


# Teens & Sleep

LINKING DISCOVERY, PRACTICE, AND POLICY

## The Biology of Teen Sleep Patterns

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in the College of Education and Human Development



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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)

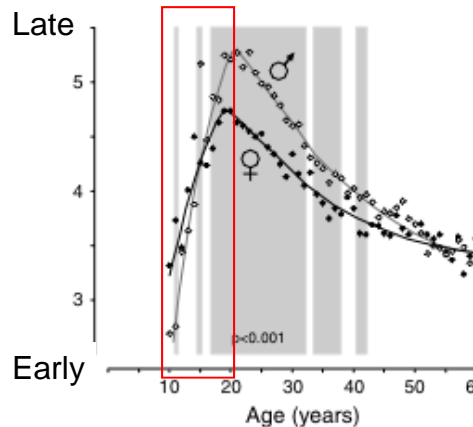


Hagenauer et al., *Devel Neurosci*, 2009



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## Chronotype and Adolescence



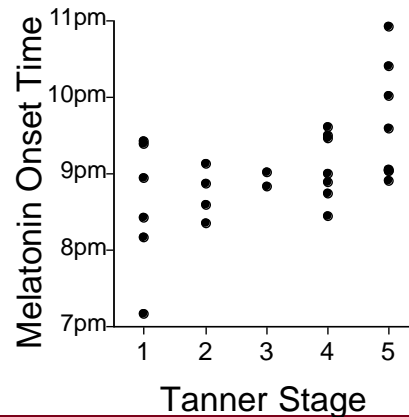
- Time of midsleep on “free” days
- Later timing is marked across the 2<sup>nd</sup> decade

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



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## Puberty and Melatonin Onset Phase: Hormonal Signal of Nighttime



Carskadon et al. *NYAS*, 2004

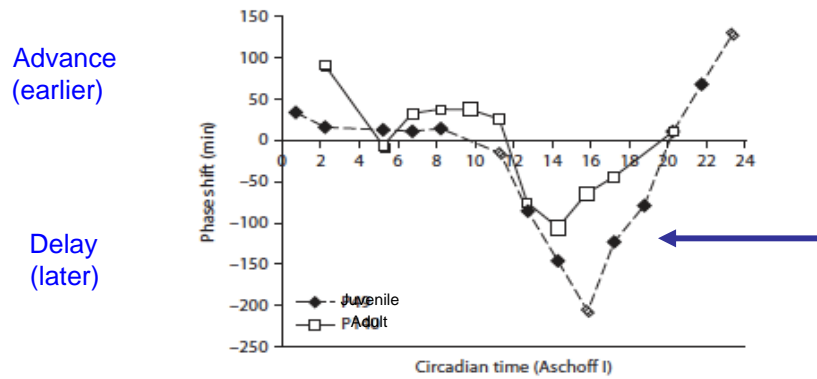
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## What might underlie phase delay?

- 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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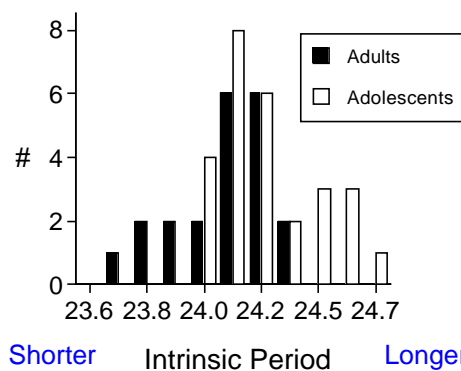
## Exaggerated phase delay to light in pubertal female mice



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



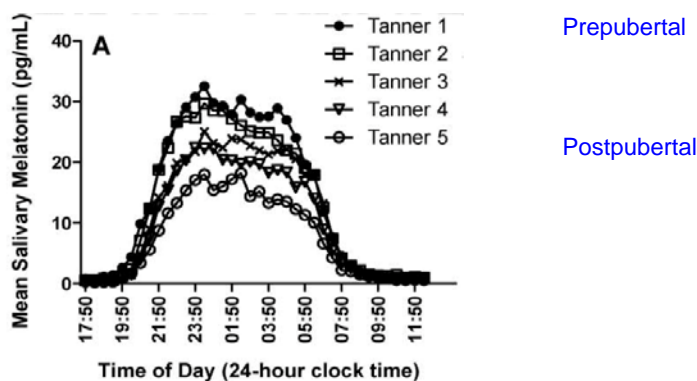
## Human Intrinsic Circadian Period— Internal Day Length



Carskadon & Acebo *Sleep*, 2005



## Adolescent Melatonin Amplitude



Crowley et al., *Dev Psychobiol*, 2011



## Summary of Process C Changes

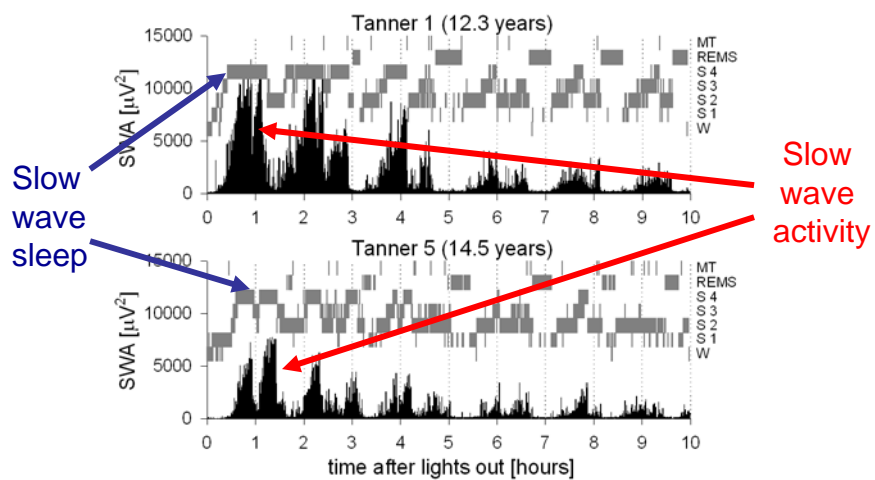
- Phase is delayed during adolescent development
  - Phase preference (chronotype) is later
  - Melatonin phase is later
- Phase-dependent light sensitivity may change
- Internal day is longer than in adults
- Amplitude of circadian nocturnal melatonin declines
- Result: late nights are favored (so,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



## Features of Adolescent Sleep-Wake Homeostasis (Human)



### The look of sleep changes



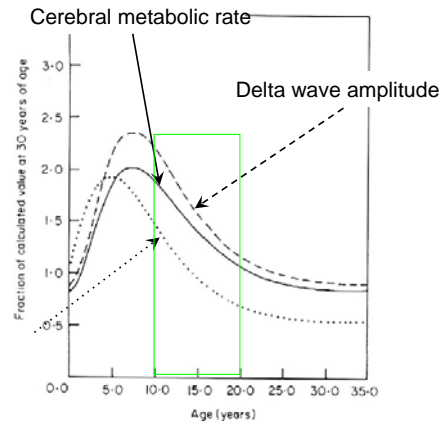
Jenni & Carskadon *Sleep*, 2004



## 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?

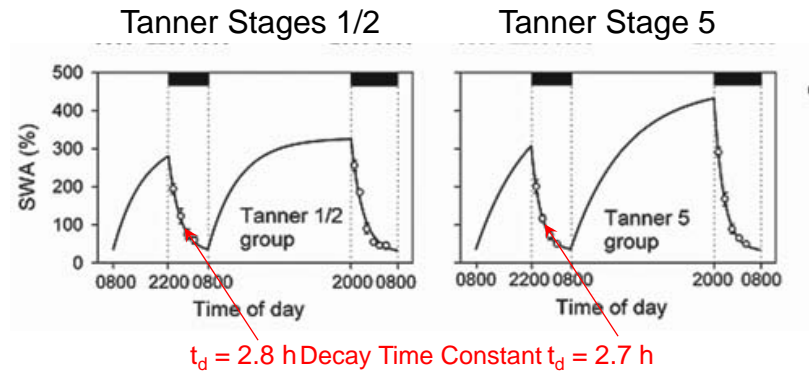
Recovery process (dissipation)

Accumulation process

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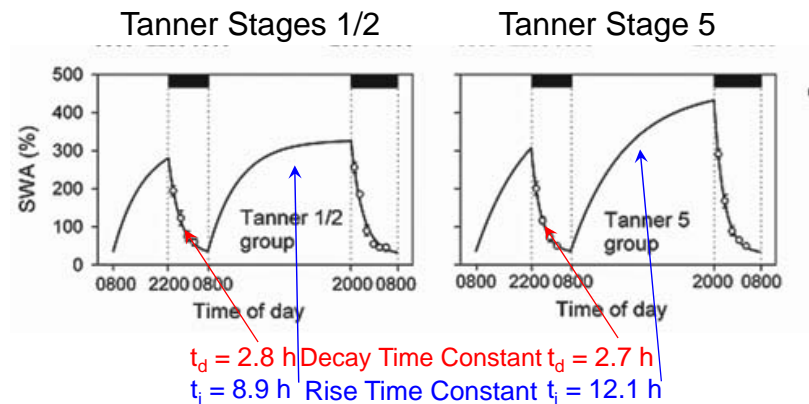
## Sleep pressure dissipation does not change in adolescence



Jenni, Achermann & Carskadon *Sleep*, 2005



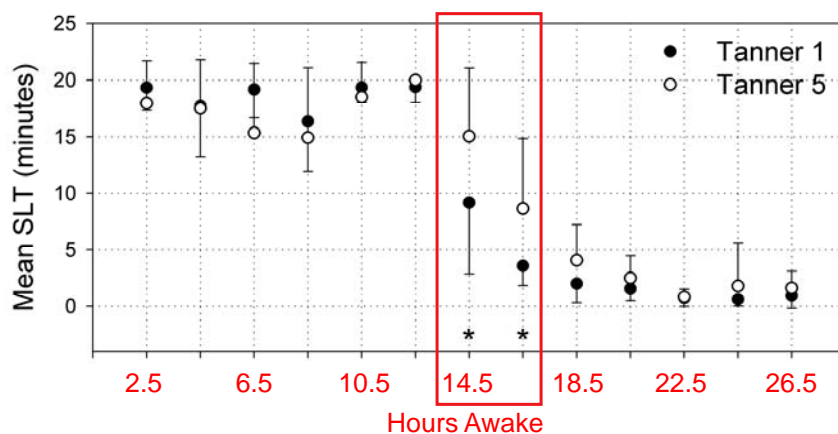
## Across pubertal development, SWA accumulation rate slows down



Jenni, Achermann & Carskadon *Sleep*, 2005



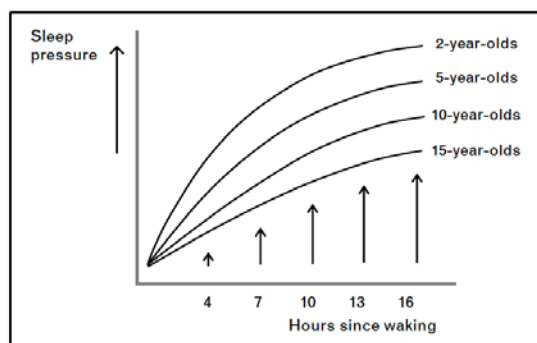
## Staying awake longer gets easier... up to a point.



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



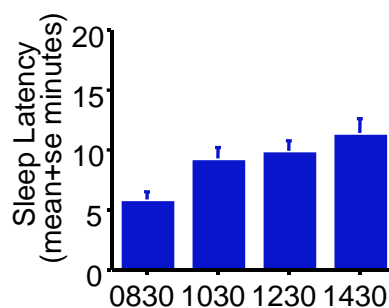
## Adolescent Sleep Behavior

- 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

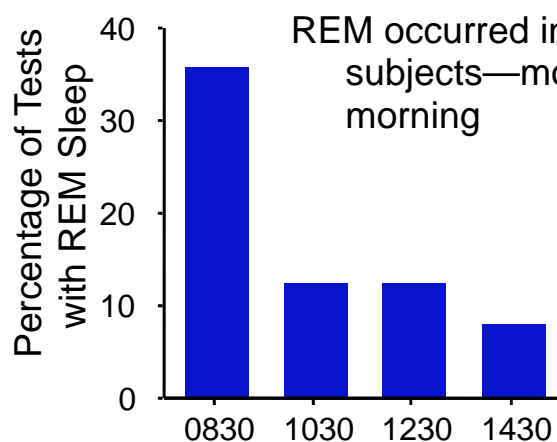


Carskadon et al. *Sleep*, 1998



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## REM sleep tendency also affected



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

**Looks like narcolepsy!**

Carskadon et al. *Sleep*, 1998



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## 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

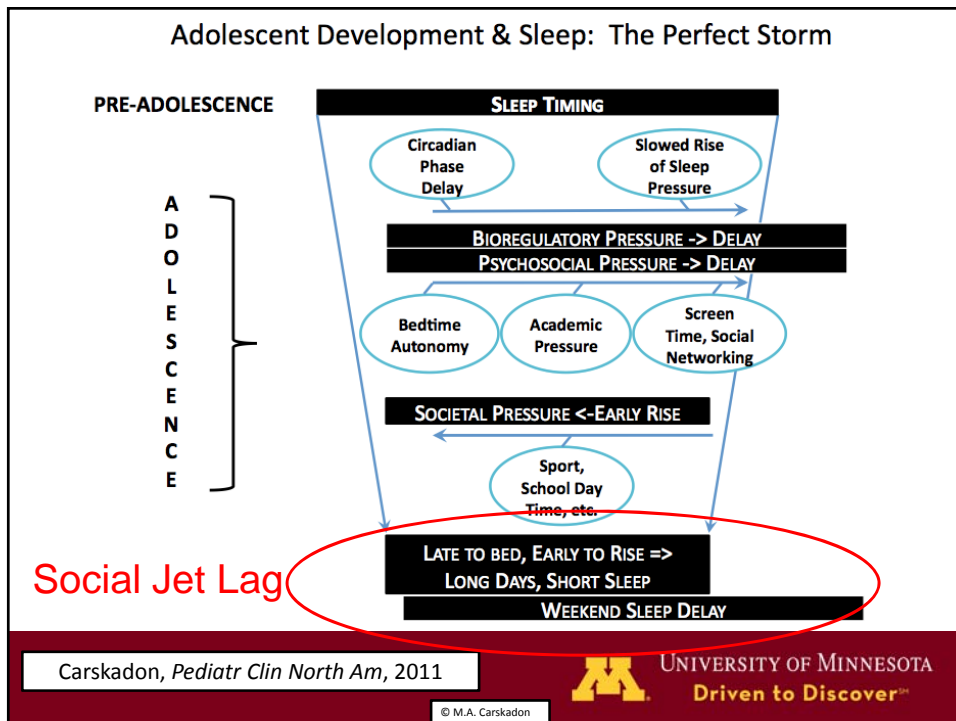
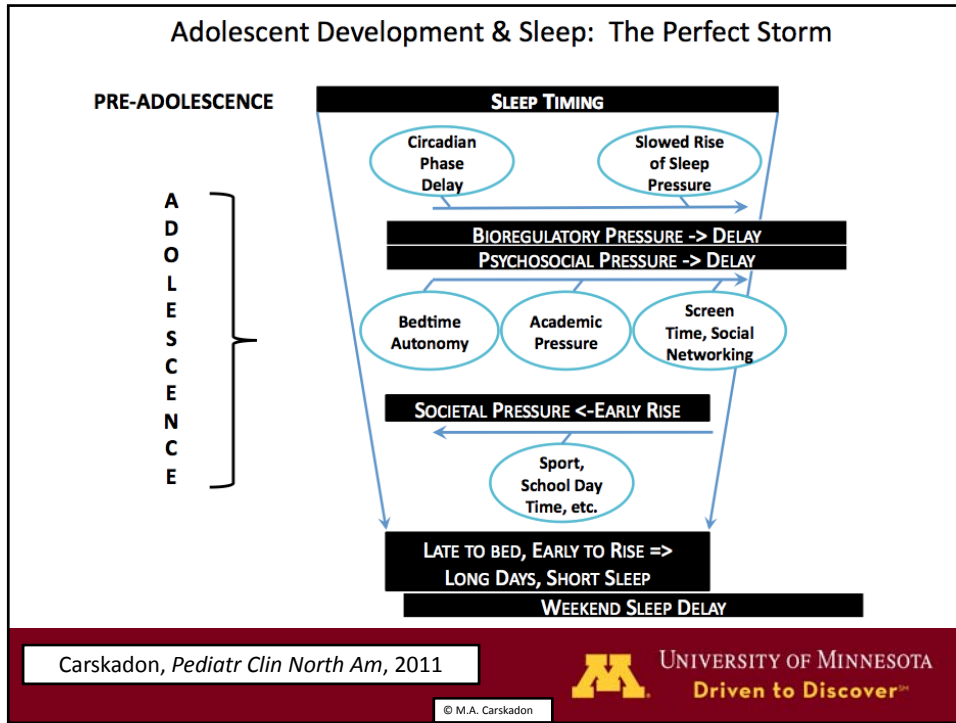


## Sleep Prepares for Performance

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









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