


Teens & Sleep

LINKING DISCOVERY, PRACTICE, AND POLICY

The Biology of Teen Sleep Patterns

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Center for Applied Research and Educational Improvement
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Overview

- Adolescent sleep biology
- Sleep biology and early rising
- Sleep and the adolescent brain
- Consequences of too little sleep for teens

Factors Affecting Sleep Patterns

- Behavior and circumstances
 - e.g., life-style choices, socio-economic status, health, employment, school
- Intrinsic biological processes
 - Sleep homeostatic system (sleep “pressure”)
 - Circadian timing system

Observed features of the circadian system during adolescence

Species Manifesting Juvenile Phase Delay

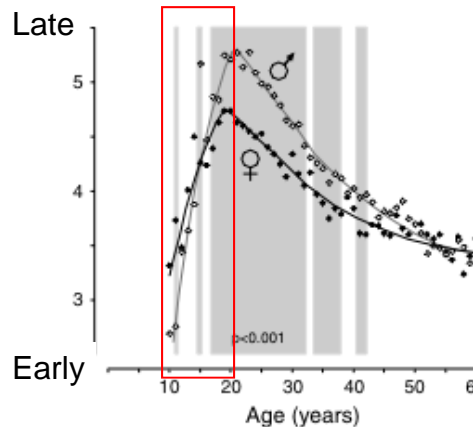
- *Homo sapiens* (humans)
- *Macca mulatta* (Rhesus monkeys)
- *Octodon degus* (degu) [some ?]
- *Rattus norvegicus* (laboratory rat)
- *Mus musculus* (laboratory mouse)
- *Psammomys obesus* (fat sand rat)



Hagenauer et al., *Devel Neurosci*, 2009

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Chronotype and Adolescence

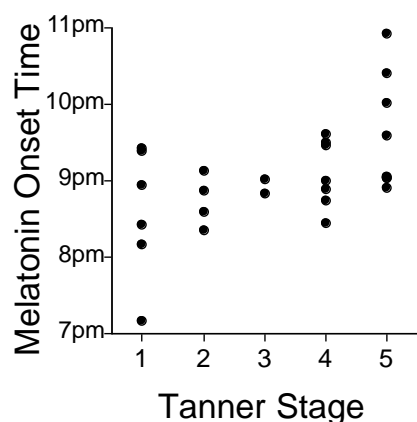


- Time of midsleep on “free” days
- Later timing is marked across the 2nd decade

Roenneberg et al., *Current Biol.*, 2004

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Puberty and Melatonin Onset Phase: Hormonal Signal of Nighttime



Carskadon et al. *NYAS*, 2004



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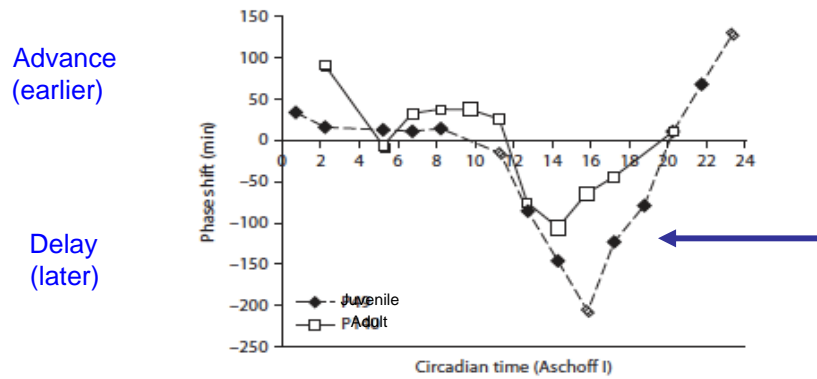
What might underlie phase delay?

- Changes in light exposure
 - Staying up later // more late light = delay
 - Waking up later // less morning light = no advance
- Change in phase-dependent sensitivity to light exposure
- Longer longer internal day length
- Diminished amplitude of the melatonin rhythm



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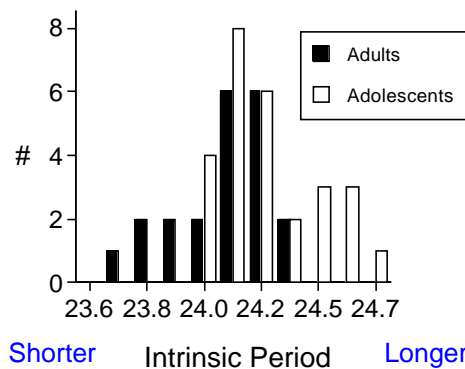
Exaggerated phase delay to light in pubertal female mice



Hagenauer et al., *Devel Neurosci*, 2001;
after Weinert & Kompaeurova, *Zoology*, 1998



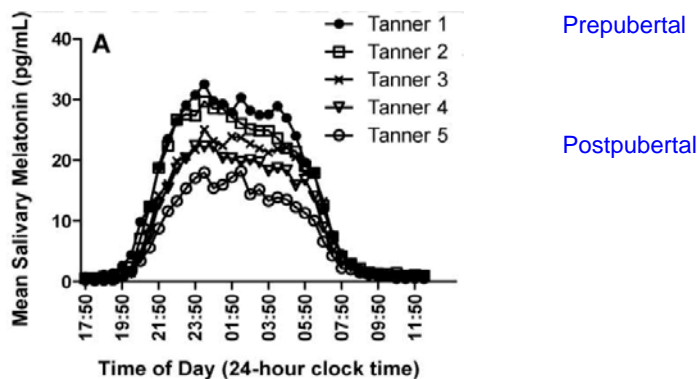
Human Intrinsic Circadian Period— Internal Day Length



Carskadon & Acebo *Sleep*, 2005



Adolescent Melatonin Amplitude



Crowley et al., *Dev Psychobiol*, 2011



Summary of Process C Changes

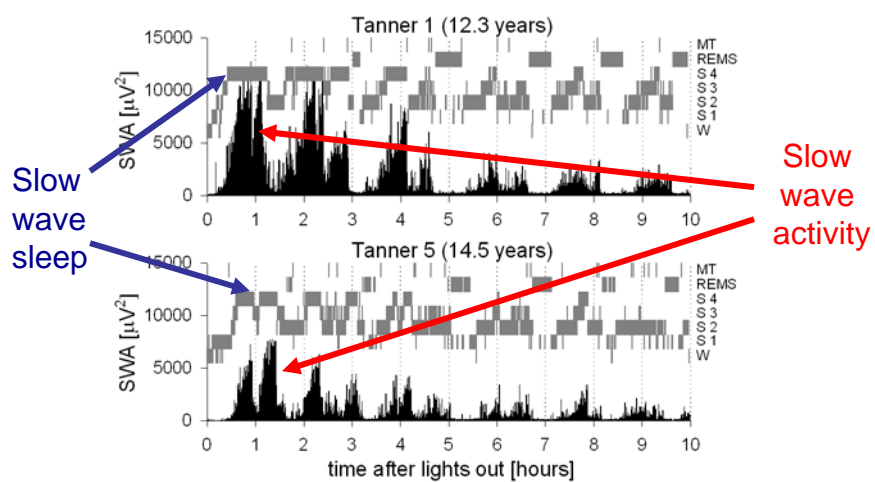
- Phase is delayed during adolescent development
 - Phase preference (chronotype) is later
 - Melatonin phase is later
- Phase-dependent light sensitivity may change
- Internal day is longer than in adults
- Amplitude of circadian nocturnal melatonin declines
- Result: late nights are favored (so, too, late mornings)



Features of Adolescent Sleep-Wake Homeostasis (Human)



The look of sleep changes



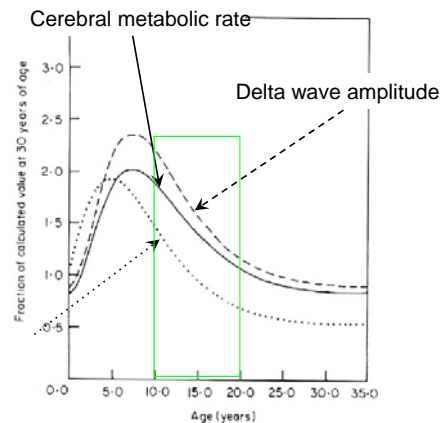
Jenni & Carskadon *Sleep*, 2004



The adolescent brain changes

Density of neuronal connections, cerebral metabolic rate, and brain wave amplitude decline during adolescence

Cortical synaptic density



Feinberg et al., *J Theor Biol*, 1990

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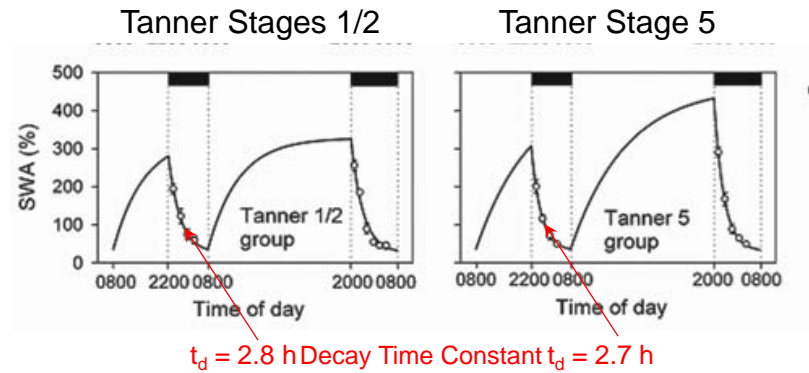
Sleep phenomenology changes;
does sleep regulation?

Recovery process (dissipation)

Accumulation process

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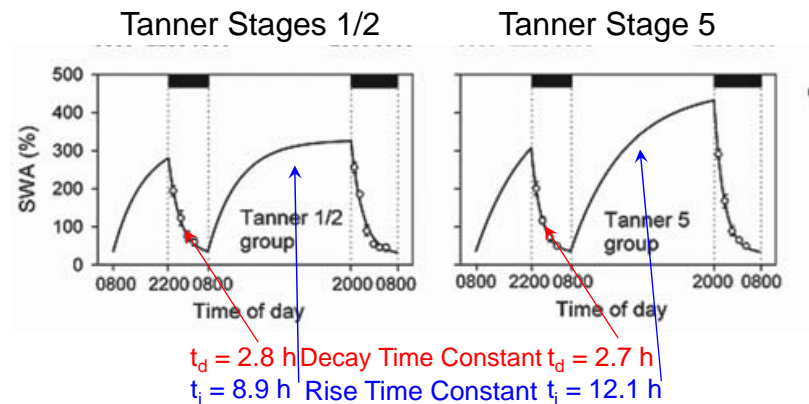
Sleep pressure dissipation does not change in adolescence



Jenni, Achermann & Carskadon *Sleep*, 2005



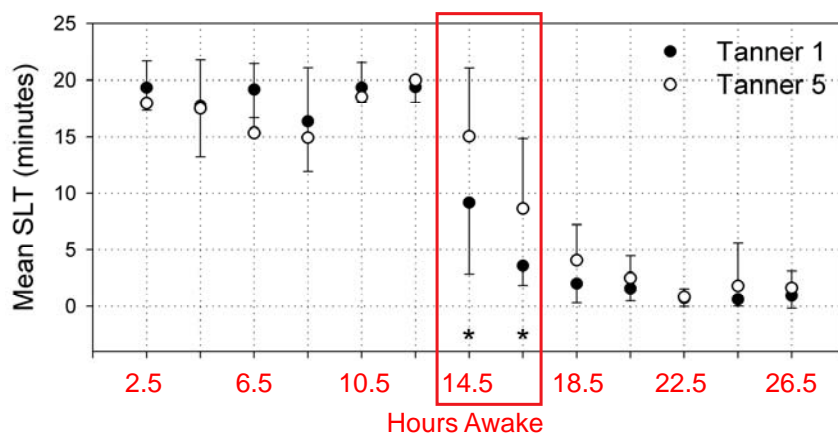
Across pubertal development, SWA accumulation rate slows down



Jenni, Achermann & Carskadon *Sleep*, 2005



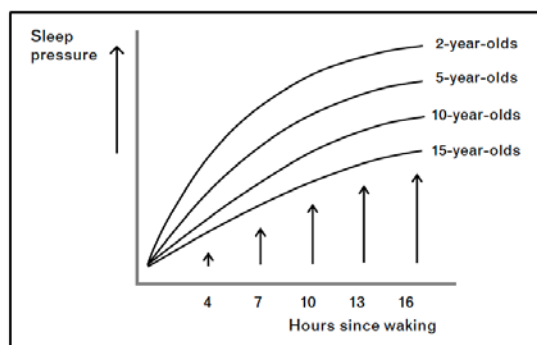
Staying awake longer gets easier... up to a point.



Taylor et al., *J Sleep Res*, 2005



Model of Process S in Development



Proposed developmental changes in accumulation of sleep pressure as a function of time since waking depicted for different ages. Sleep pressure accumulates more slowly during the day with increasing age.

Jenni & LeBourgeois *Curr Op Psychiatry*, 2006



Summary of Process S Change

- Recovery sleep process does not change across adolescence
 - Need for sleep is stable
- Accumulation of sleep pressure slows
 - Staying awake longer is easier
- Result: late nights are easier to achieve, but the same amount of sleep is needed



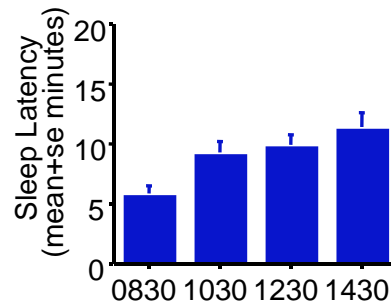
Adolescent Sleep Behavior

- Bedtime becomes later
- Rise time becomes earlier (school dependent)
- Total amount of sleep is reduced
- Chronic insufficient sleep affects morning alertness most, especially when waking at an adverse circadian phase
- Evening alertness is bolstered by the clock-dependent alerting signal



Daytime sleep tendency in early-rising high school students

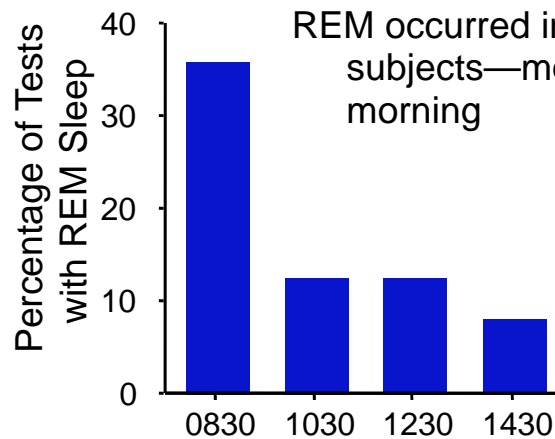
- 10th grade
- Start time = 0720
- Sleeping about 7 hours a night



Carskadon et al. *Sleep*, 1998



REM sleep tendency also affected



REM occurred in 12 of 25 subjects—most in the morning

Looks like narcolepsy!

Carskadon et al. *Sleep*, 1998



Consequences of Clock/Homeostasis/Lifestyle Interaction

- Chronic insufficient sleep
- Variable sleep timing
 - Social Jet Lag (à la Roenneberg, *Curr Biol*, 2012)
- Deficits in mood, learning, impulse control, etc.
- Excessive sleepiness & possible substance use



Why should we care about short sleep? Sleep's role in achievement and learning



Sleep Prepares for Learning

- Too little sleep impairs information *acquisition*
 - Sleepiness
 - Irritability
 - Distractibility
 - Inattention
 - Motivation
- That is, ability to **process input** is diminished



Sleep Prepares for Performance

- Too little sleep impairs information *retrieval*
 - Sleepiness
 - Irritability
 - Distractibility
 - Inattention
 - Motivation
- That is, ability to **access** learned information suffers



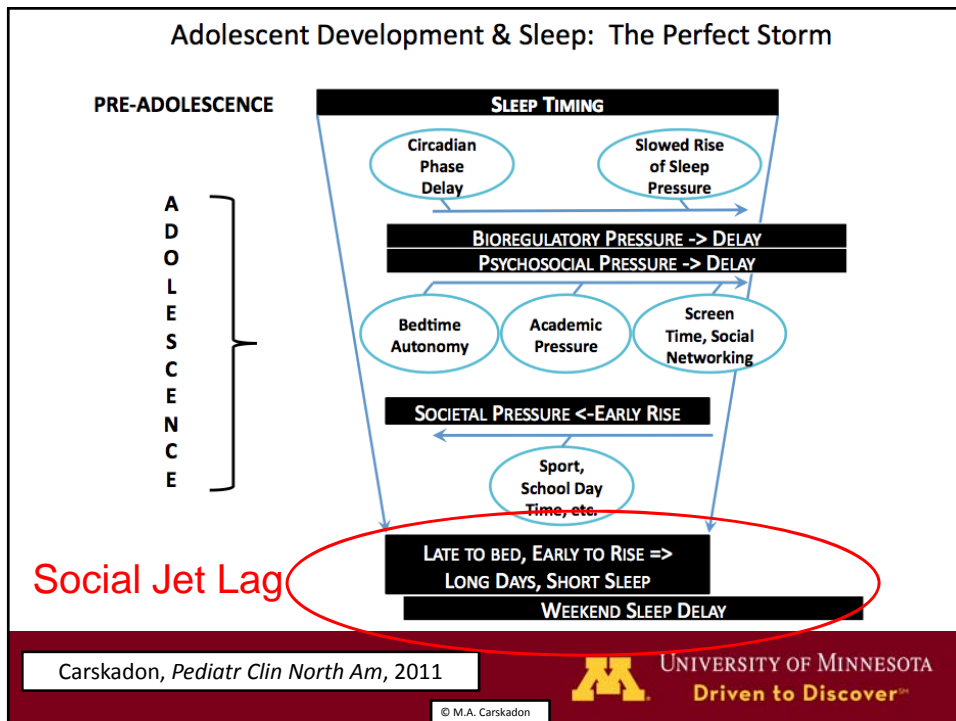
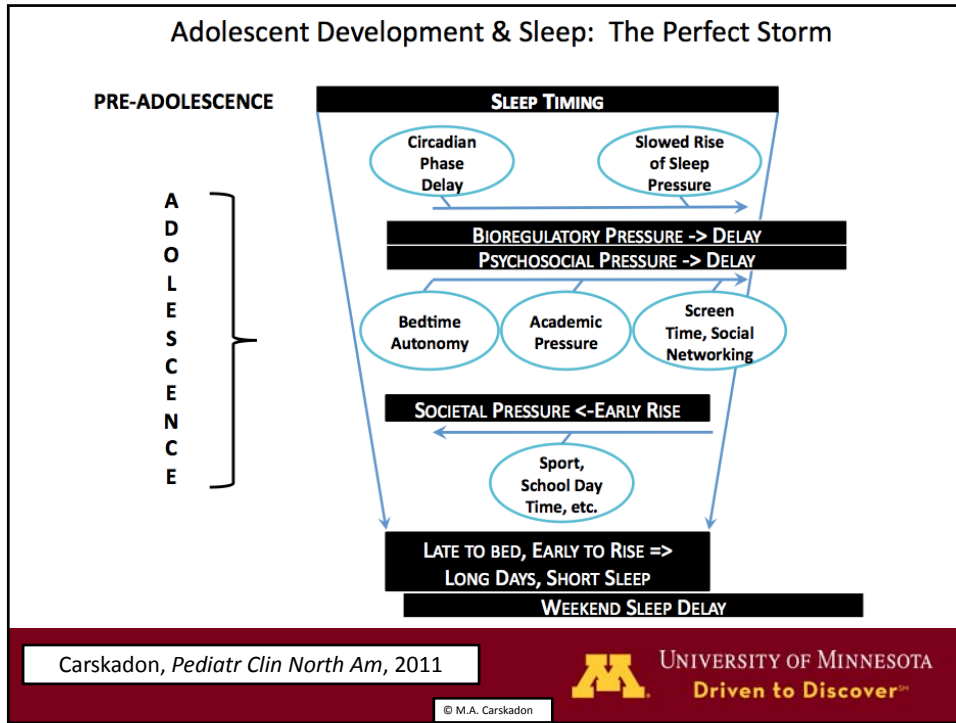
Caffeine or other stimulants may help, but they cannot substitute for sleep, especially because...



Sleep Enhances Learning

Information acquisition





Acknowledgements

Collaborators/Fellows

Ron Seifer, PhD
Christine Acebo, PhD
Oskar G. Jenni, MD
Peter Achermann, PhD
Leila Tarokh, PhD
Eliza Van Reen, PhD
Katherine Sharkey, MD, PhD

Research Assistants

Lab Staff

Participants



Summer Research Apprentices!

Funding Sources

MH52415 MH01358 MH58879
AA13252 MH076969
Periodic Breathing Foundation

