Designers Light Forum

# The Design Implications of Circadian Lighting

Dorothy Underwood

3/13/2019

leducation.org

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

---

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Learning Objectives

At the end of the this course, participants will be able to:

1. Understanding the impacts that circadian lighting has on design

2. Explore the decisions that the owner of a building will need to talk through with the design team

3. Discuss the importance of CCT and SPD on CS, and the aesthetic implications of each

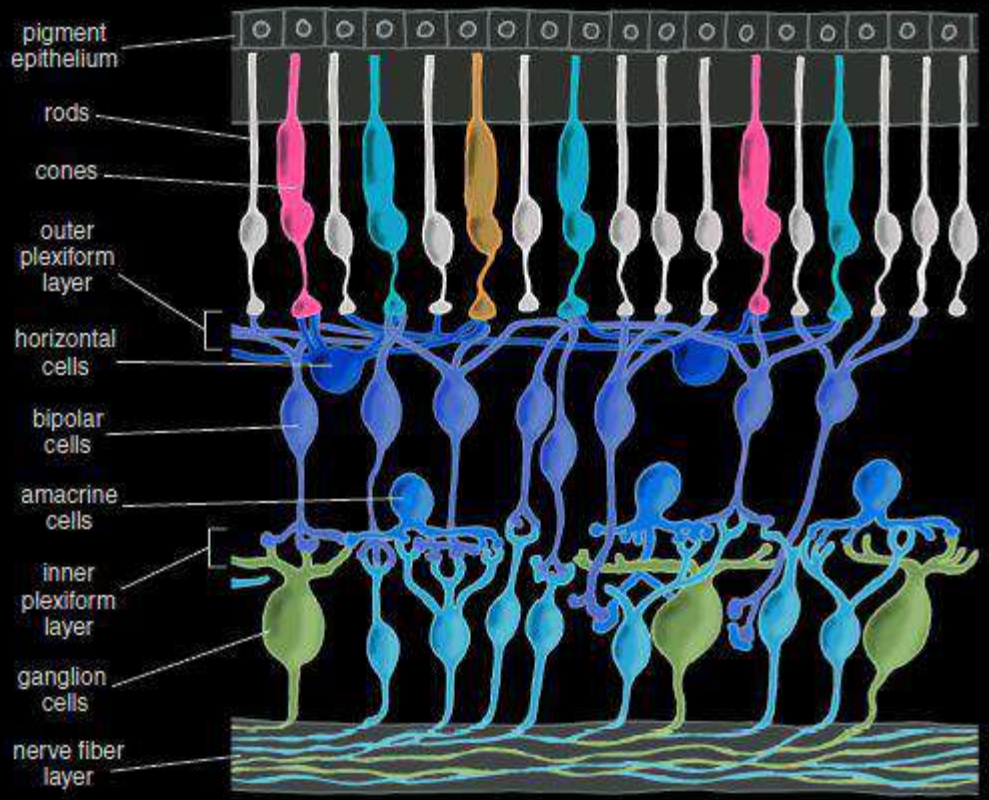
4. Identify the appropriate level of lighting controls for a building's individual needs

LEDucation®

"An important note of caution here is that it is not always clear whether lighting design should aim to maximize or minimize non-visual responses. In many ways, light can be considered a drug, having the potential for both beneficial and deleterious effects. These conflicting effects can occur concurrently, and in a single individual and context… Balancing the desirable and undesirable impacts of light or darkness requires careful, informed consideration of the context and of the myriad effects of light on physiology, perception, and cognition."

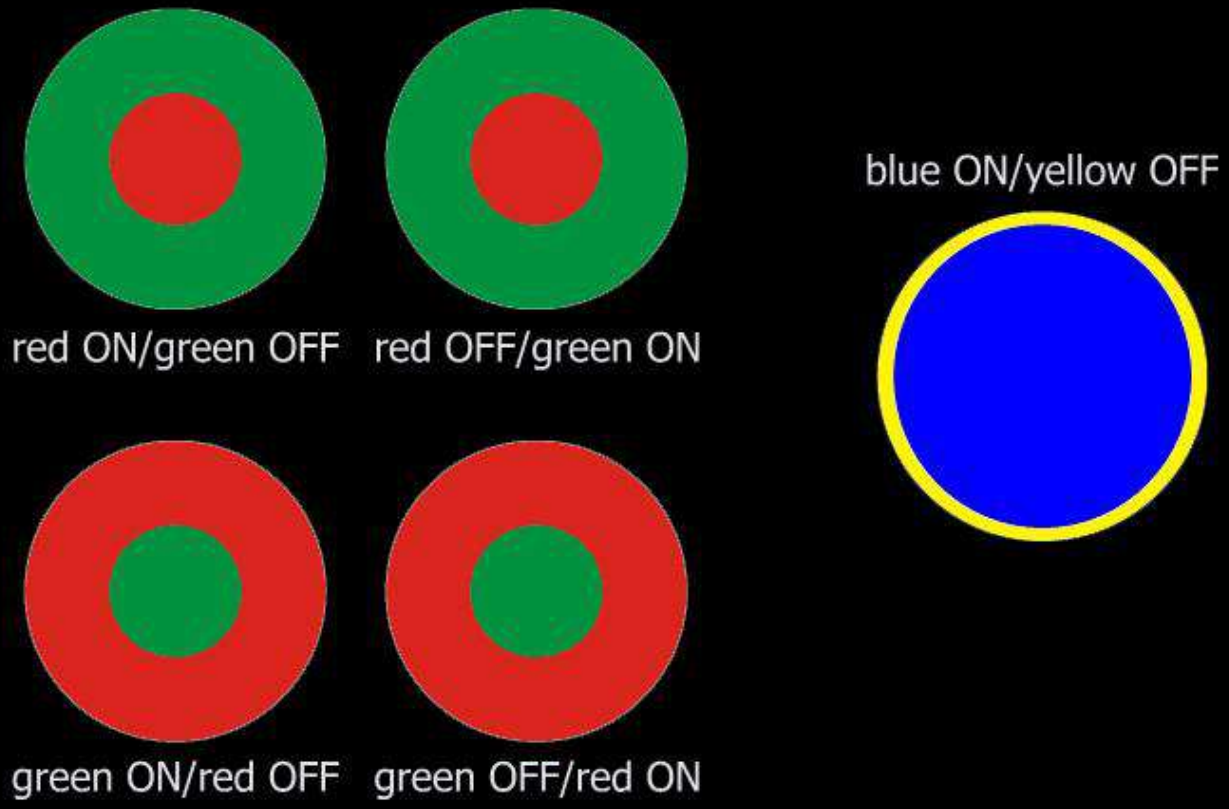
Lucas et al., "Measuring and Using Light in the Melanopsin Age." Trends in Neuroscience, Jan 2014.

# Background: Photoreceptors




Kolb, Helga. "How the Retina Works." American Scientist, Volume 91. January-February 2003. p30

# Background:  Color Opponent Channels




Figueiro, Mariana.  “Human Factors – Light & Color.” Human Factors in Lighting Class, LRC, Fall 2014, Troy, NY.

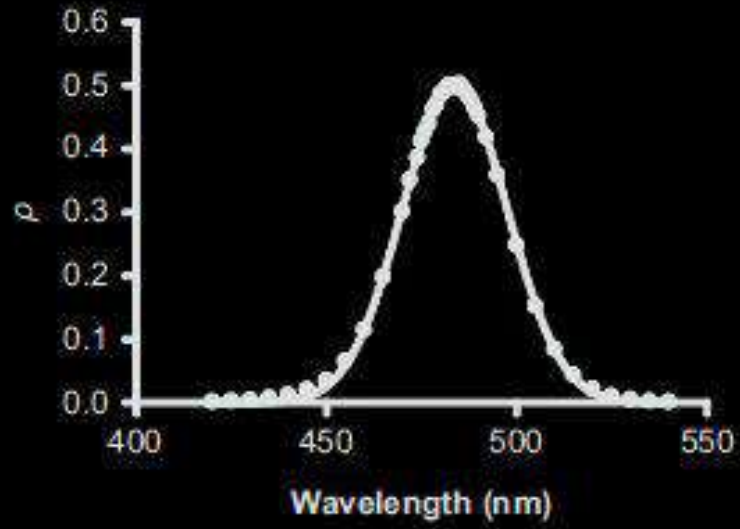
# Scientific Debate:  Lucas Group

Equivalent Melanopic Lux (EML):  The weighting of visual light to reflect the spectral sensitivity of ipRGCs

Melanopic Lux Calculator:
http://lucasgroup.lab.manchester.ac.uk/research/measuringmelanopicilluminance/

Application:

- 200 EML from 9am to 1pm or during daytime
- No more than 50 EML during the nighttime




El Enezi, Jazi, Victoria Revell, Timothy Brown, Luc Schlangen, and Robert Lucas, "A 'Melanopic" Spectral Efficiency Function Predicts the Sensitivity of Melanopsin Photoreceptors to Polychromatic Lights." Journal of Biological Rhythms 2011, 26: 320

# Scientific Debate:  LRC Recommendations

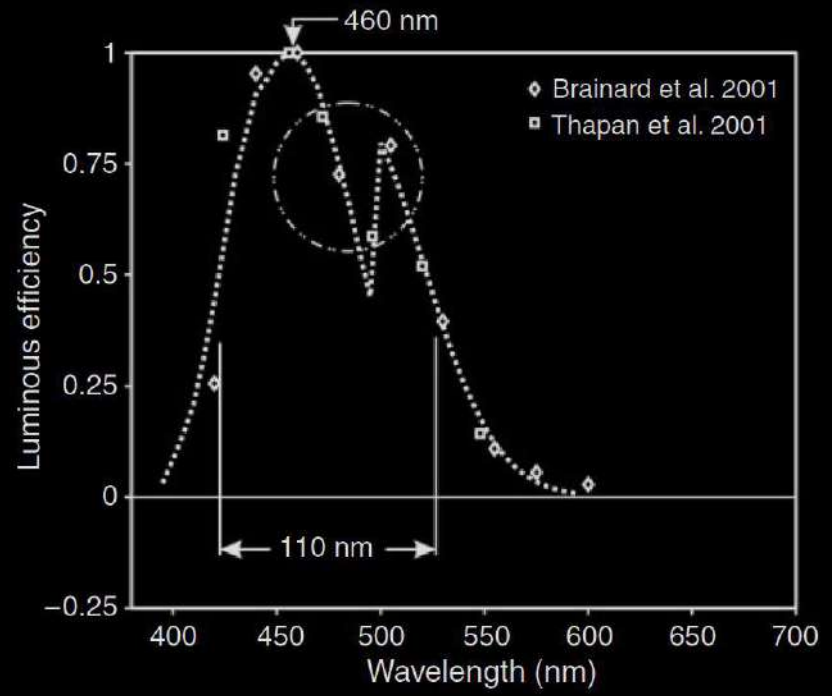
Circadian Stimulus (CS):  The effectiveness of spectrally weighted irradiance at the cornea from threshold to saturation

Circadian Light ($CL_A$):  Irradiance at the cornea weighted to reflect the spectral sensitivity of the human circadian system as measured by acute melatonin suppression after one hour of exposure

CS Calculator:  https://www.lrc.rpi.edu/programs/lighthealth/

Application:

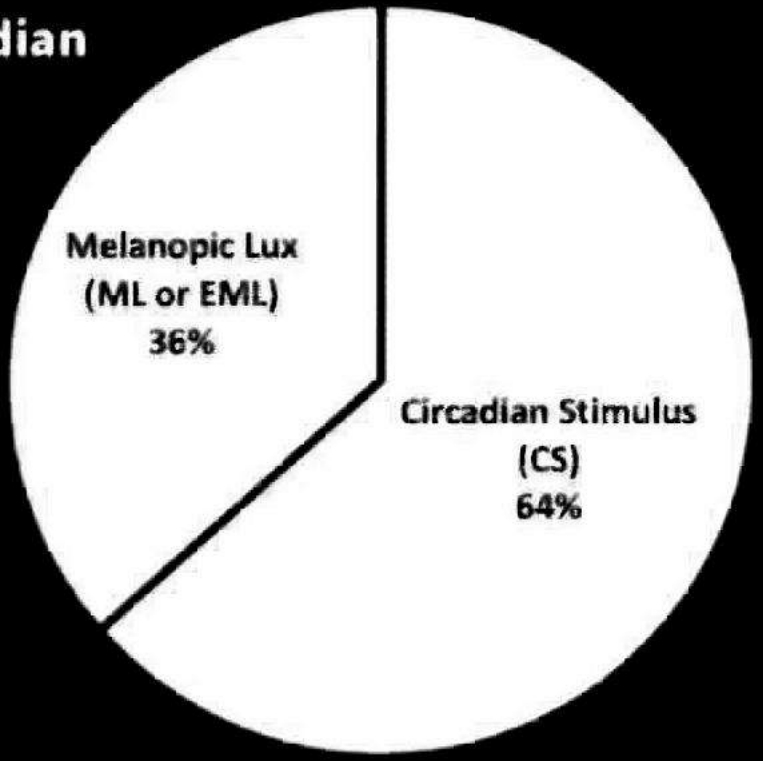
- Exposure to a CS value of at least 0.3 for at least 1-2 hours in the circadian morning
- Exposure to CS of less than 0.1 in the circadian evening




Rea, MS and MG Figueiro, "Light as a Circadian Stimulus for Architectural Lighting." Lighting Res. Technol. 2018; 50: 498

# LD+A Survey:

**3. Which circadian metric do you use?**




Lesniak, Natalia and Ed Clark, “Putting it Into Practice: Circadian Survey.” LD+A Oct 2018, p45

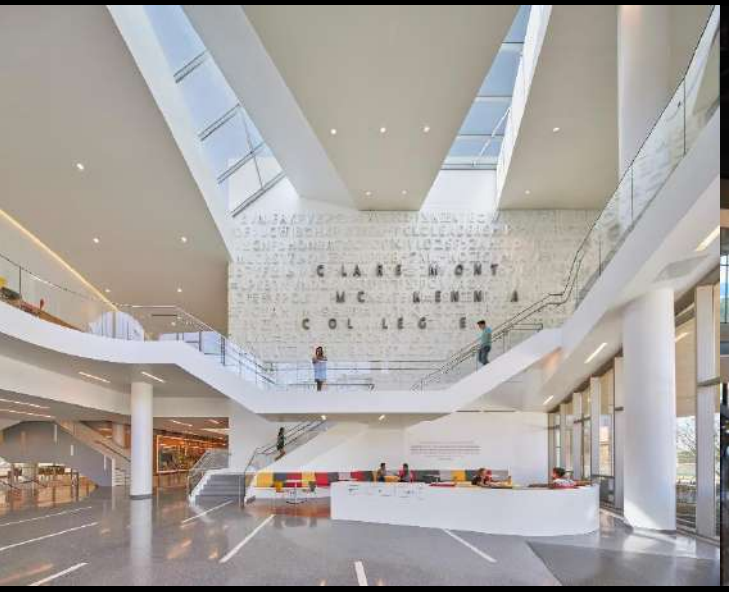
# Client’s Needs

# Client's Needs:  Building Use Type




# Client's Needs:  Age of Occupants

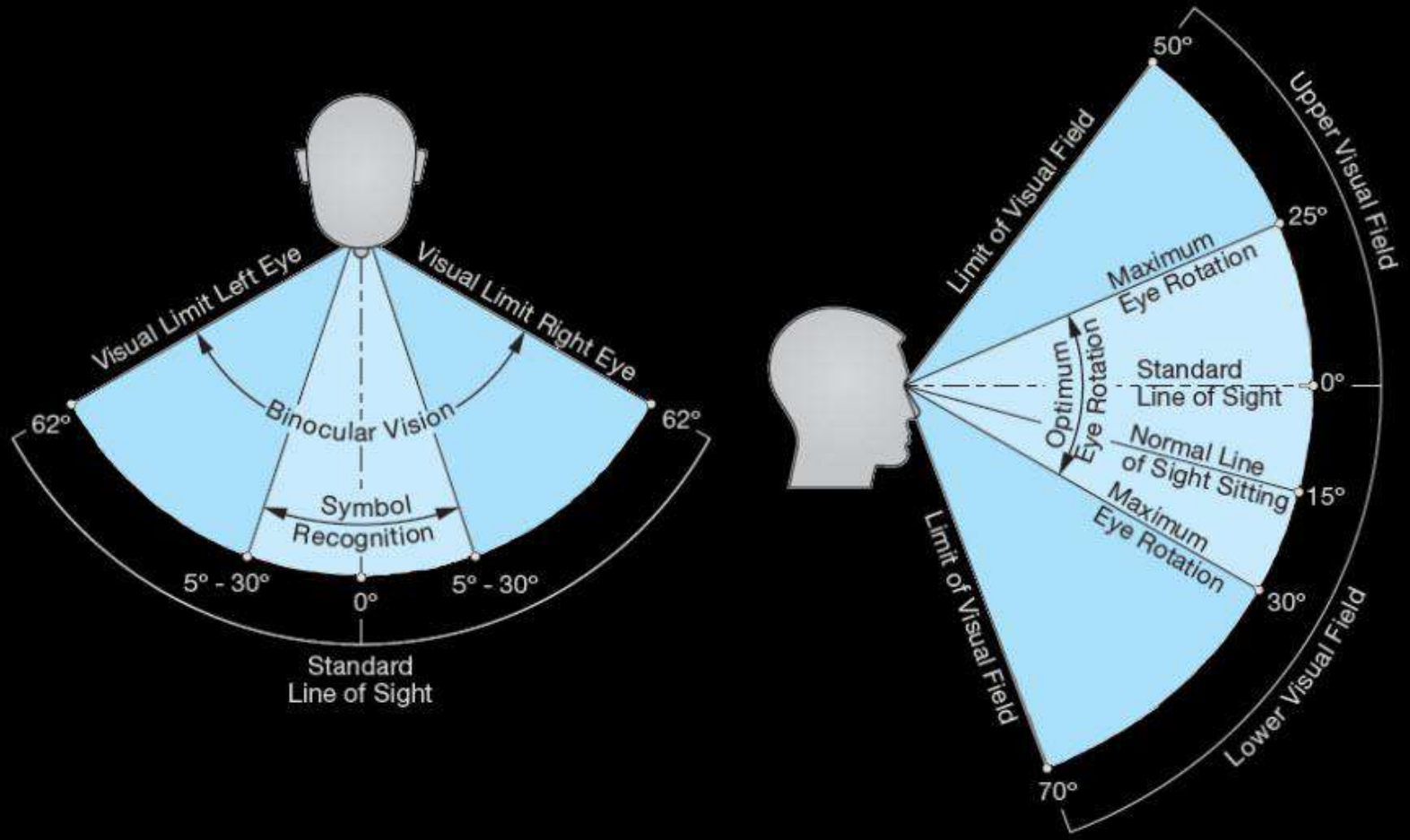
# Client's Needs:  Aesthetic



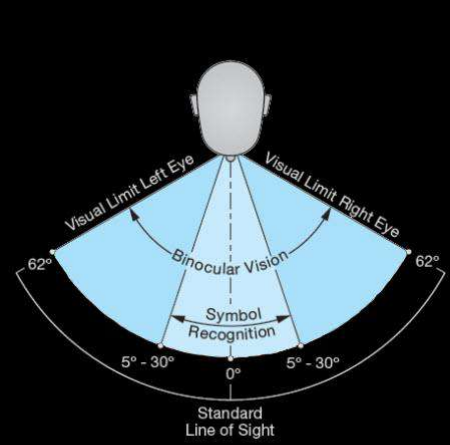

# Use of Light

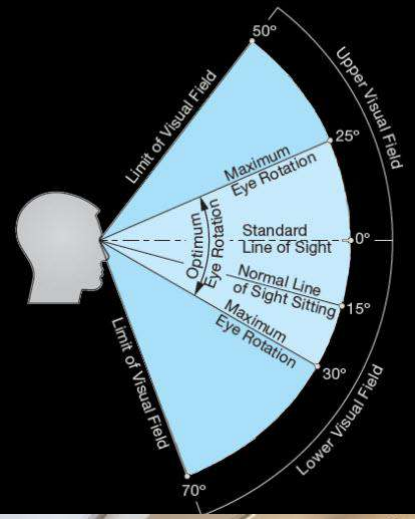
# Delivery of Light:  Circadian Morning



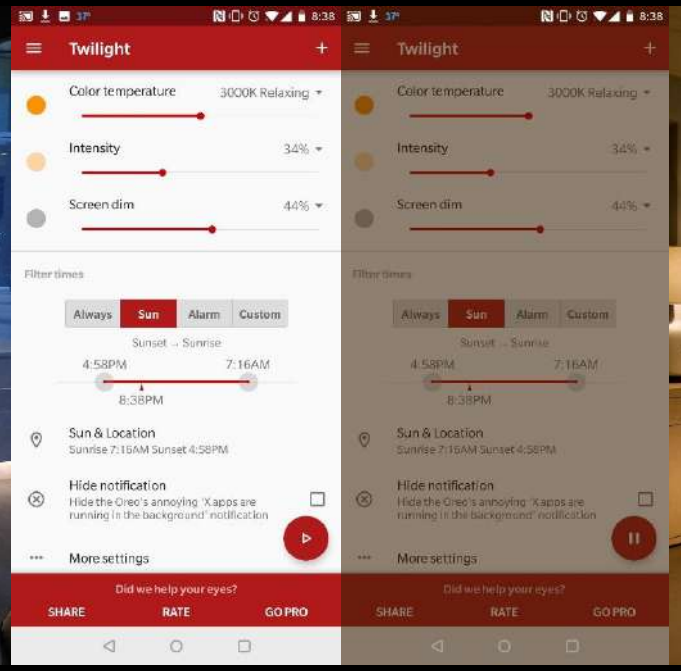
# Delivery of Light:  Circadian Morning




leducation.org

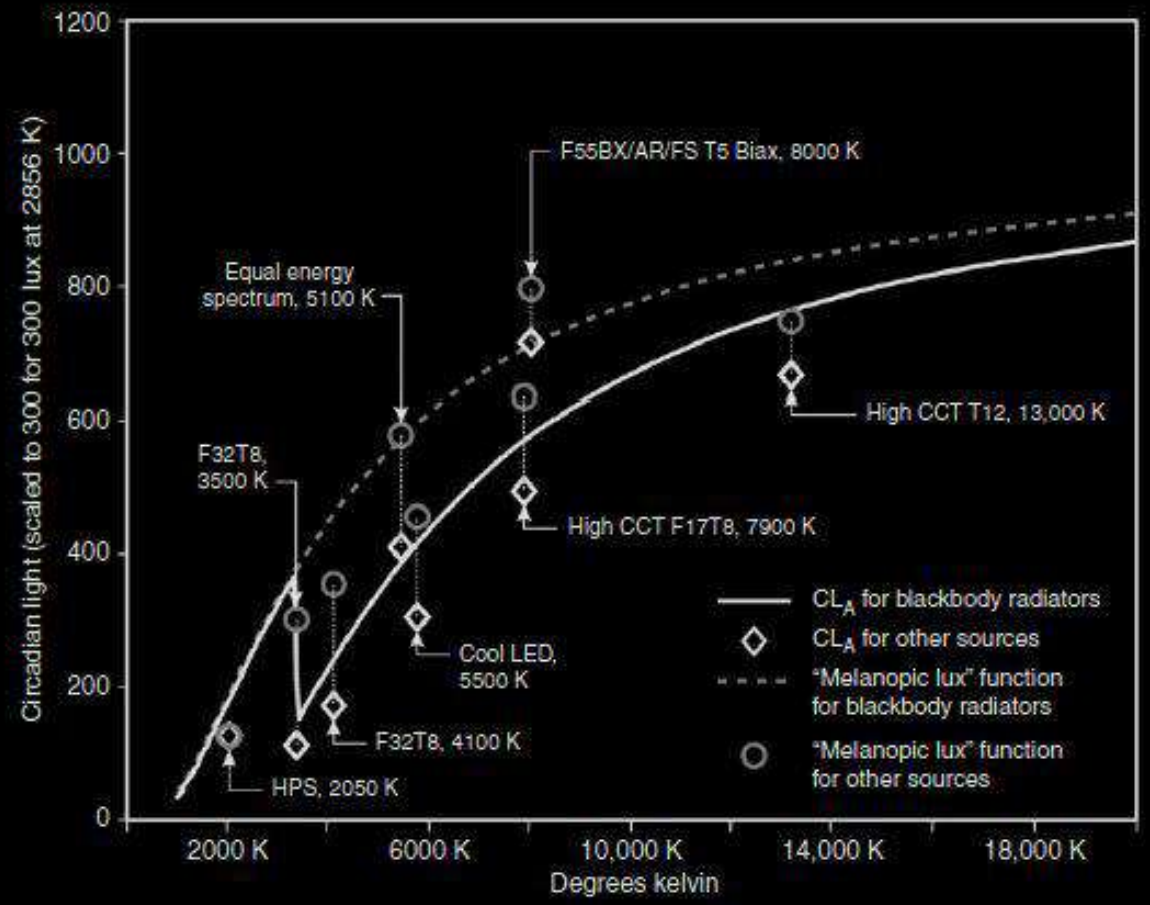
# Removal of Light:  Circadian Evening




# Removal of Light:  Circadian Night

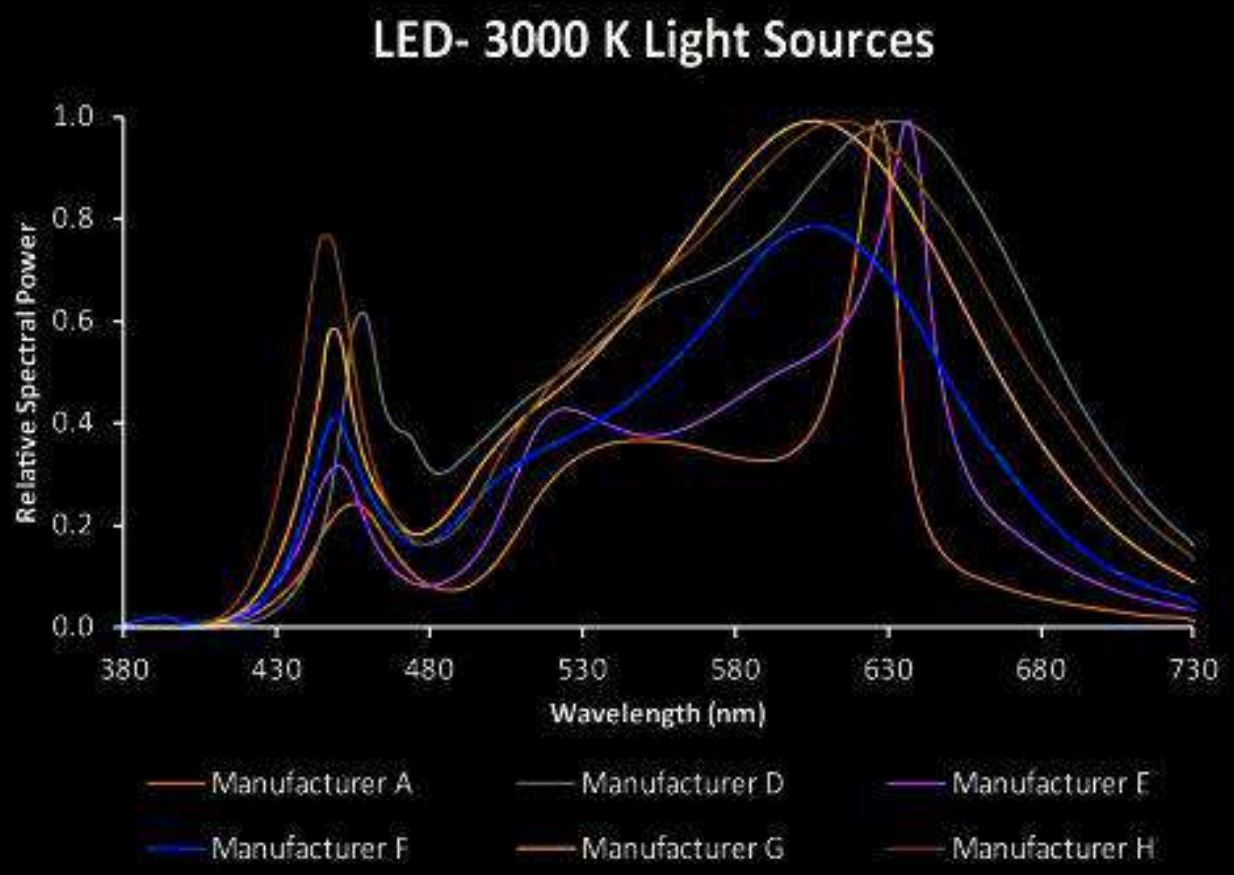
# Benefits of Single Spectrum Light

# CCT and SPD of White Light




Rea, MS and MG Figueiro, "Light as a Circadian Stimulus for Architectural Lighting." Lighting Res. Technol. 2018; 50: 503

# CCT and SPD of White Light




**Circadian Stimulus (CS) at the Eye**

| Horizontal Illuminance (lux) | Manufacturer | | | | | |
|---|---|---|---|---|---|---|
| | A | D | E | F | G | H |
| 300 | 0.23 | 0.26 | 0.24 | 0.24 | 0.23 | 0.12 |
| 325 | 0.25 | 0.27 | 0.25 | 0.25 | 0.25 | 0.13 |
| 350 | 0.26 | 0.29 | 0.26 | 0.27 | 0.26 | 0.14 |
| 375 | 0.27 | **0.30** | 0.28 | 0.28 | 0.27 | 0.14 |
| 400 | 0.29 | **0.31** | 0.29 | 0.29 | 0.28 | 0.15 |
| 425 | **0.30** | **0.33** | **0.30** | **0.30** | **0.30** | 0.16 |
| 450 | **0.31** | **0.34** | **0.31** | **0.31** | **0.31** | 0.17 |
| 475 | **0.32** | **0.35** | **0.32** | **0.32** | **0.32** | 0.18 |
| 500 | **0.33** | **0.36** | **0.33** | **0.33** | **0.33** | 0.19 |

Values in **BOLD** meet or exceed the recommended CS of 0.3 or higher.

Lighting Research Center, "Circadian Stimulus Look-Up Charts – Direct/Indirect." p5. https://www.lrc.rpi.edu/programs/lightHealth/index.asp

# Architectural Finishes








leducation.org

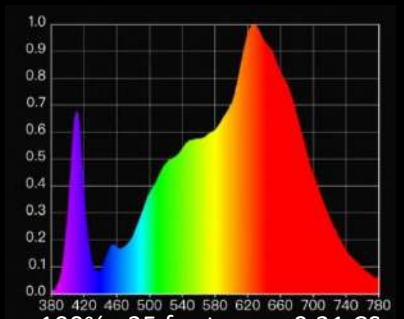
# Architectural Finishes

# Controlling the Light

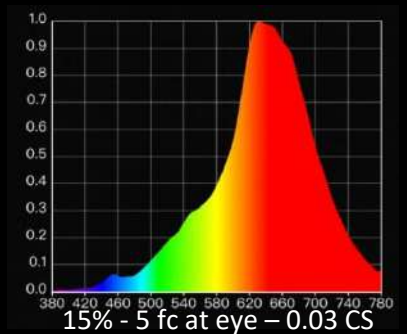
# Controls: Simple

Tunable task lighting (4200K vs. 2700K)

Use different fixtures at different times of day




100% - 35 fc at eye – 0.31 CS




15% - 5 fc at eye – 0.03 CS

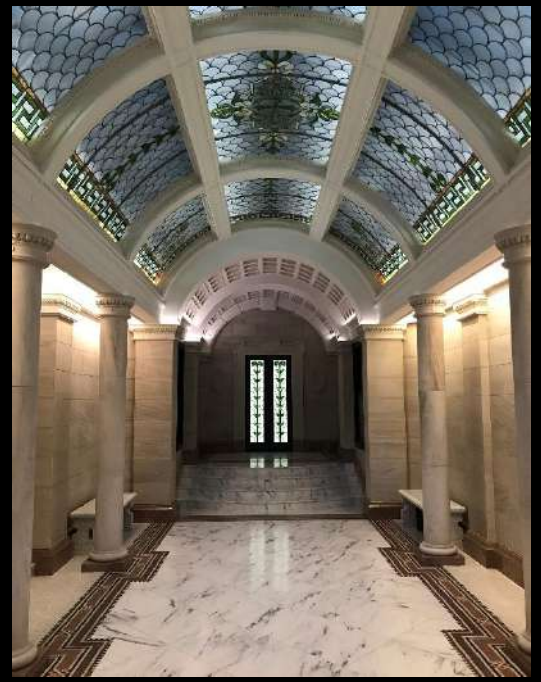
Warm dim downlights (100% vs. 10%)

# Controls:  Medium Level



# Controls:  High Tech

“Sunrise”



“Morning”

“Afternoon”

“Sunset”

# On the Horizon

UL Task Group Developing Circadian Lighting RP
Delivery Goal:  May 2019


ALFA
Modeling software based on melanopic lux

# The Most Important Factor

Occupant Training/Education

LEDucation®

# Thank you!

AIA®

leducation.org

# References:


- Burgess, Helen and Thomas Molina, “Home Lighting Before Usual Bedtime Impacts Circadian Timing: A Field Study.” Photochemistry and Photobiology, 2014, 90; 723-726.
- El Enezi, Jazi, Victoria Revell, Timothy Brown, Luc Schlangen, and Robert Lucas, “A ‘Melanopic” Spectral Efficiency Function Predicts the Sensitivity of Melanopsin Photoreceptors to Polychromatic Lights.” Journal of Biological Rhythms 2011, 26: 320
- Figueiro, Mariana, Andrew Bierman, Barbara Plitnick, and Mark Rea, “Preliminary Evidence that Both Blue and Red Light Can Induce Alertness at Night.” BMC Neuroscience 2009, 10: 105
- Figueiro, Mariana, Andrew Bierman, John Bullough, and Mark Rea, “A Personal Light-Treatment Device for Improving Sleep Quality in the Elderly: Dynamics of Nocturnal Melatonin Suppression at Two Exposure Levels.” Chronobiology International, 26; 4, 726-739.
- Figueiro, Mariana, Kassandra Gonzales, and David Pedler, “Designing with Circadian Stimulus.” LD+A October 2016; pp 30-34.
- Figueiro, Mariana and Mark Rea, “Quantifying Circadian Light and Its Impact.” Architectural Lighting; 2/13/2017
- Figueiro, Mariana. “Human Factors – Light & Color.” Human Factors in Lighting Class, LRC, Fall 2014, Troy, NY.
- Kolb, Helga. “How the Retina Works.” American Scientist, Volume 91. January-February 2003. p28-35
- Lennie, Peter, “Color Vision: Putting it Together.” Current Biology 2000, 10; R589-R591.
- Lesniak, Natalia and Ed Clark, “Putting it Into Practice: Circadian Survey.” LD+A Oct 2018, p44-48
- Lighting Research Center, “Circadian Stimulus Look-Up Charts – Direct/Indirect.” p5. https://www.lrc.rpi.edu/programs/lightHealth/index.asp

# References:


- Lucas, Robert J, Stuart N Pierson, David M Berson, Timothy M Brown, Howard M Cooper, Charles A Czeisler, Mariana G Figueiro, Paul D Gamlin, Steven W Lockley, John B O'Hagan, Luke LA Price, Ignacio Provencio, Debra J Skene, and George C Brainard, "Measuring and Using Light in the Melanopsin Age." Trends in Neurosciences, January 2014, Vol. 37, No. 1
- Pechacek, Christopher S, Marilyne Andersen, Steven W Lockley, " Preliminary Method for Prospective Analysis of the Circadian Efficacy of (Day)Light with Applications to Healthcare Architecture." LEUKOS - The Journal of the Illuminating Engineering Society of North America, vol 5 (1), pp. 1-26, July 2008.
- Rea, MS and MG Figueiro, "Light as a Circadian Stimulus for Architectural Lighting." Lighting Res. Technol. 2018; 50: 498
- Rea, Mark, and Mariana Figueiro, "What is Healthy Lighting?" International Journal of High Speed Electronics and Systems, Vol 20, No 2 (2011) 321-342
- Rea, MS, MG Figueiro, and JD Bullough, "Circadian Photobiology: an Emerging Framework for Lighting Practice and Research." Lighting Res. Techology 34,3 (2002) pp.177-190.
- Rea, Mark, Mariana Figueiro, John Bullough, and Andrew Bierman, "A Model of Phototransduction by the Human Circadian System." Brain Research Reviews, vol 50 (2005), pages 213-228.
- Rea, Mark, Mariana Figueiro, Andrew Bierman, and John Bullough, "Circadian Light." Journal of Circadian Rhythms 2010, 8: 2.
- Rea, Mark, "Opinion: On the Horizon: A Recommended Practice for Circadian Regulation." Lighting Res. Technol. 2018; 50: 800.

# References:


- Stevens, Richard, George Brainard, David Blask, and Steven Lockley, “Adverse Health Effects of Nighttime Lighting: Comments on American Medical Association Policy Statement.” American Journal of Preventative Medicine 2013; 45 (3), 343-346.
- Weale, RA, “Retinal Illumination and Age,” Transactions of the Illuminating Engineering Society [London] Vol 26(2), pp. 95-100 (1961).
- WELL v1
- Wood B, MS Rea, B Plitnick, MG Figueiro. “Light Level and Duration of Exposure Determine the Impact of Self-Luminous Tablets on Melatonin Suppression.” Applied Ergonomics 2013. 44(2): 237-240.

This concludes The American Institute of Architects Continuing Education Systems Course

leducation.org