



Pacific Northwest
NATIONAL LABORATORY

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Tunable LED Lighting: What's the buzz?

Bob Davis, Ph.D., FIES

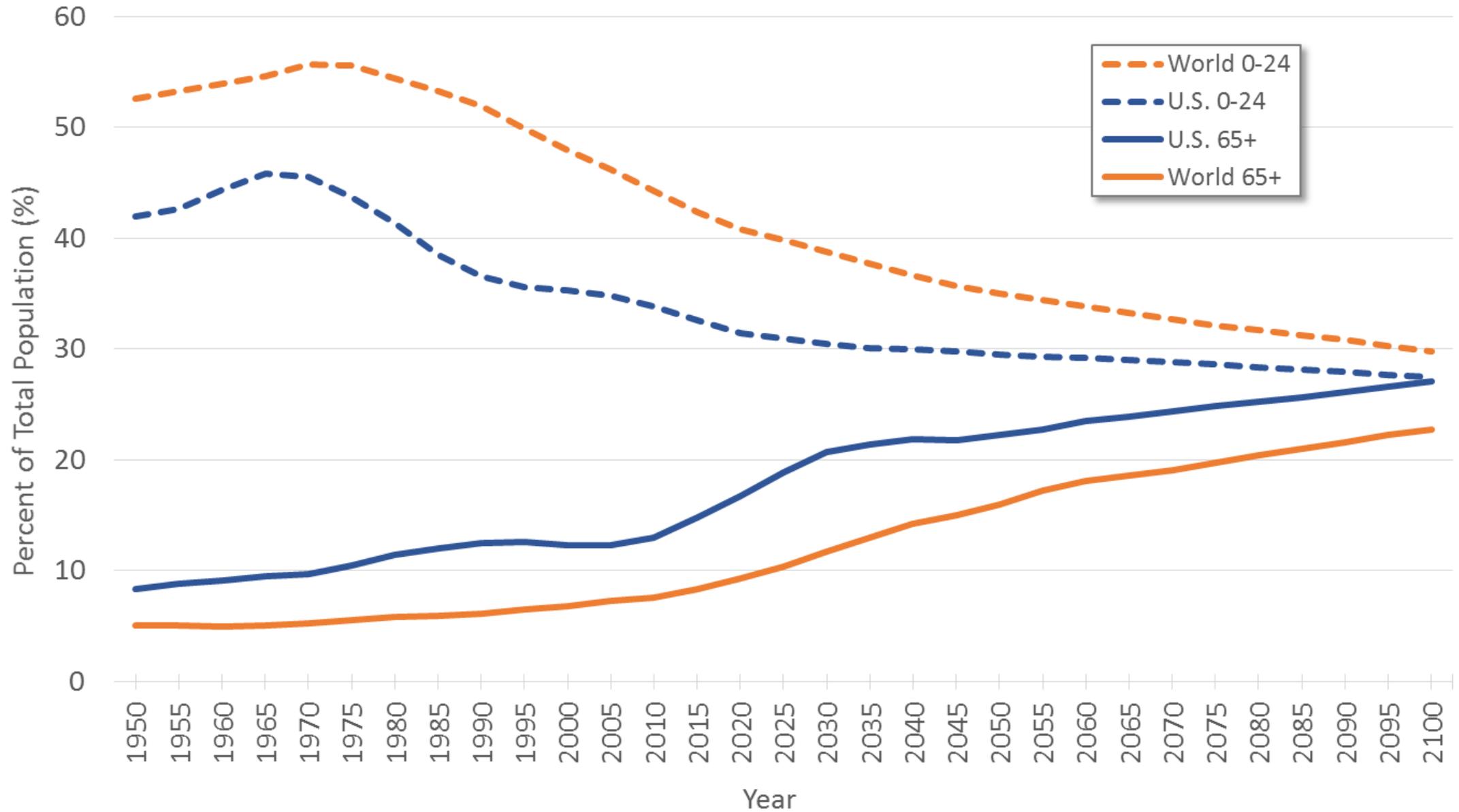
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0-24 and 65+ as a Percent of the Global and US Population



Sleep stats you probably didn't know...

1 Number of mammal species (humans) that voluntarily delay sleep

37% Percentage of Americans that have admitted to falling asleep at the wheel

70,000,000
Number of Americans who have some form of sleep disorder

1.9
Average number of hours a giraffe sleeps in a day

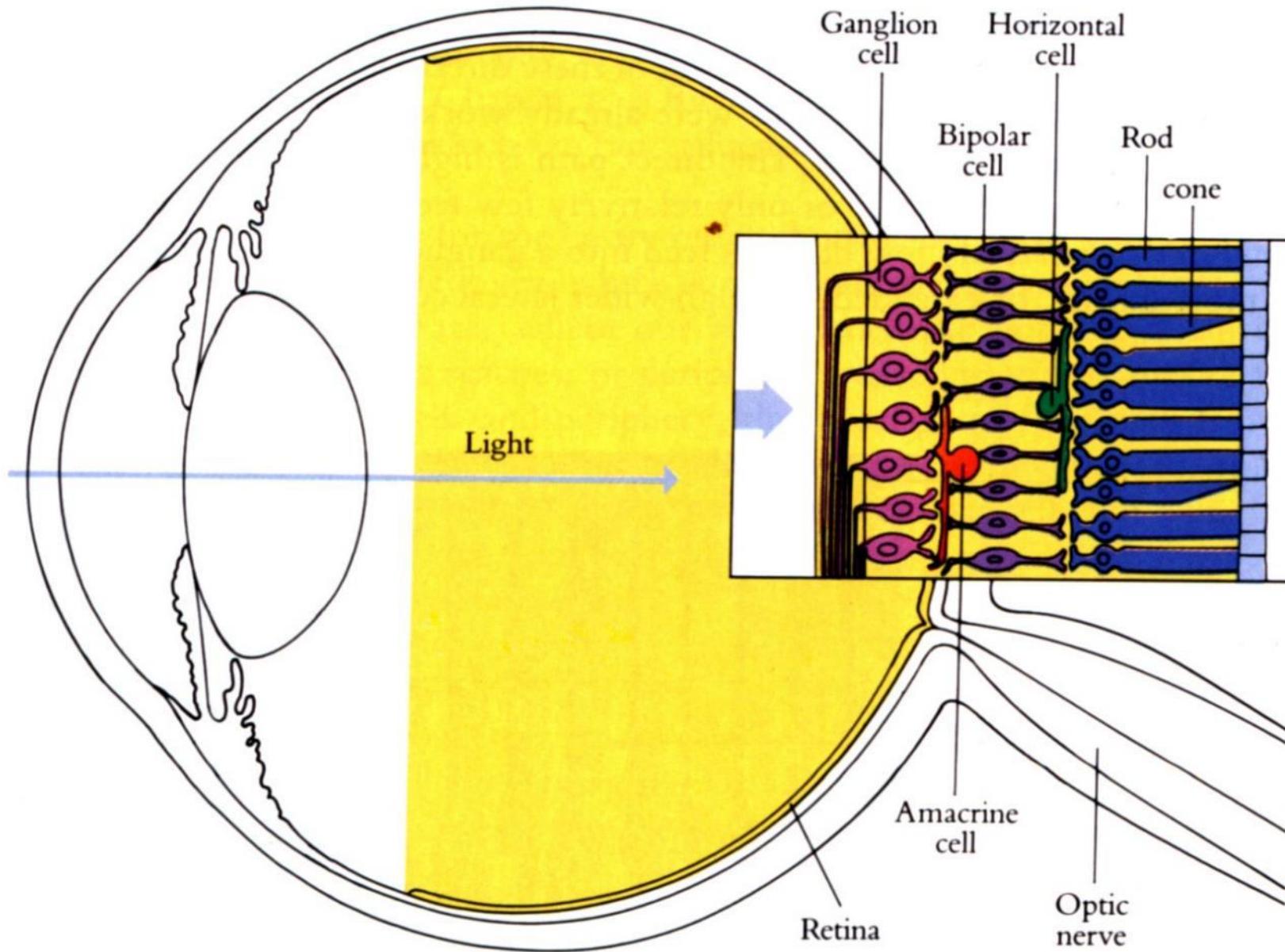
7-10
The maximum number of consecutive days doctors recommend using OTC sleep aids.

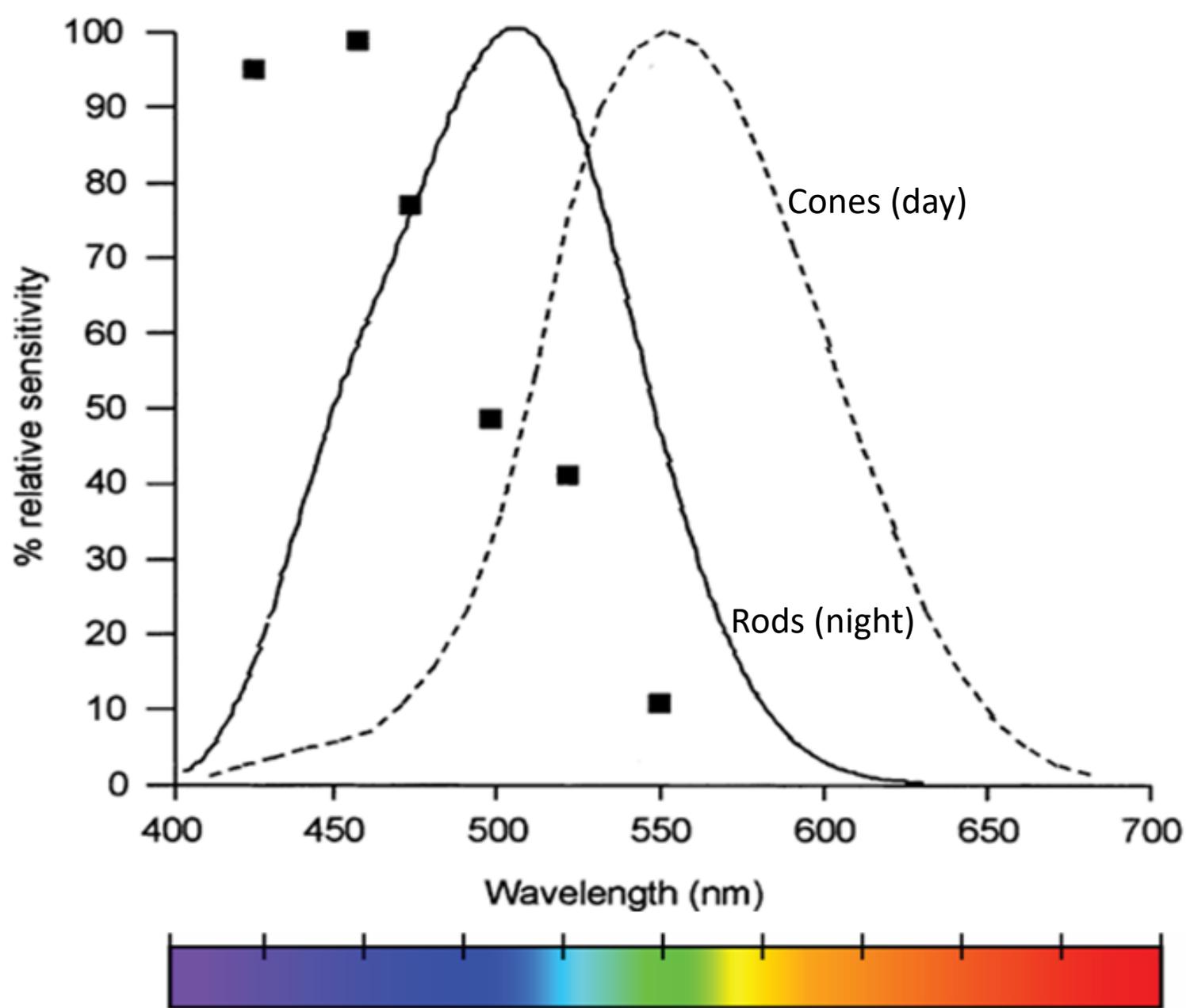
1,055 Number of hours of sleep a new parent loses in just the first years of a child's life

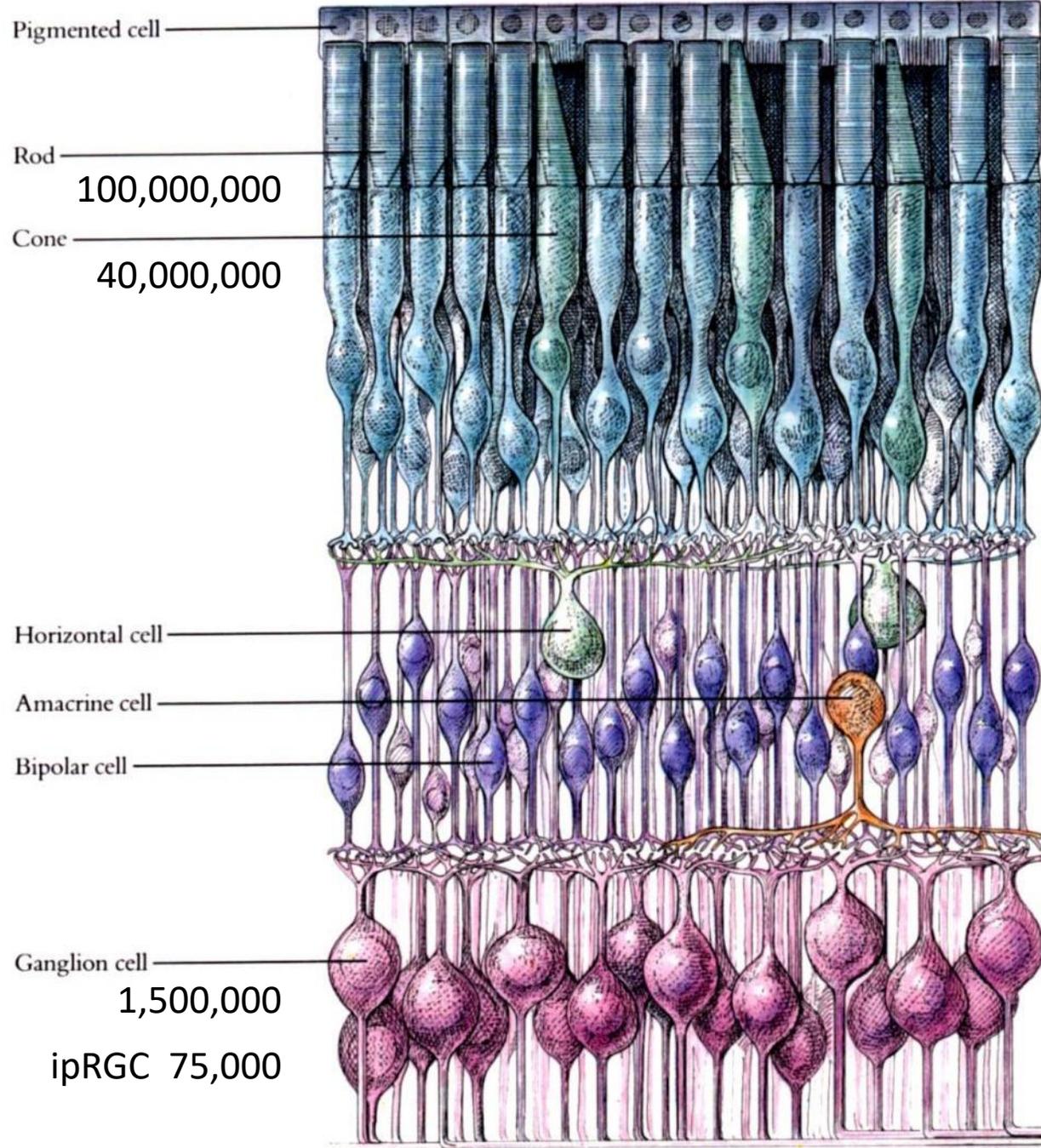
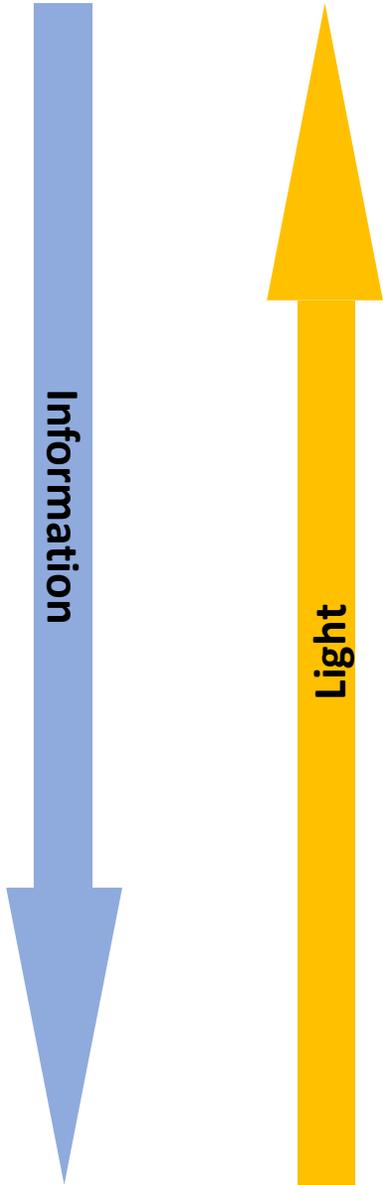
25%
Percentage of married couples who report sleeping in separate beds

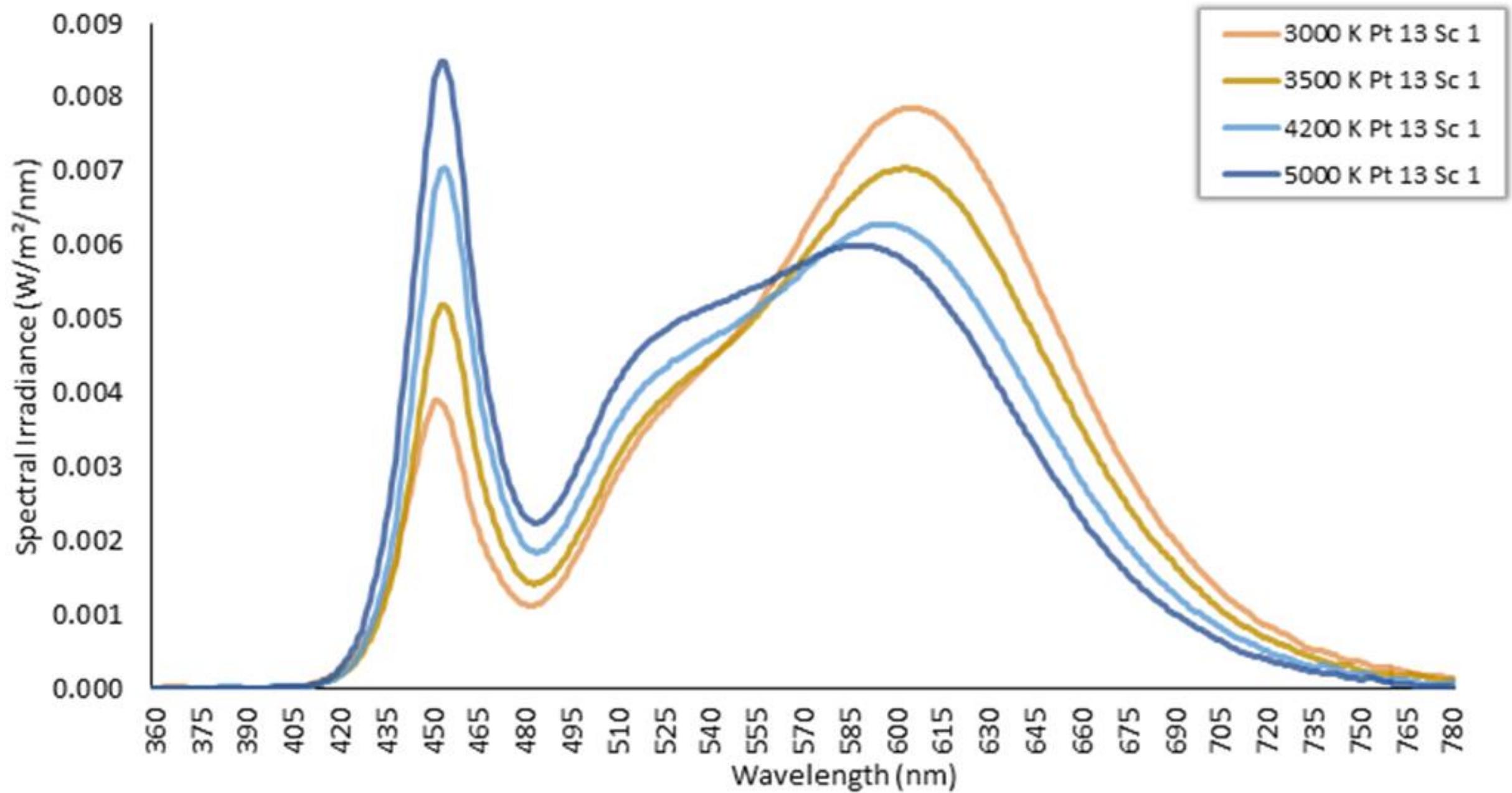
\$100,000,000,000
Annual cost to Americans from lost productivity, medical expenses, sick leave, and property damage caused by sleep deprivation











Tunable Lighting

EBD?

Intensity . . . Spectrum . . . Duration . . . Timing

Biophilic

Behavioral cues

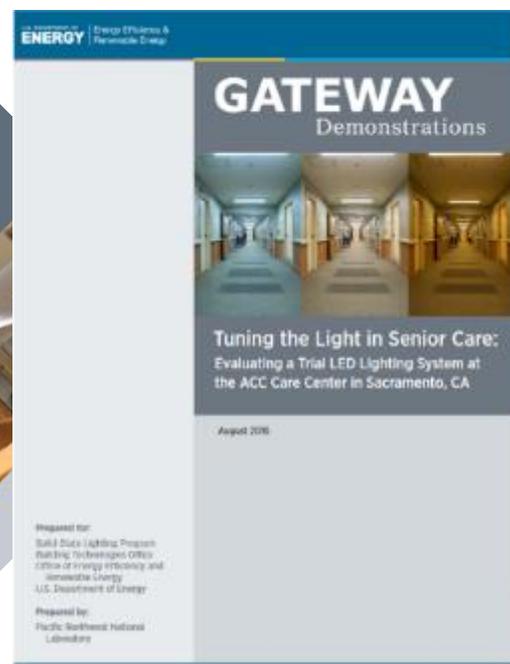
Preferences

Circadian

Matching

Control

Atmosphere

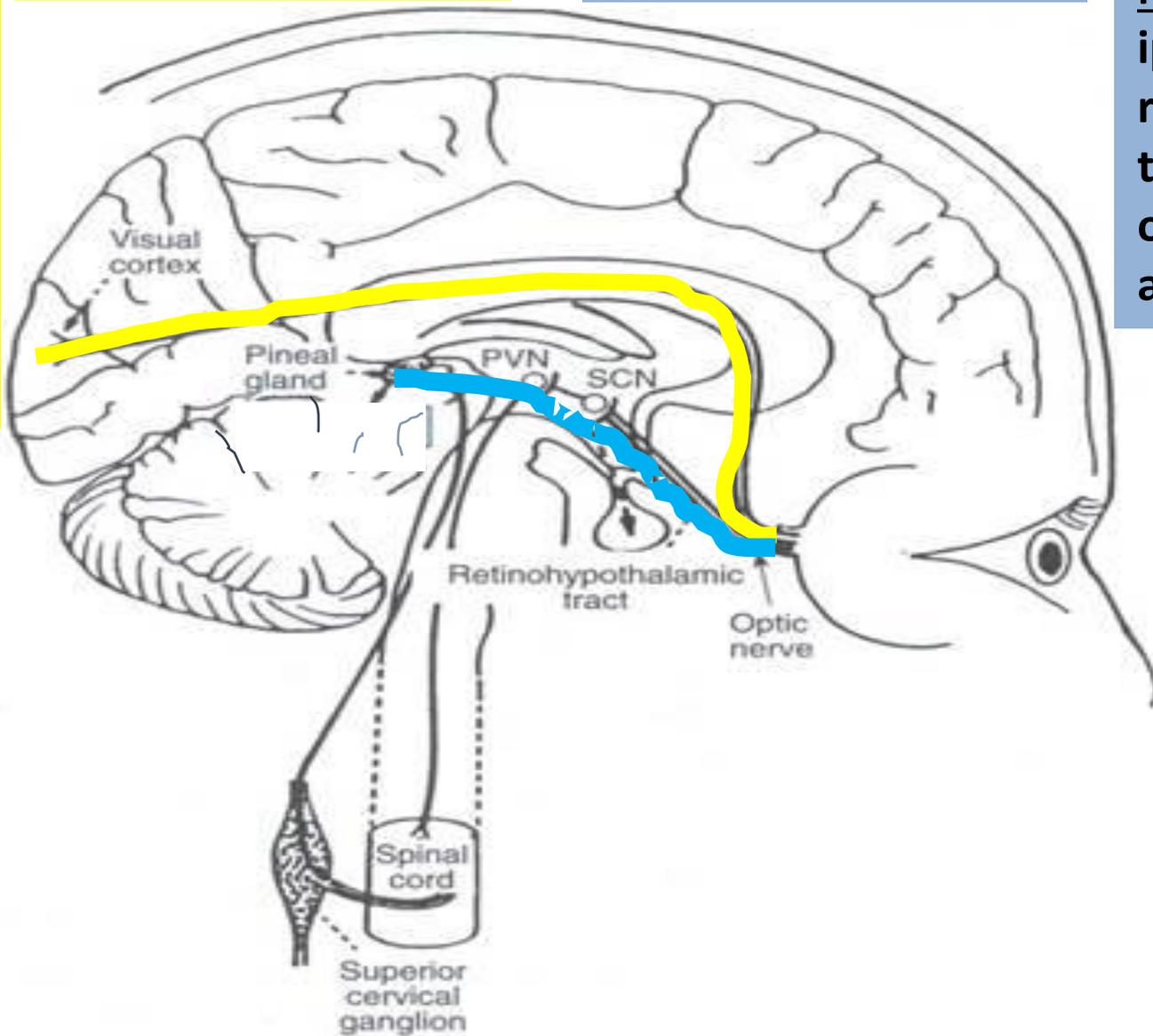


Visual Pathway
Retinal Ganglion Cells (RGCs) carry signals from the rods and cones to the visual cortex, which controls vision

- *Writing*
- *Reading*
- *Watching*
- *Communicating*
- *Learning*
- *Focusing*
- *Appreciating*
- *Enjoying*

- *Lumens*
- *Lux (fc)*

- *EML, M/P*
- *CL_α, CS*



Non-Visual Pathway
ipRGCs are photo-receptors connected to the hypothalamus and other parts of the brain, affecting many responses

- *Melatonin*
- *Alertness*
- *Cognition*
- *Mood*

- *Photic*
- *Non-photic*

Energy Implications?

- **ACC Care Center**
 - Corridors versus existing: 68% savings
 - Savings could be more if designer knew how much light for how long in AM
- **Swedish Medical BHU**
 - Versus high light level (“circadian”) non-tunable base case: 41% savings
 - Versus recommended light level non-tunable base case: 18% increase
 - 6 hours of circadian stimulating light accounted for 74% of lighting energy
- **Carrolton – Farmers Branch Classrooms**
 - 58% power reduction; more savings through dimming

Lessons learned?

- Contractors are not familiar with these systems
- Commissioning is . . . Interesting
 - “eyeball” or control settings vs. measurements
- Automatic vs. Manual tuning is. . . Complex
 - People may not know what’s good for them
 - People may save more energy
- Energy story can provide mixed messages
 - Dimming saves lots; color tuning doesn’t add savings
 - Non-visual goals may require higher light levels and energy than visual
- Evidence is still emerging and needs multi-disciplinary teams for projects

- The potential for “doing good” is great!!

Current projects

We are now collaborating with partners who can broaden the story:

- Folsom Cordova Unified School District pilot - SMUD
- ACC Care Center Phase 2 – Brown U
- U of Kentucky NICU – UK, Pivotal
- Patient Room lighting mock-up at SimTigrate / GA Tech
- Boulder Community Health IBHU / Boulder Associates



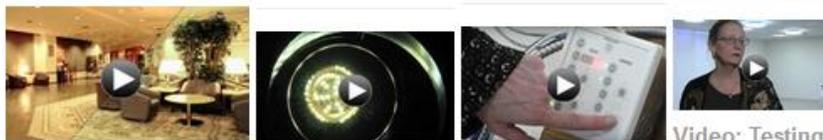
DOE SSL Program Website – Color Tuning and More

LED COLOR-TUNABLE PRODUCTS

- Solid-State Lighting Home
- About the Solid-State Lighting Program
- Research & Development
- LED R&D
- OLED R&D
- Technology Application R&D
- LED Lighting Facts
- CALiPER Testing
- Application Reports
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Color-tunable LED luminaires are a nascent and growing product category. Beyond the inherent energy efficiency of LEDs, these luminaires offer other potential benefits including improved health and well-being, increased productivity, enhanced mood or alertness, and higher occupant satisfaction. Consequently, there is reason to believe that color-tunable luminaires will gain market share. At this point, however, it is important to **understand** the potential tradeoffs, limitations, and issues surrounding this emerging product category, so that the industry can work together to address challenges needing attention as these products mature. DOE evaluation of color-tunable products demonstrates the variety of approaches that different manufacturers use to achieve color tuning, and highlights the challenges involved in **testing, controlling, and specifying** color-tunable products.

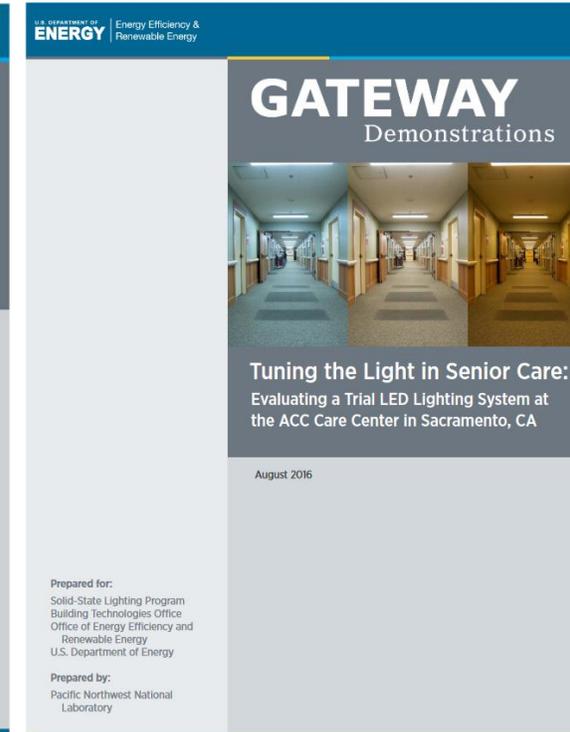
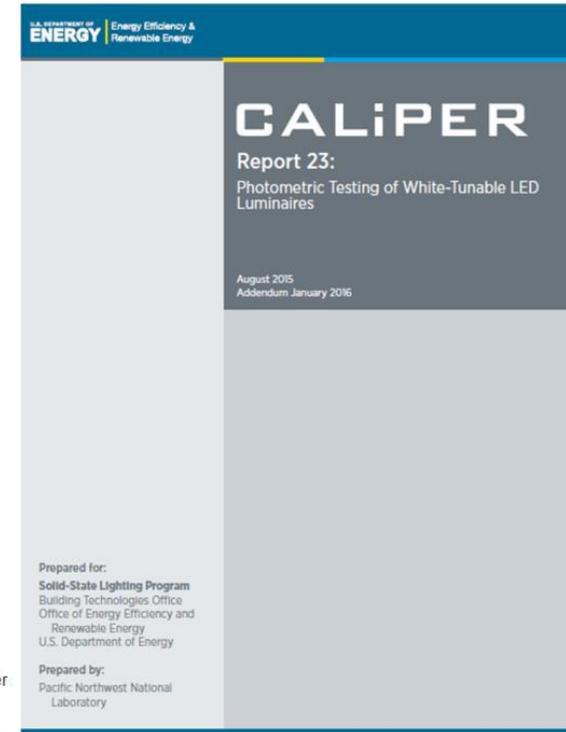


Video: Understanding LED Color-Tunable Products

Video: Specifying LED Color-Tunable Products

Video: Controlling LED Color-Tunable Products

Video: Testing LED Color-Tunable Products



<https://www.energy.gov/eere/ssl/led-color-tunable-products>