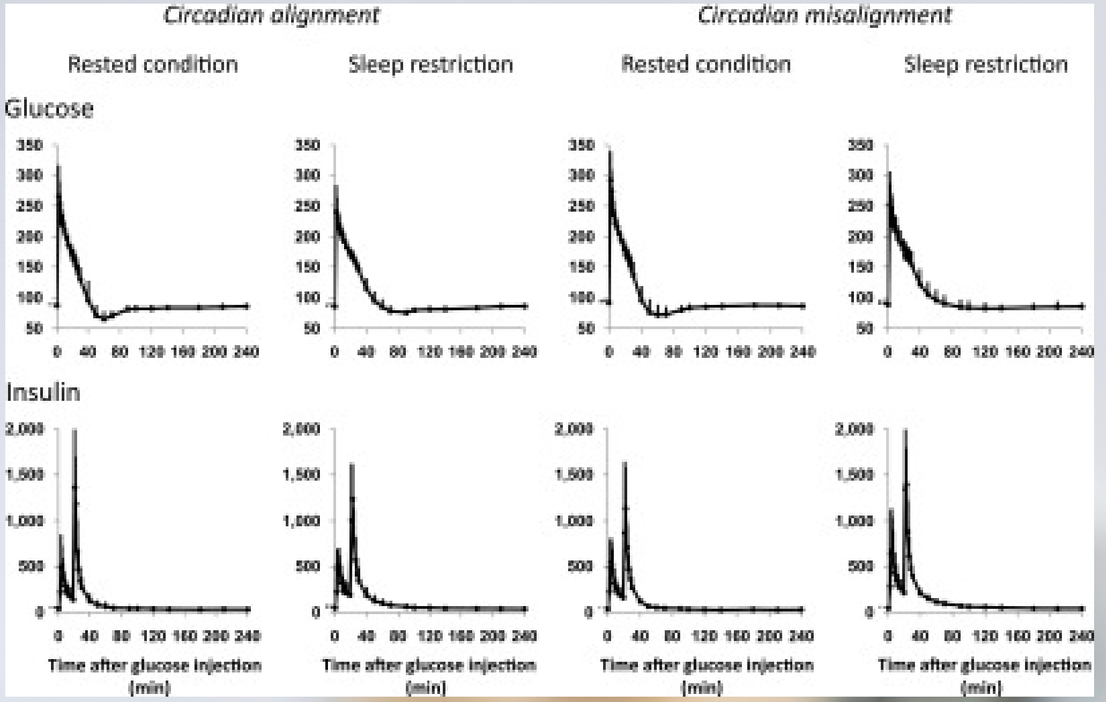




Tucker *et al*. 2017 *SLEEP*

Consequences of Sleep Loss and Circadian Misalignment

Impaired Metabolic Function

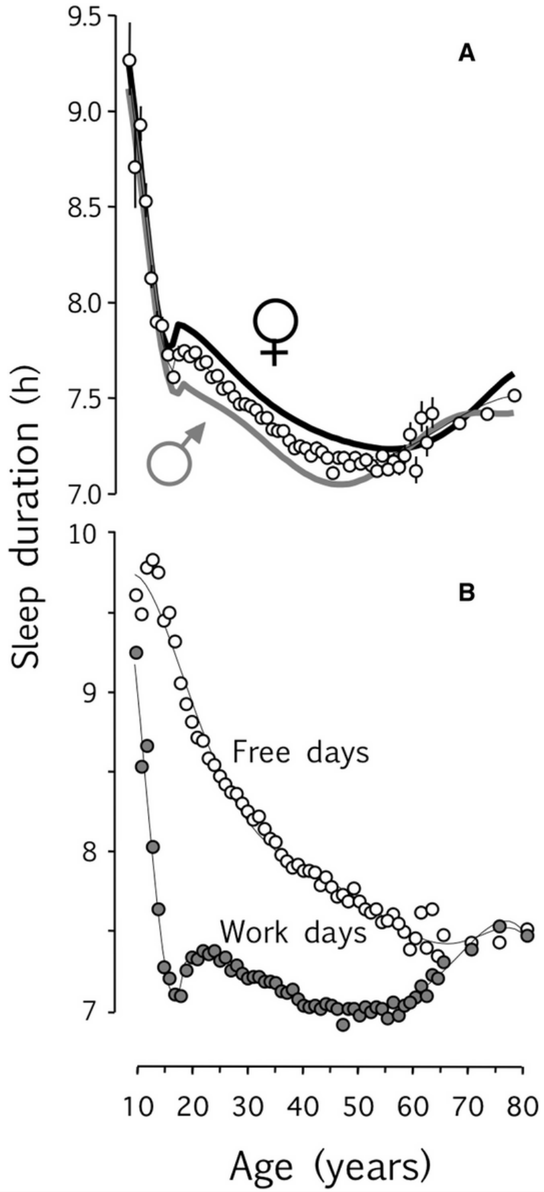


Leproult *et al*. 2014 *Diabetes*

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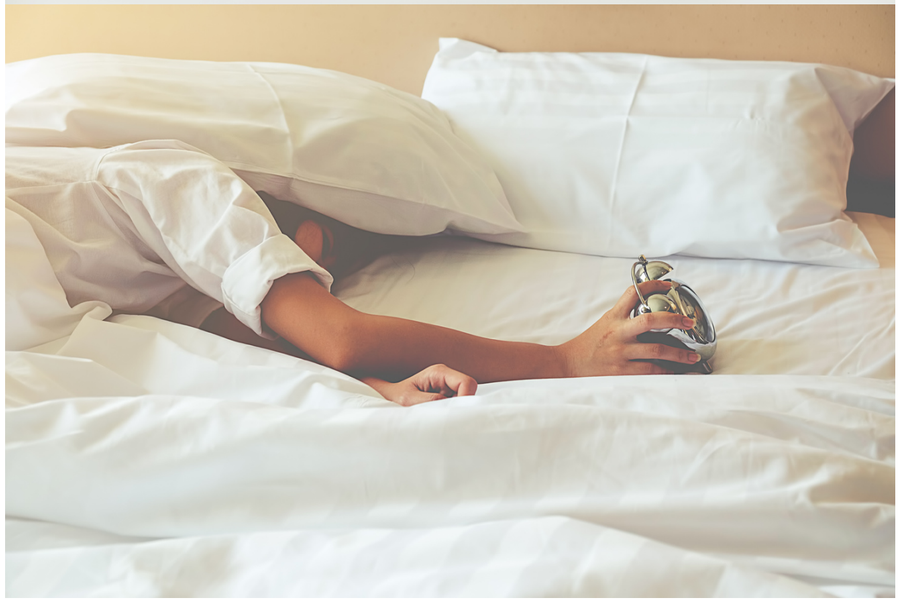
Consequences of Sleep Loss and Circadian Misalignment

Social Jet Lag



Roenneberg *et al.* 2012 *Curr Biol*

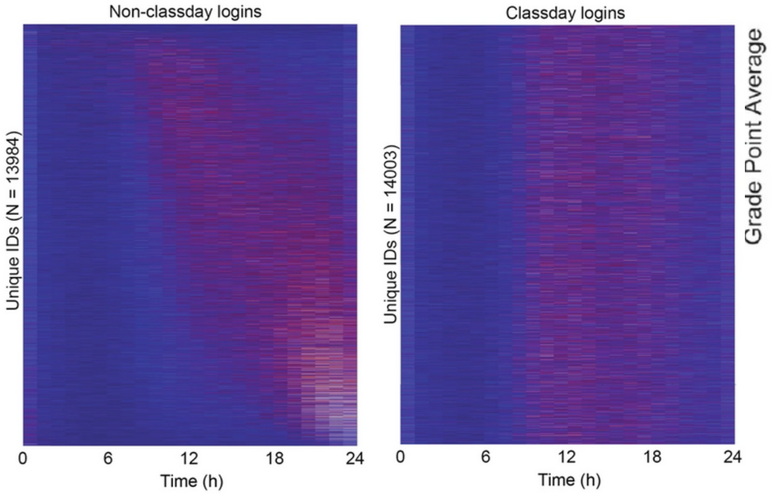


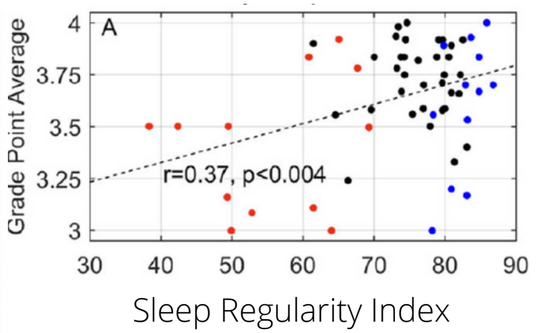


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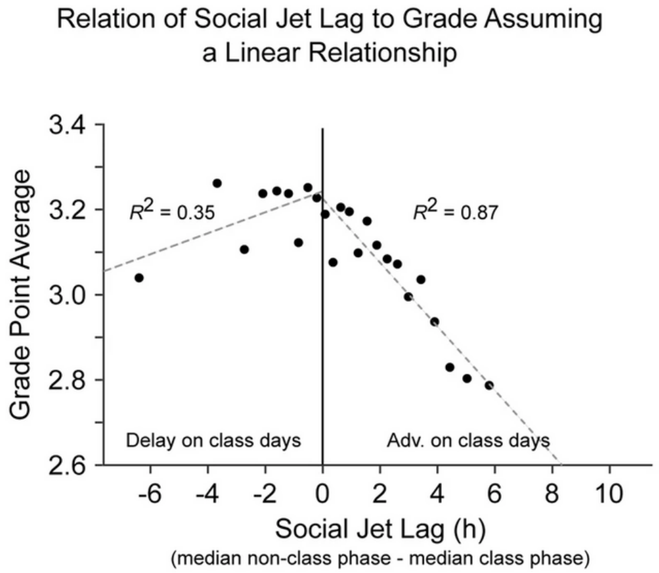
Circadian Misalignment

Poor Academic Performance

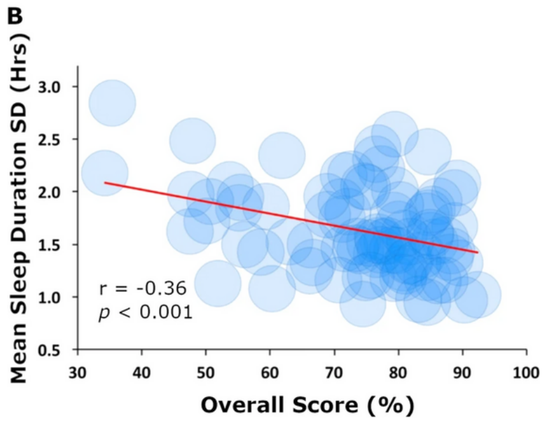




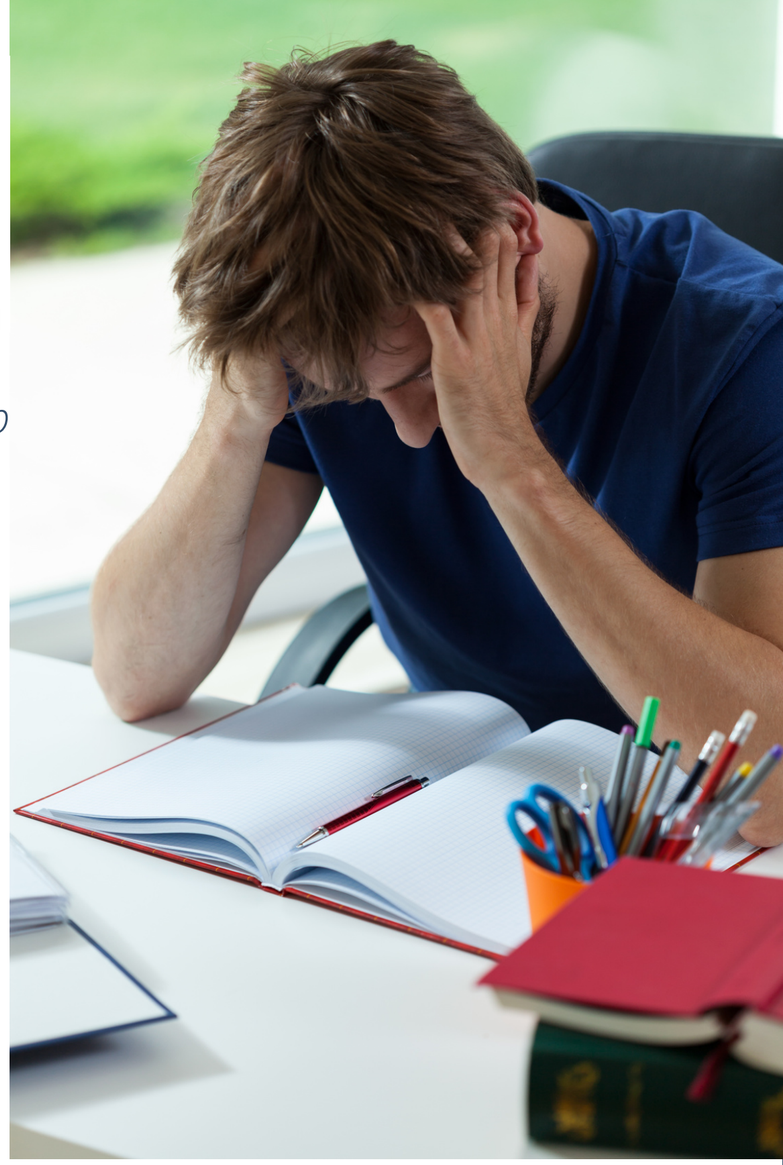
Phillips *et al*. 2017 *Sci Rep*



Smarr and Shirmer 2018 *Sci Rep*



Okano *et al*. 2019 *Sci of Learn*



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Consequences of Social Jet Lag

What can you do to improve your sleep?

Optimize your sleep hygeine



ASSESS DON'T OBSESS

Situational insomnia arises from a variety of causes
Rumination can increase insomnia frequency

PRACTICE MEDITATION/DEEP BREATHING

Deep breathing exercises can help with the transition to sleep

KEEP A BEDSIDE JOURNAL

Write down concerns to deal with them in the morning

DON'T SPEND HOURS AWAKE IN BED

If you can't fall asleep within ~20 minutes or if wake during the night and cannot fall asleep, then get out of bed
Don't look at screens
Engage in low-key activities in dim light (e.g. read a book in dim light)



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Transient Insomnia



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COOL

< 72 degrees

Comfortable microclimate

DARK

Use blackout shades (especially shiftworkers)

Cover indicator lights

QUIET

Use white noise if needed (especially shiftworkers)

Optimize Your Sleep Environment

TURN DOWN THE LIGHTS 1-2 H BEFORE BED

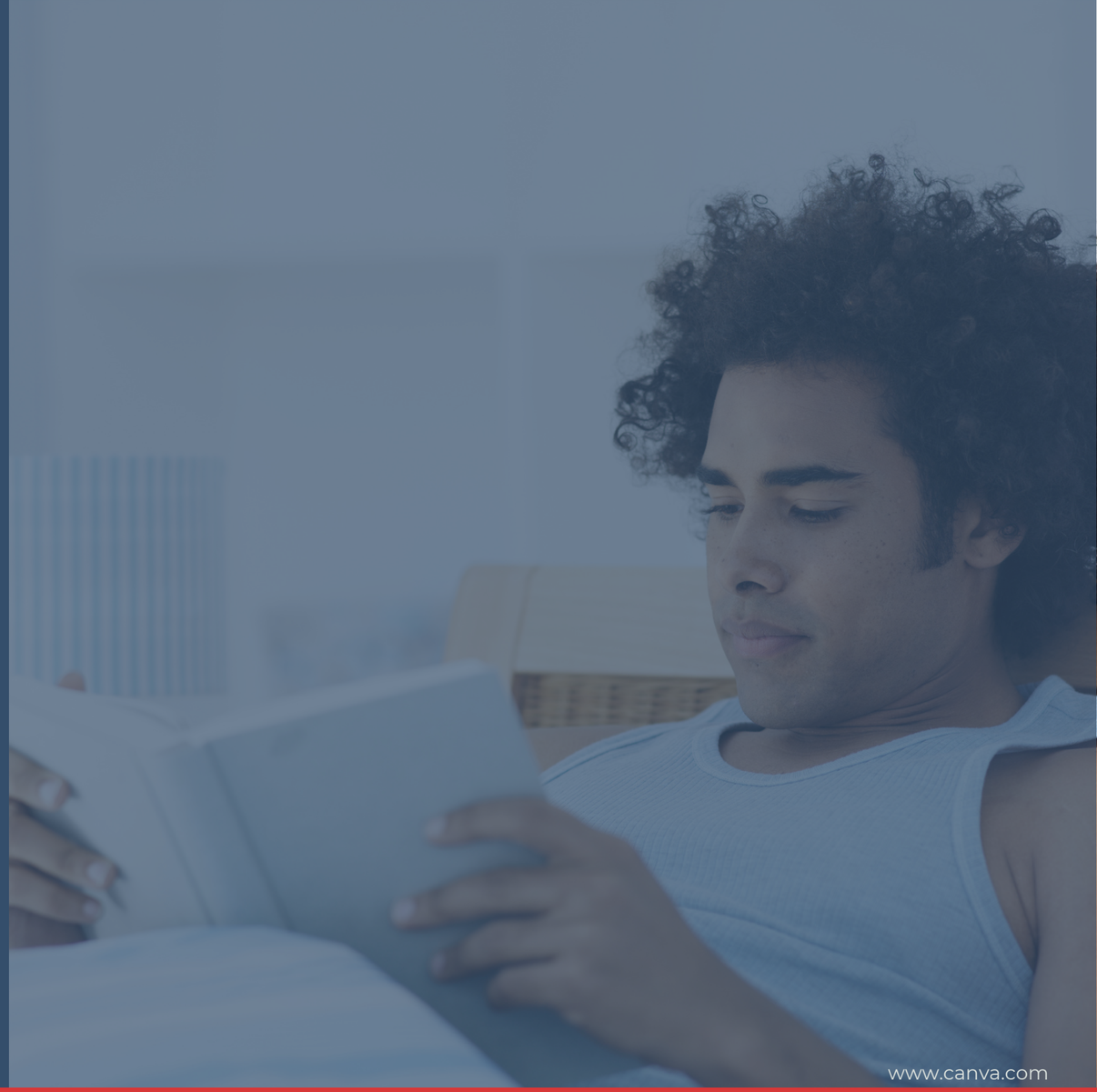
Evening light is alerting and can shift your circadian rhythm
Melatonin is not produced in the presence of light

SKIP THE SCREENS

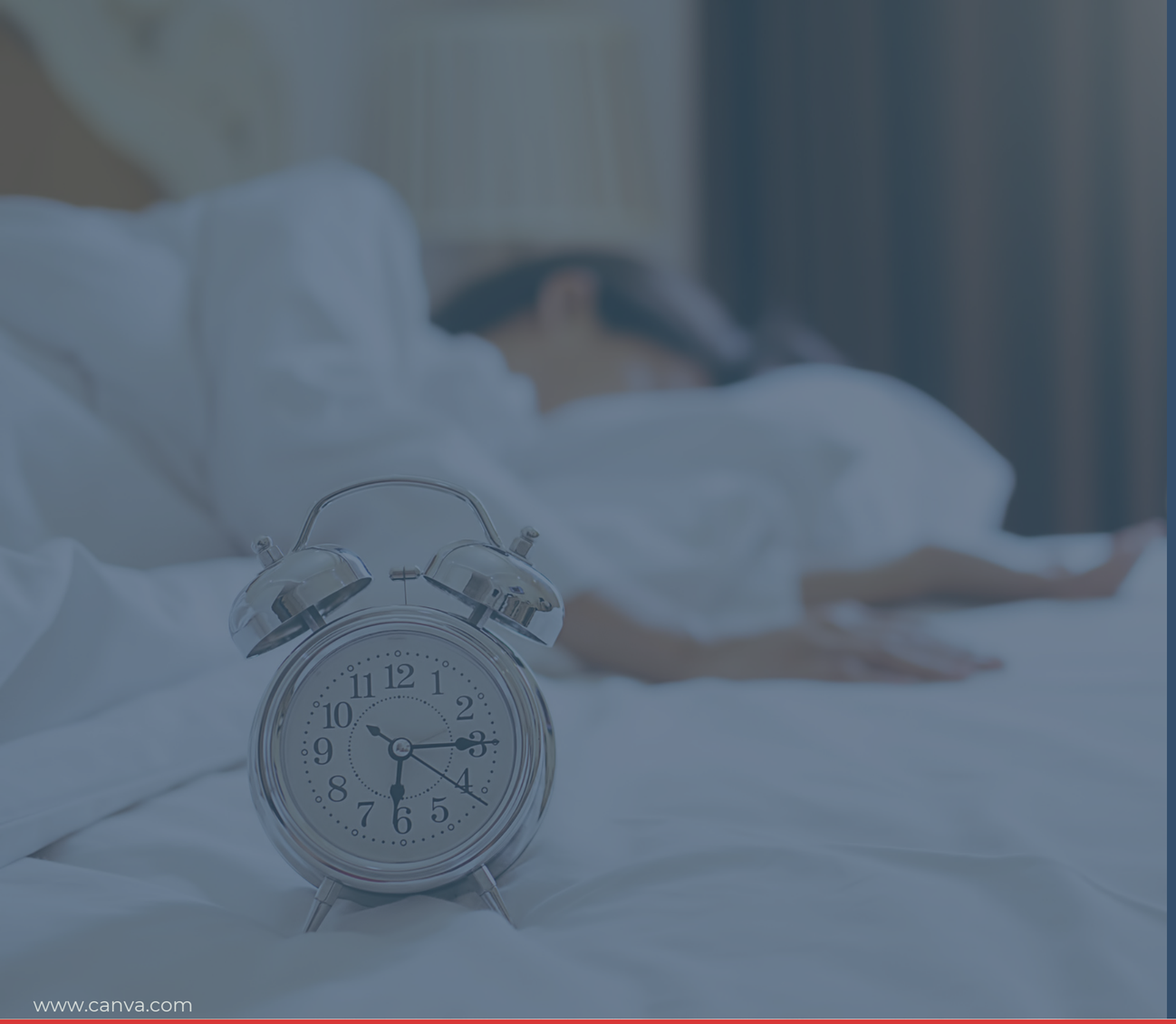
Light from computers/tablets phones shifts the circadian rhythm
Avoid screens 1-2 hours before bed
Put your phone in another room (yes, really)

TAKE 20 MINUTES TO WIND DOWN

Take a bath
Read a book
Listen to music



Create a Bedtime Routine



SLEEP REGULARITY ASSOCIATED WITH:

Better quality sleep
Lower weight gain
Improved alertness and performance
Better academic performance

WEEKENDS COUNT TOO!

Switching schedules between weekends and weekdays causes social jet lag

MAXIMIZE MORNING LIGHT

Regular timing of morning light helps stabilize your internal clock
Keep it dark until your target wake time

Maintain a Regular Bed & Wake Time



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AVOID CAFFEINE WITHIN 6 HOURS OF BEDTIME

Caffeine will change your sleep architecture even if you are able to fall asleep right after consuming it

Caffeine in the morning can still affect your sleep

There are individual differences in caffeine sensitivity

AVOID ALCOHOL BEFORE BED

Alcohol may help you fall asleep, but it will reduce sleep quality and sleep architecture

DISCUSS MEDICATIONS WITH YOUR PHYSICIAN

Some medications may cause insomnia, discuss these issues with your personal physician for guidance

Manage Sleep Disrupting Substances



What if you don't work typical shifts?

Is it possible to get good quality sleep?

CIRCADIAN MISALIGNMENT

The circadian rhythm promotes waking during the day and sleep at night

Makes it difficult to stay awake during the day

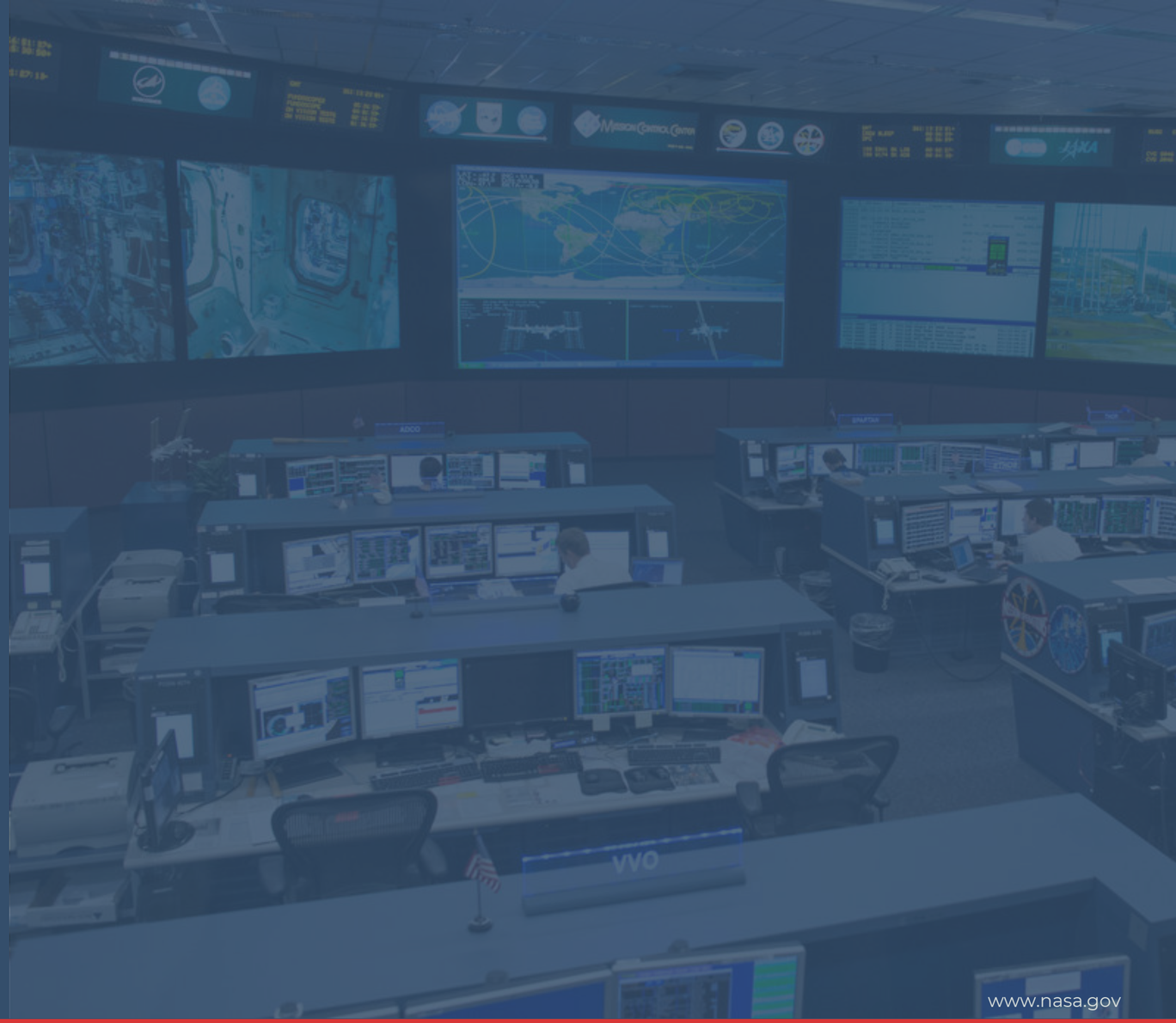
Makes it difficult to sleep during the day

Reduced alertness and performance during shifts

SOCIAL/BEHAVIORAL

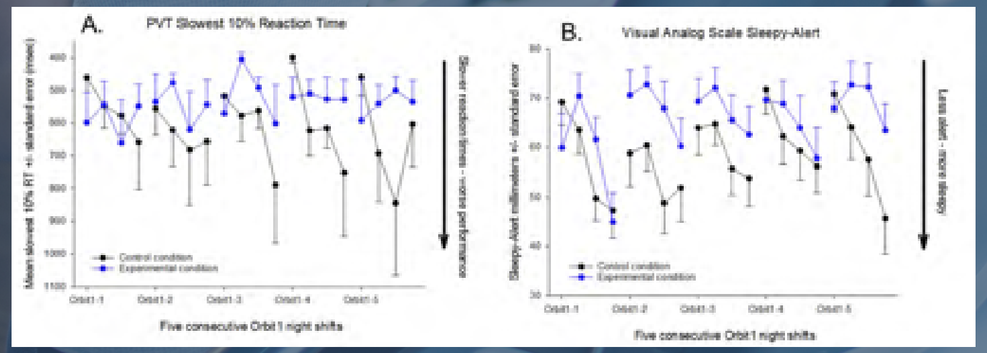
Increased pressure to engage with friends family during the day

Environmental sleep disruption (e.g., noise, light)



www.nasa.gov

Shiftwork Challenges



Barger et al. 2021

www.canva.com

TAKE A NAP

Before or during shift

Naps are associated with improved alertness and performance (>20 minutes)

Plan on ~20 minutes to "wake up"

USE CAFFEINE STRATEGICALLY

Performance maintained with ~50 mg of caffeine (weak cup of coffee, tea) every hour is associated with improved performance

USE BRIGHT LIGHT DURING SHIFT

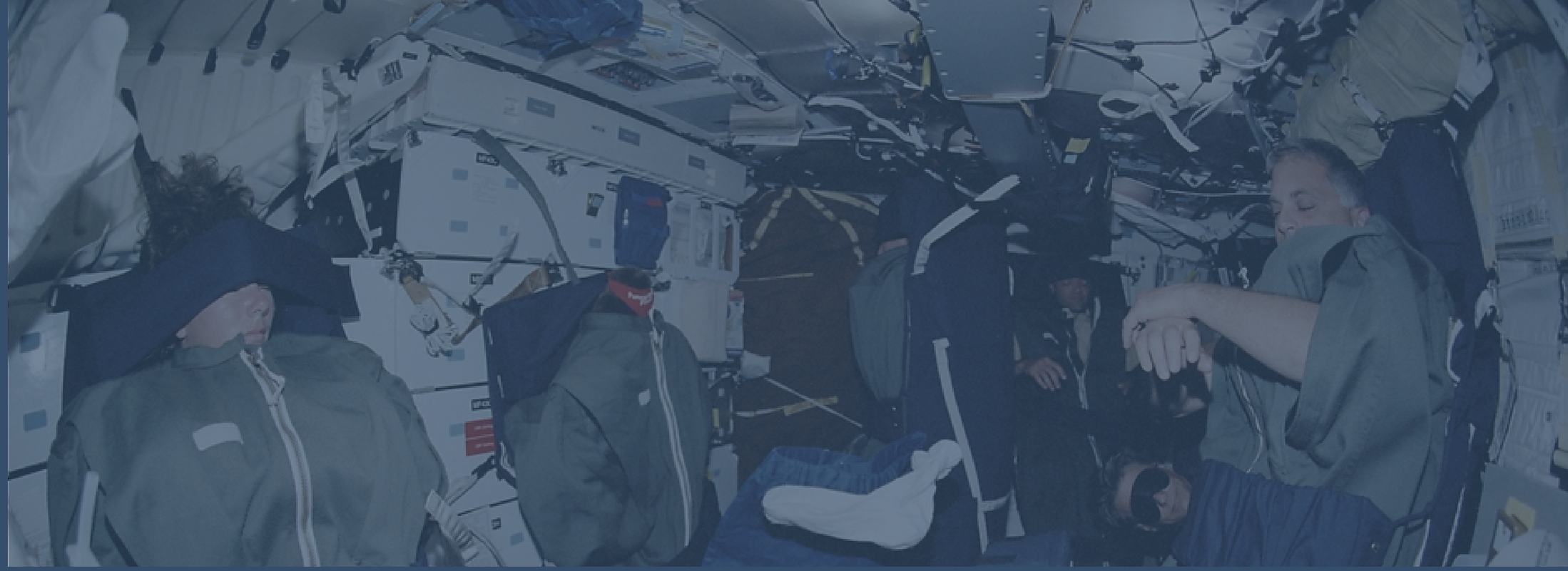
Blue light has a stronger impact on alertness

Used on ISS to help crew stay alert

TAKE AN EXERCISE BREAK

JSC Flight Controller study showed improved performance following 20 minutes of vigorous exercise

Enhancing Alertness During Work



What if your sleep is still not restorative?

Understanding sleep disorders





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3 DIFFERENT SUBTYPES

Chronic insomnia disorder, short-term insomnia disorder, other insomnia disorder

Can arise from situational/psychological stressors or physiological causes

Symptoms may include any of these

DIFFICULTY INITIATING SLEEP

Taking an excessive duration of time to fall asleep

DIFFICULTY MAINTAINING SLEEP

Waking during the night with an inability to fall back to sleep within a few minutes

EARLY MORNING WAKING

Waking earlier than desired an unable to go back to sleep

SYMPTOMS LASTING AT LEAST 3 MONTHS

Symptoms at least 3 nights per week

Insomnia

FREQUENT BRIEF PAUSES IN BREATHING DURING SLEEP

Associated with frequent waking at night (>5x per h)
Often associated with snoring, snorting, or gasping

DAYTIME FATIGUE

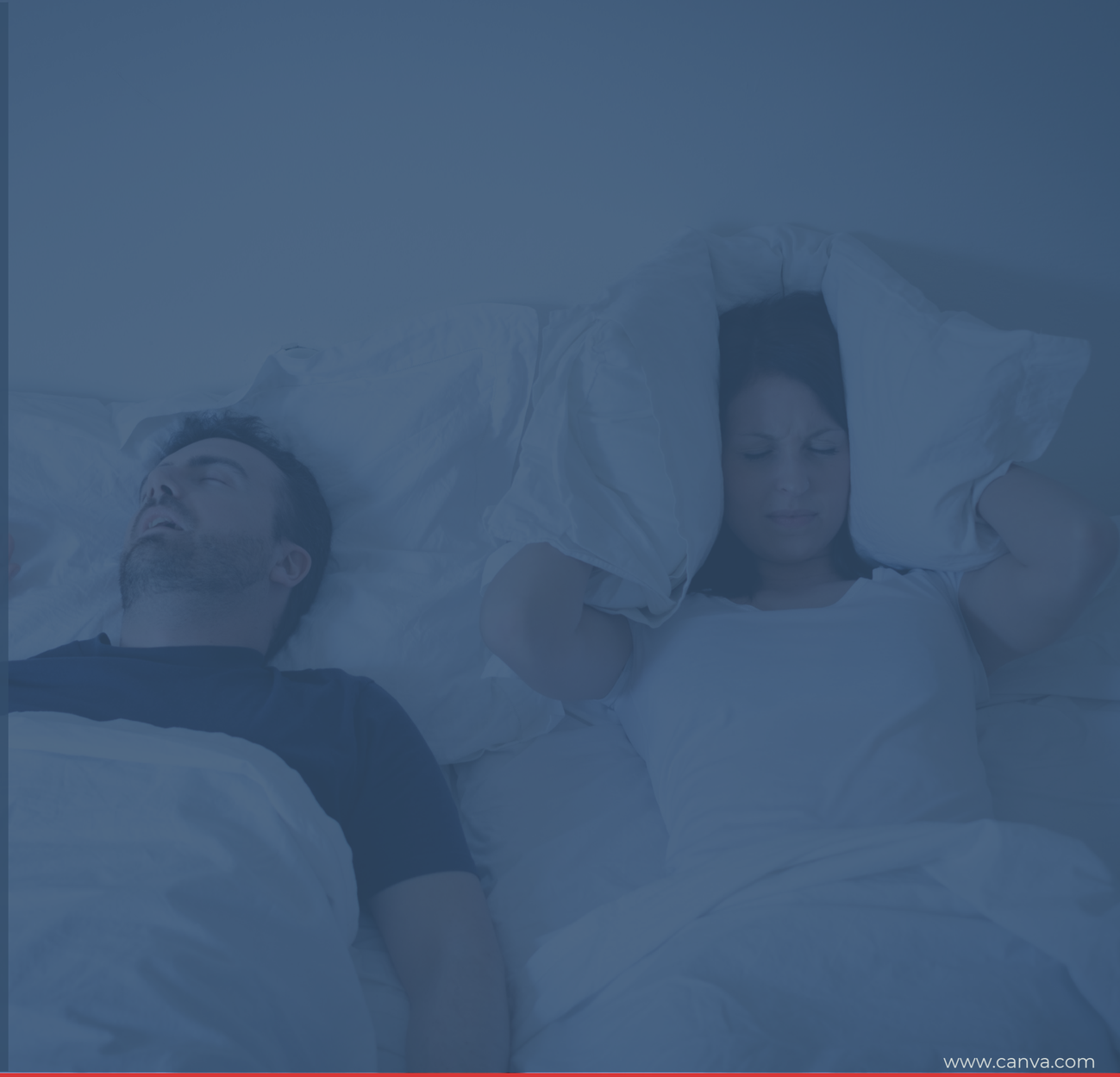
Individuals with undiagnosed sleep apnea often spend a long time in bed, but do not feel refreshed
Fall asleep easily in situations requiring sustained attention such as in meetings

OBSTRUCTIVE SLEEP APNEA

Associated with obstruction of the airway during sleep
Associated with excess weight

CENTRAL SLEEP APNEA

Neurological origin



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Sleep Apnea

DIFFICULTY COPING WITH SHIFTWORK

Occurs among those working night, early, or rotating shifts

affects ~20% of shiftworkers

DIFFICULTY SLEEPING

Difficulty falling asleep, staying asleep, or waking too early

REDUCED SLEEP DURATION

Loss of 1-4 h of sleep

EXCESSIVE FATIGUE/SLEEPINESS DURING WAKE EPISODES

Associated with obstruction of the airway during sleep

Associated with excess weight

PERSISTENT FOR >3 MONTHS



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Shiftwork Disorder

ADVANCED OR DELAYED SLEEP-WAKE DISORDER

Sleep is shifted too early or too late relative to your social schedule

NON-24 HOUR SLEEP-WAKE DISORDER

Affects people who are totally blind

NARCOLEPSY

Inability to maintain sleep at night and wake during the day

REM BEHAVIOR DISORDER

Lack of REM paralysis
Acting out dreams



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Other sleep disorders

Summary

TWO SLEEP DRIVES

Circadian rhythm
- Internal clock
- Reset by light exposur

Homeostatic sleep pressure

LIGHT AFFECTS YOUR CIRCADIAN RHYTHM

Light in the evening shifts the drive to sleep and wake later, light in the morning shifts the drive to sleep and wake earlier

Keep the lights off around sleep times

SLEEP LOSS AND CIRCADIAN MISALIGNMENT

Short and long-term consequences

GOOD SLEEP HYGIENE CAN IMPROVE SLEEP

Optimize your sleep environment

Avoid substances that affect sleep

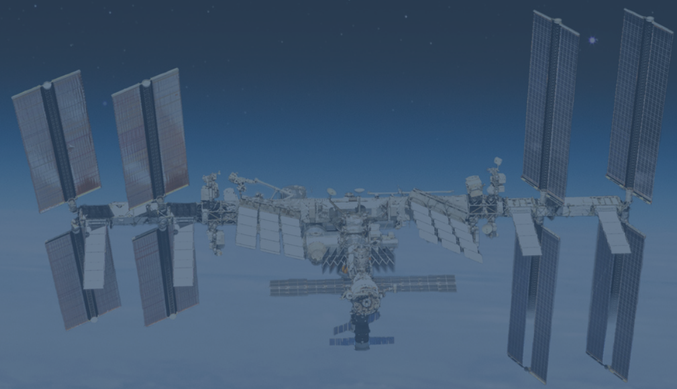
SHIFTWORK CAUSES CIRCADIAN MISALIGNMENT

May require strategies to enhance alertness and facilitate sleep

SLEEP DISORDERS ARE COMMON

Talk with your physician if you think you may have a sleep disorder

THANK YOU!



erin.e.flynn-evans@nasa.gov

Do other factors influence the circadian rhythm?

EXERCISE/ACTIVITY



TIMED FOOD INTAKE



MEDICATIONS



Weak Non-photic Zeitgebers

Do other factors influence the circadian rhythm?

EXERCISE/ACTIVITY

- Intense exercise in the evening can cause moderate phase delays (30 min - 2 h; Mistleberger and Skene 2005)
- Influence on phase advances less clear (Mistleberger and Skene 2005)
- Difficult to disentangle light effects from exercise effects (Atkinson et al. 2007)
- Regular exercise can aid in sleep consolidation (Driver and Taylor 2000)

TIMED FOOD INTAKE



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TIMED FOOD INTAKE

- Time-restricted feeding in rodents shifts the circadian rhythm (Pendergast et al. 2018)
- Peripheral oscillators in the liver and gut (Brown et al. 2019)
- Limited evidence to support a role for circadian shifting via timed food intake in humans (Adafer et al. 2020)
- Eating at adverse circadian phases may lead to diabetes & obesity (Mason et al. 2020)

MEDICATIONS



Weak Non-photic Zeitgebers

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- Time-restricted feeding in rodents shifts the circadian rhythm (Pendergast et al. 2018)
- Peripheral oscillators in the liver and gut (Brown et al. 2019)
- Limited evidence to support a role for circadian shifting via timed food intake in humans (Adafer et al. 2020)
- Eating at adverse circadian phases may lead to diabetes & obesity (Mason et al. 2020)

MEDICATIONS

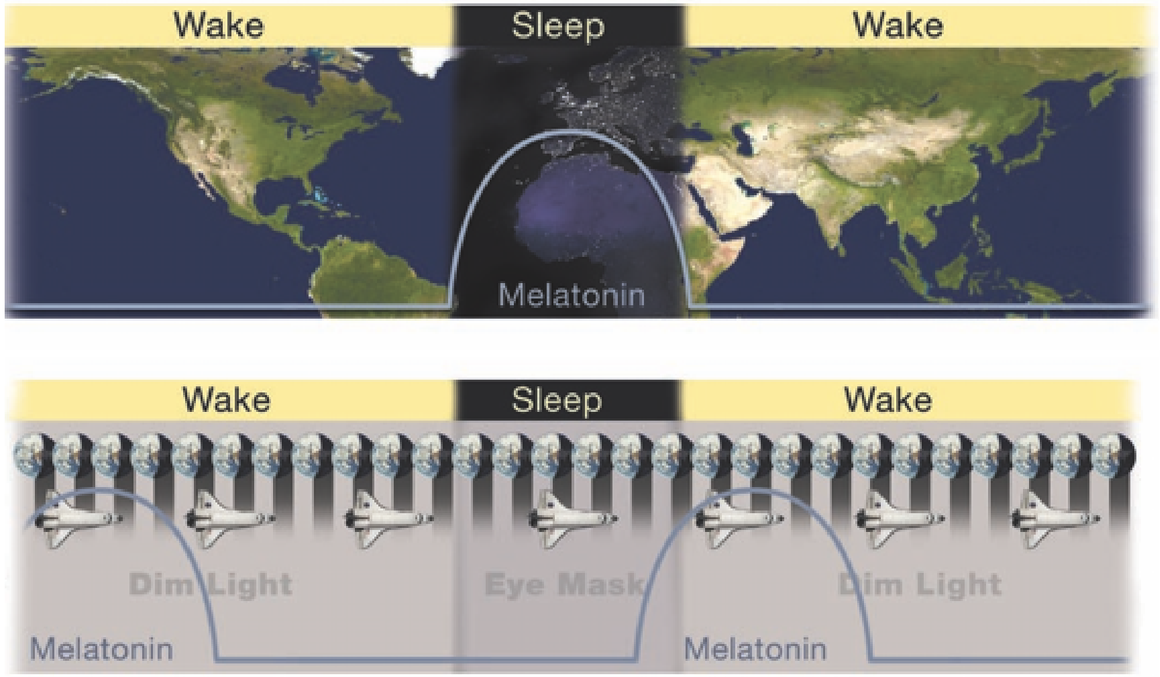
- Chronobiotics such as melatonin and tasimelteon can cause phase advances when taken in the evening (Arendt et al. 1997; Lockley et al. 2015)
- Caffeine may have a modest phase shifting effect (Burke et al. 2015)
- Hypnotics do not shift the circadian rhythm

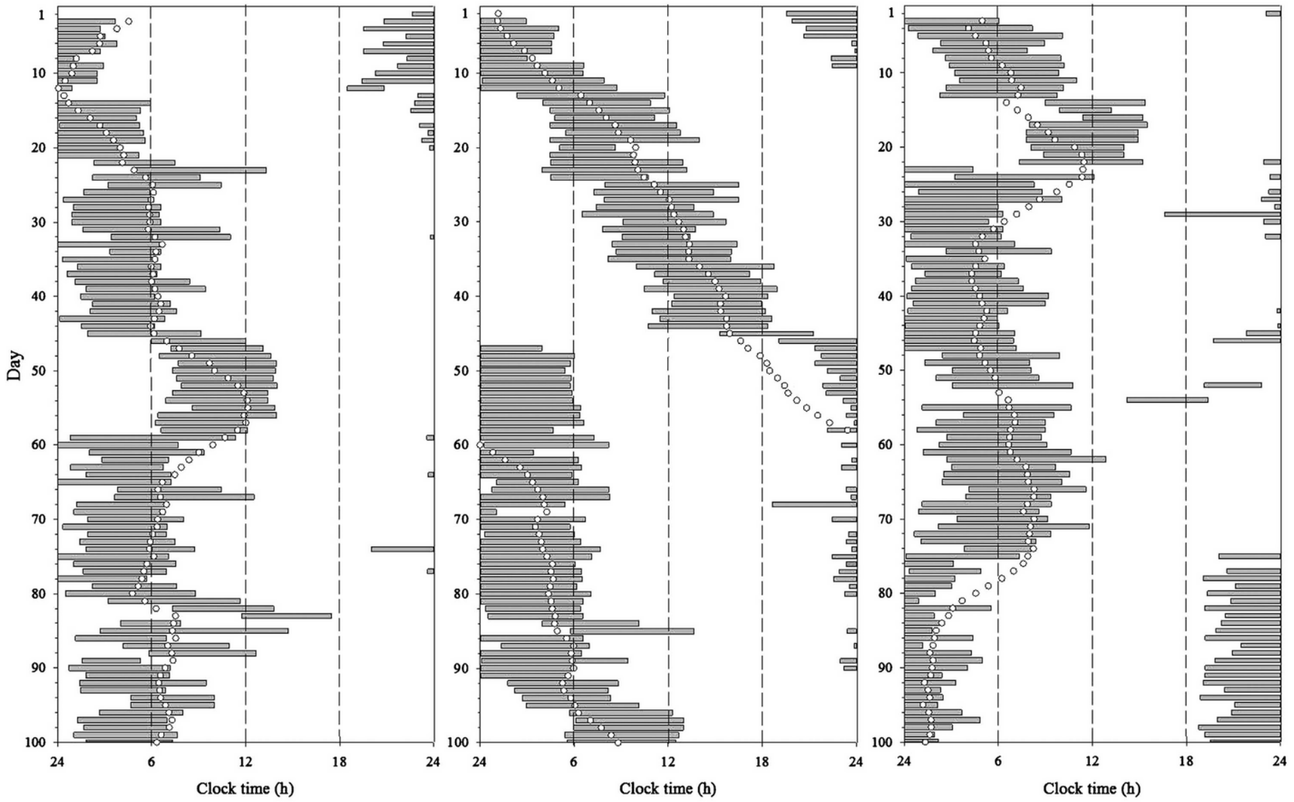
Weak Non-photic Zeitgebers



How do we manage sleep issues at NASA?

Circadian Misalignment in Space





Flynn-Evans *et al*. 2018 *Nature Microgravity*

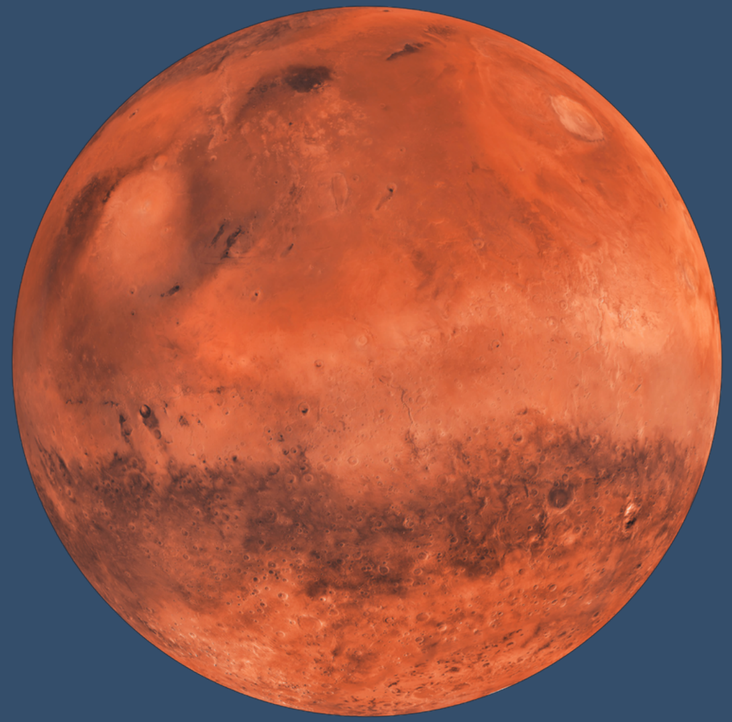
Consequences of Circadian Misalignment

	Aligned	Misaligned
Sleep duration (h)	6.4 (1.2)	5.5 (1.2)
Latency (m)	10 (15)	13 (25)
# wakings	1.7 (1.9)	1.8 (1.8)
Sleep efficiency (%)	89 (7)	90 (7)
Sleep quality	67 (18)	60 (21)



Flynn-Evans *et al*. 2016 *Nature Microgravity*



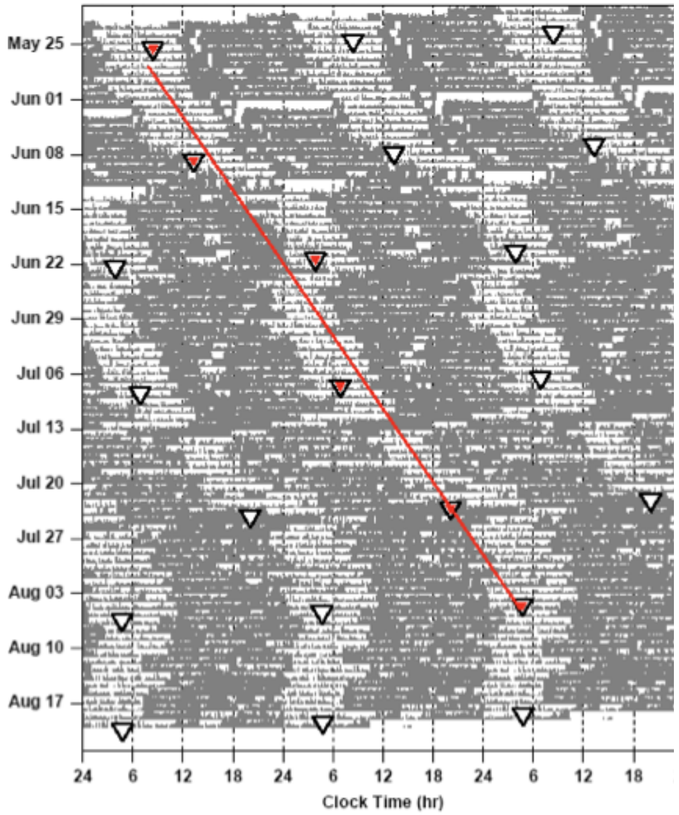


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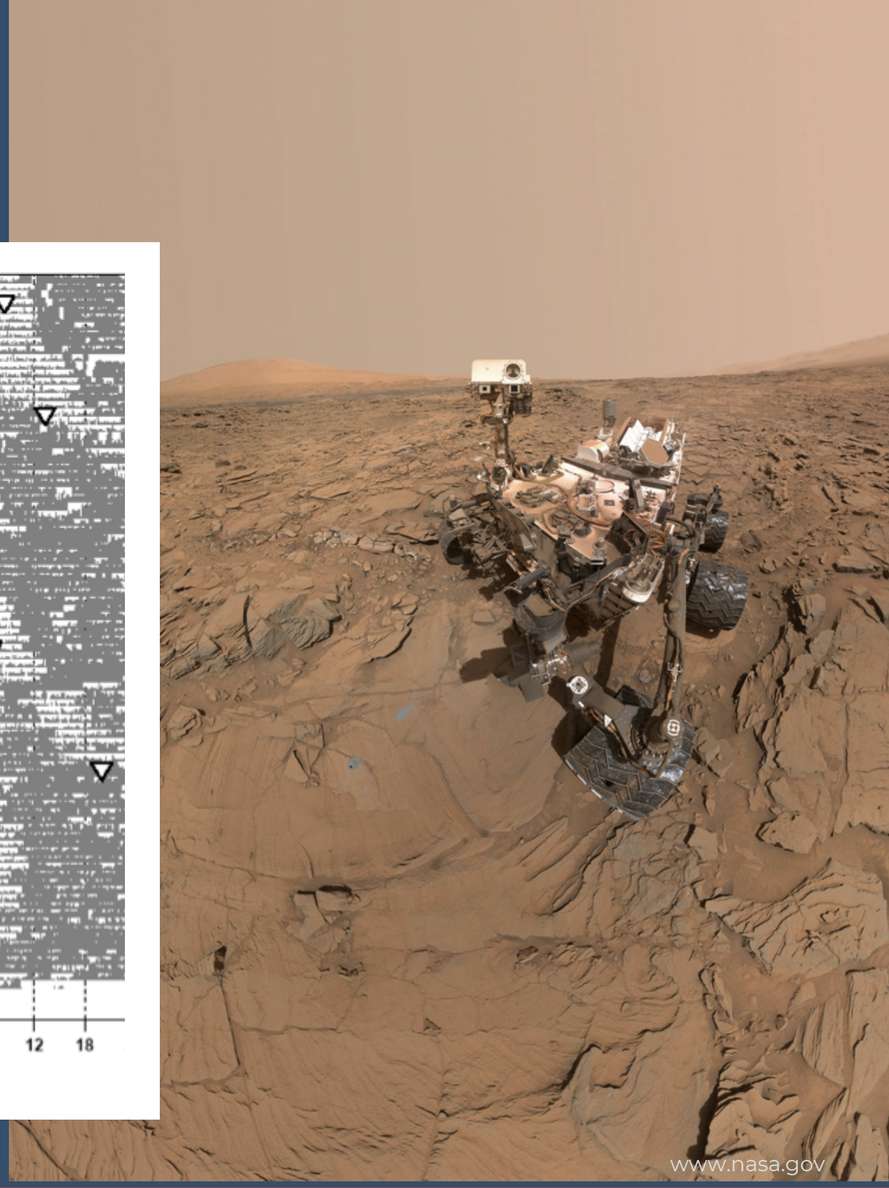
Applied Research at NASA

Spaceflight Analog Studies





Barger *et al*. 2012 *SLEEP*



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