

The background features a light gray grid pattern overlaid with various orange hand-drawn scribbles, including loops, swirls, and zig-zags. Two four-pointed starburst shapes are also present, one in the upper left and one in the lower right.

# Lighting Design in Education Environments

**Circadian Rhythm Edition**

# Hi I'm Alexey

- P.Eng, MBA, PMP, MIES
- Stantec in Edmonton
- Senior Electrical Engineer

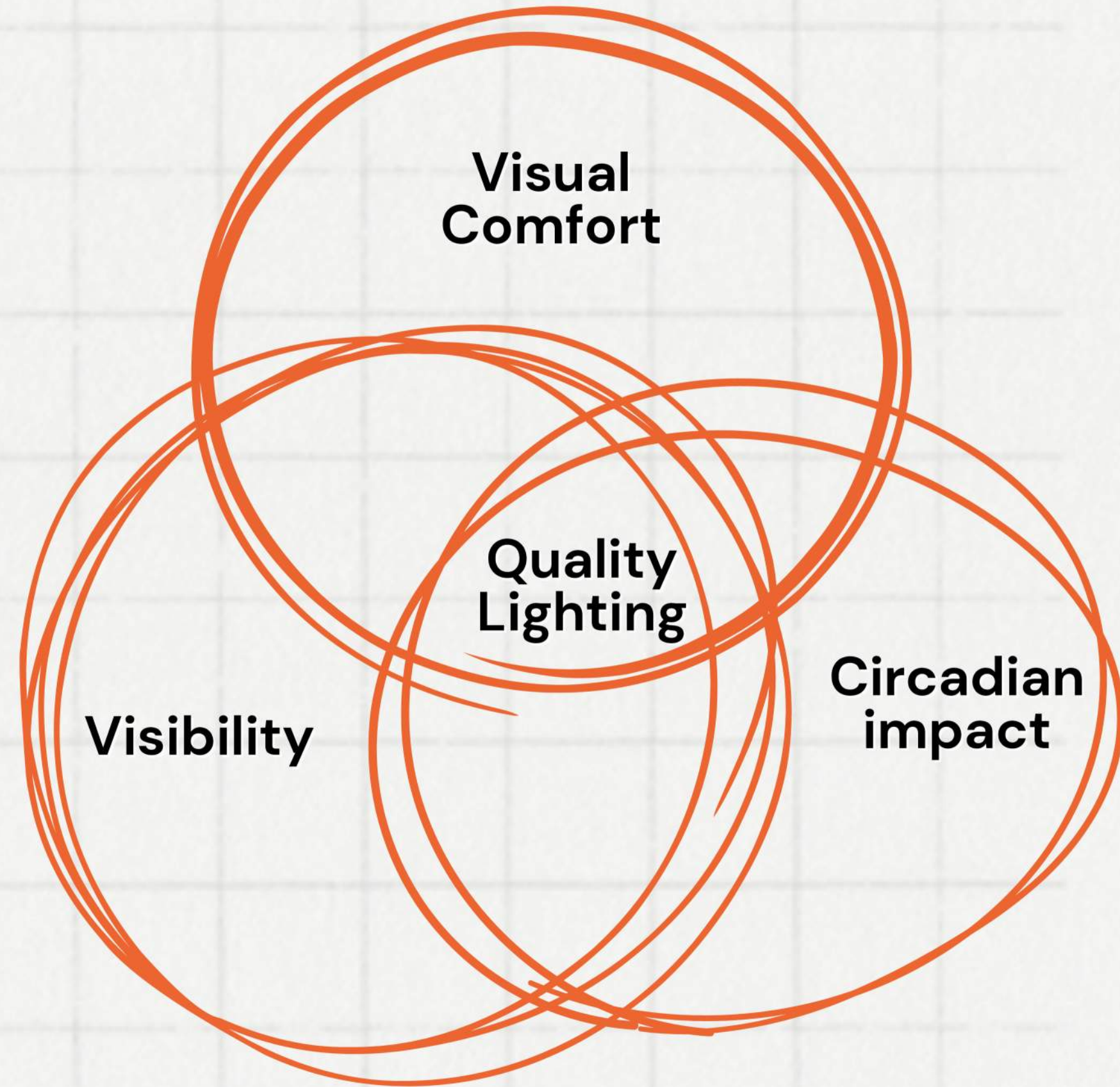
phone: +1 587 756 6249

e-mail: [alexey.kalinin@stantec.com](mailto:alexey.kalinin@stantec.com)



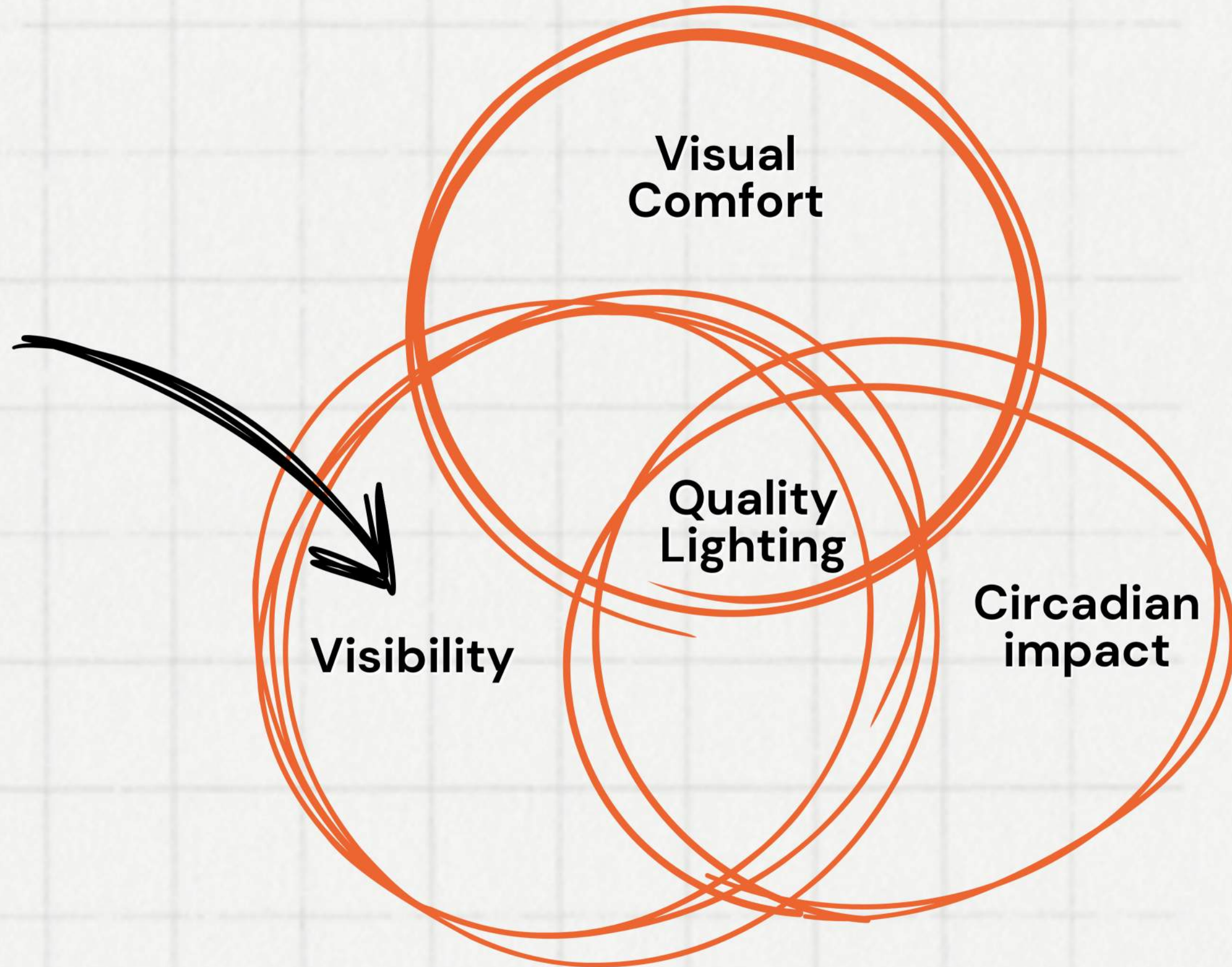
# Quality Lighting

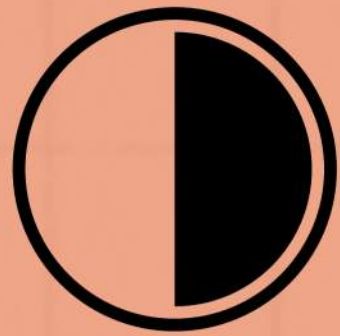
- See what you need to see
- See task quickly and easily
- No visual discomfort
- Raise the human spirit



# Quality Lighting

- Visibility
- Visual Comfort
- Circadian Impact





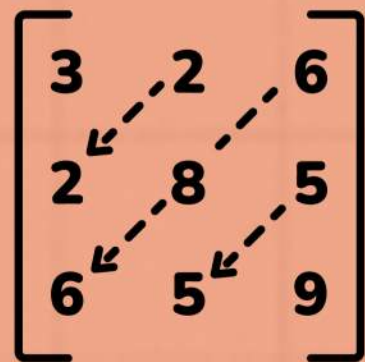
## Contrast

Luminance difference is necessary for vision



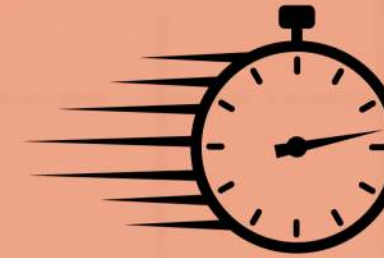
## Color

Similar to contrast, variable colours help with task identification



## Illuminance

Higher illuminance increases visibility of the task



## Time

Less time = harder to identify objects



## Age

Lens becomes less transparent



## Task Size

Larger objects are easier to see

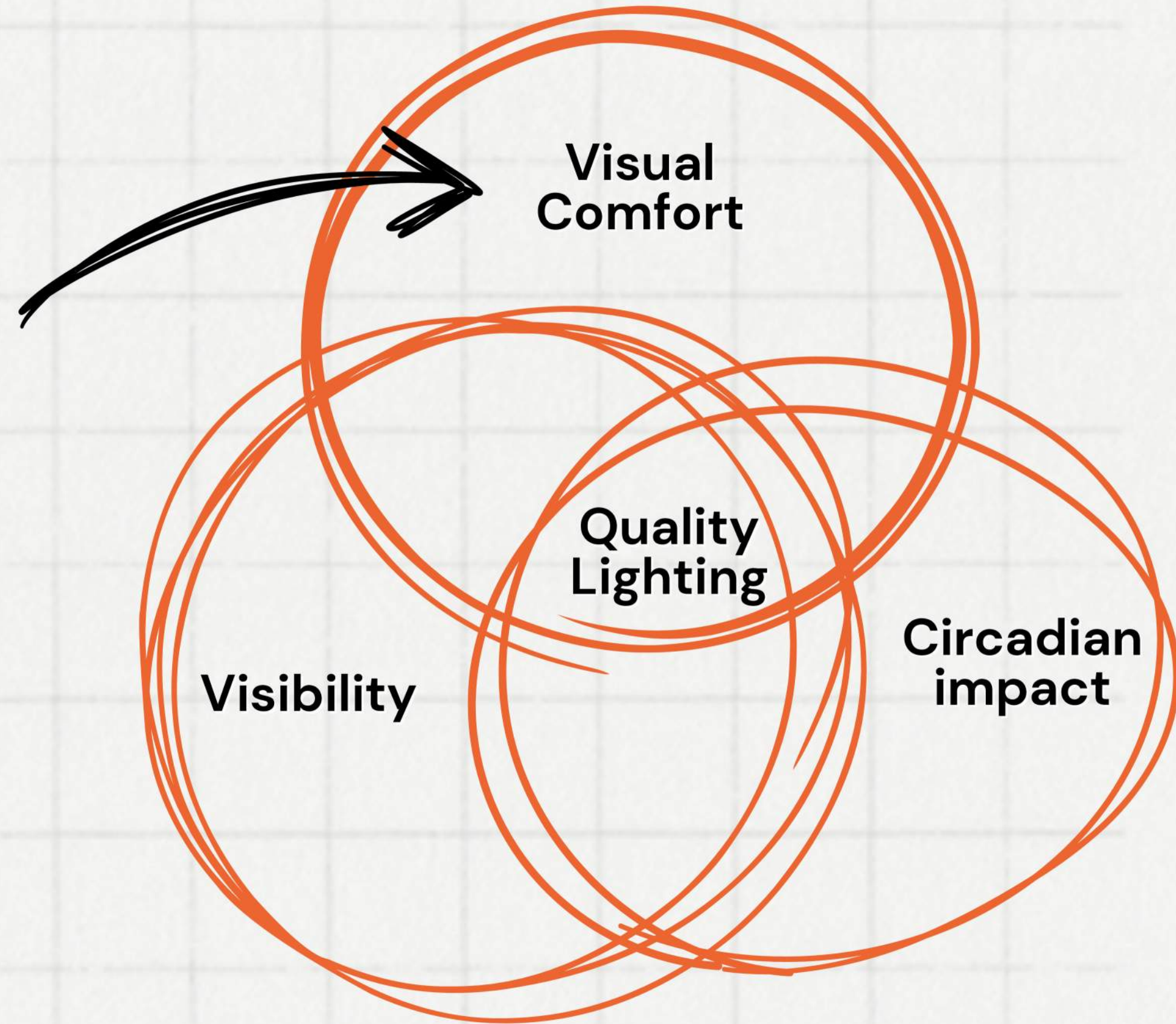
Larger objects are easier to see

# Visibility

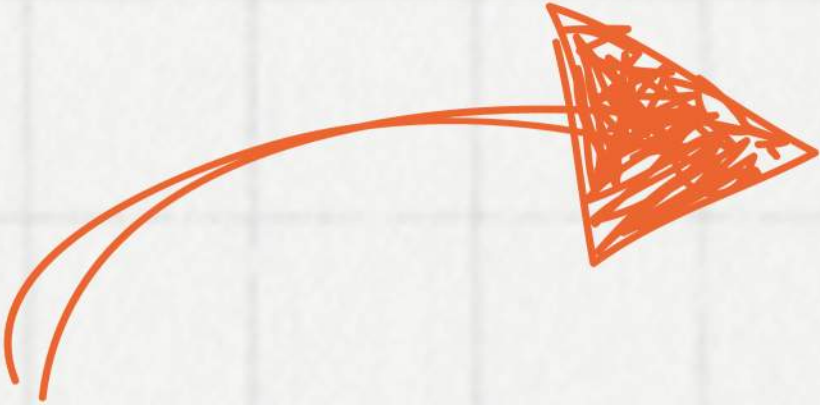


# Quality Lighting

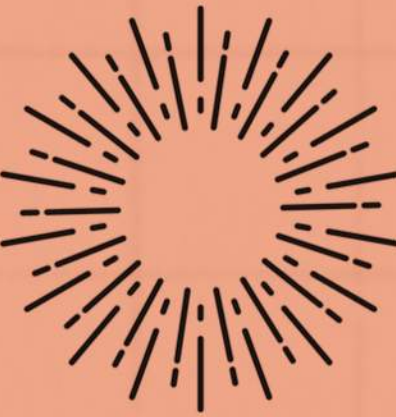
- Visibility
- Visual Comfort
- Circadian Impact



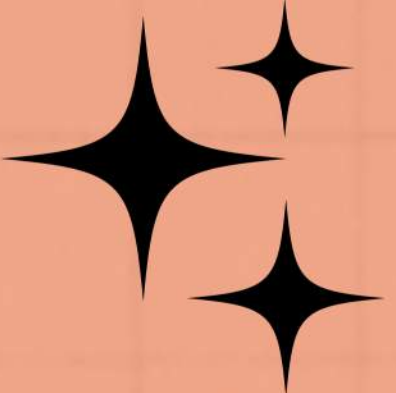
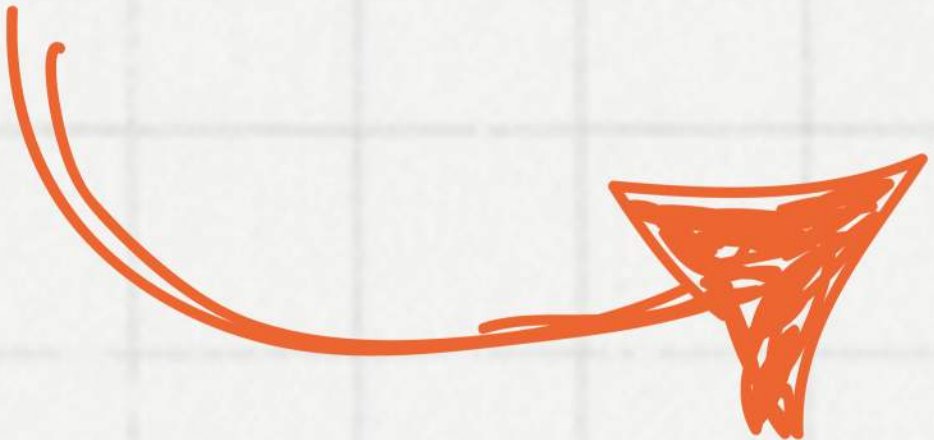
# Visual comfort



**Eye  
Adaptation**



**Glare**



**Flicker**



# Light level

- Adjacency and eye adaptation
- Account for the transition to outdoors
- Circulation and wayfinding
- Draw attention to art or signage

# Glare

The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss of visual performance and visibility

01.

## Disability

Impairs visual performance.

02.

## Discomfort

Causes discomfort and annoyance.



# Glare

The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility

01.


## Disability

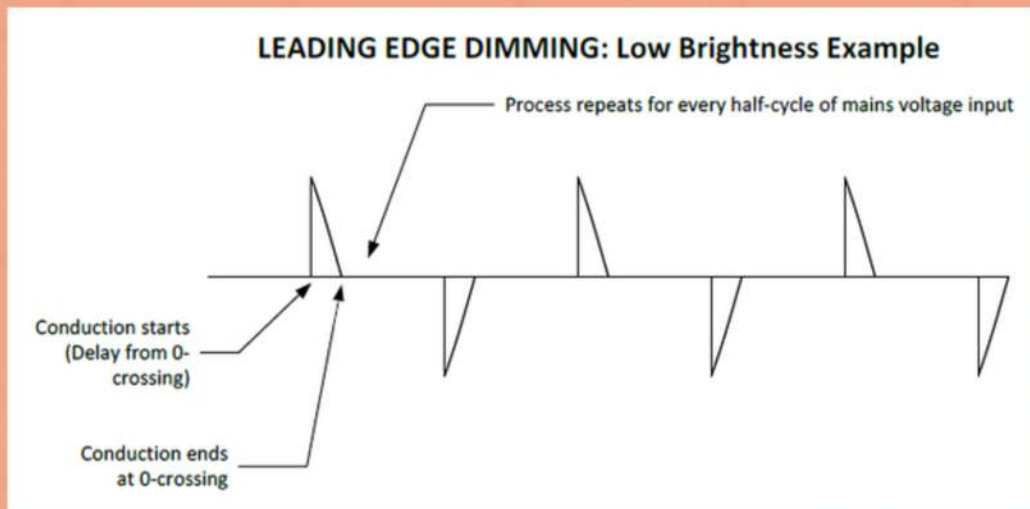
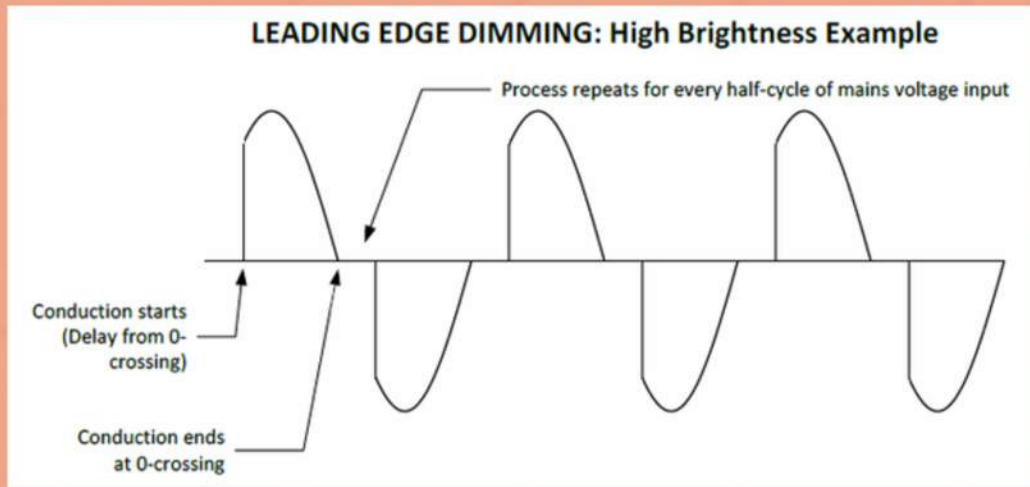
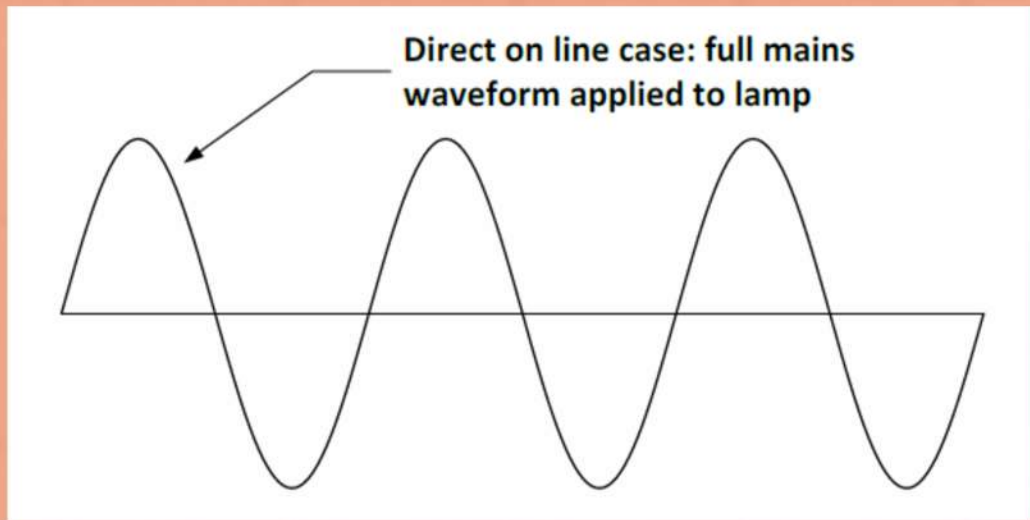
Impairs visual performance.

02.

## Discomfort

Causes discomfort and annoyance.





# Flicker

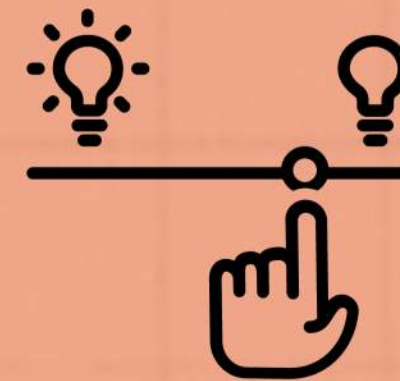
Temporal Light Modulation (TLM)



Incompatible controls



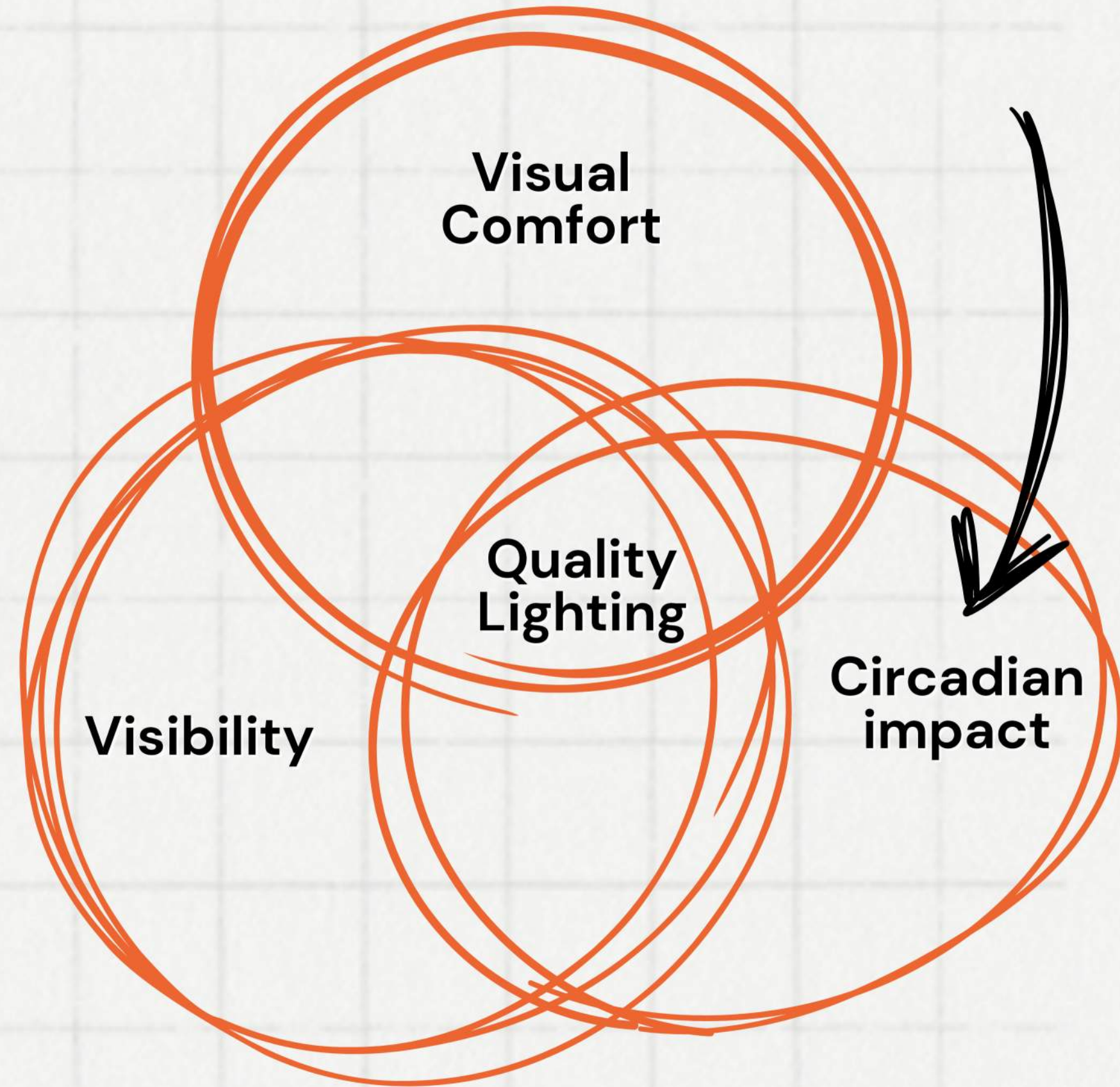
Poor quality of components



Dimming  
Color tuning

# Quality Lighting

- Visibility
- Visual Comfort
- Circadian Impact



# Circadian rhythm



**Built in body clock**

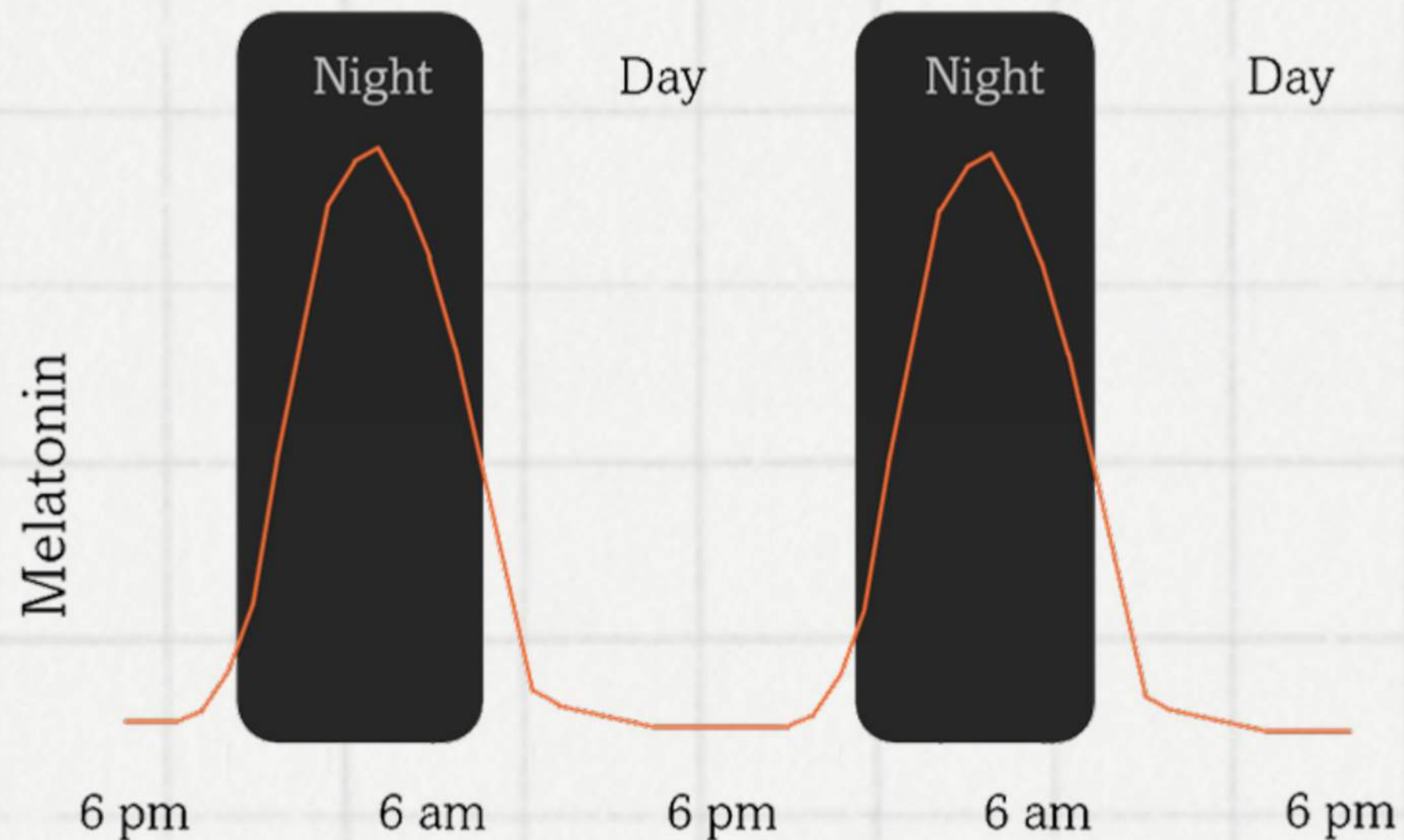


**Controls sleep cycle**



**Melatonin!**

# Circadian rhythm



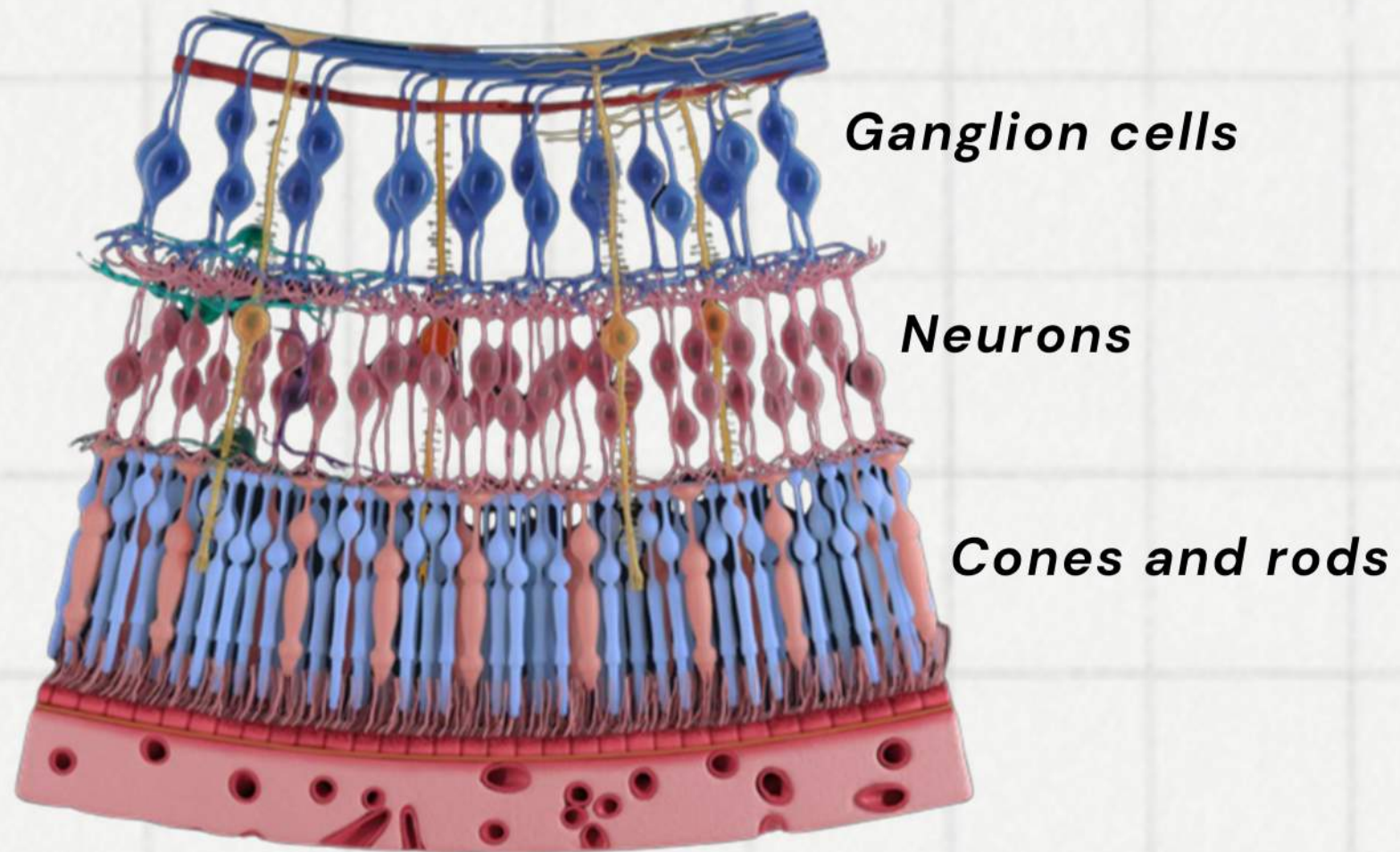
Adapted from Arendt, 2005

Circadian cycle repeats approximately every 24 hours

24.2 hours for most people, so needs to be reset

Resets every day:  
Morning light - advances  
Evening light - delays

# New cell discovered!



No cones, no rods – still circadian response.

*Freedman et al., 1999*

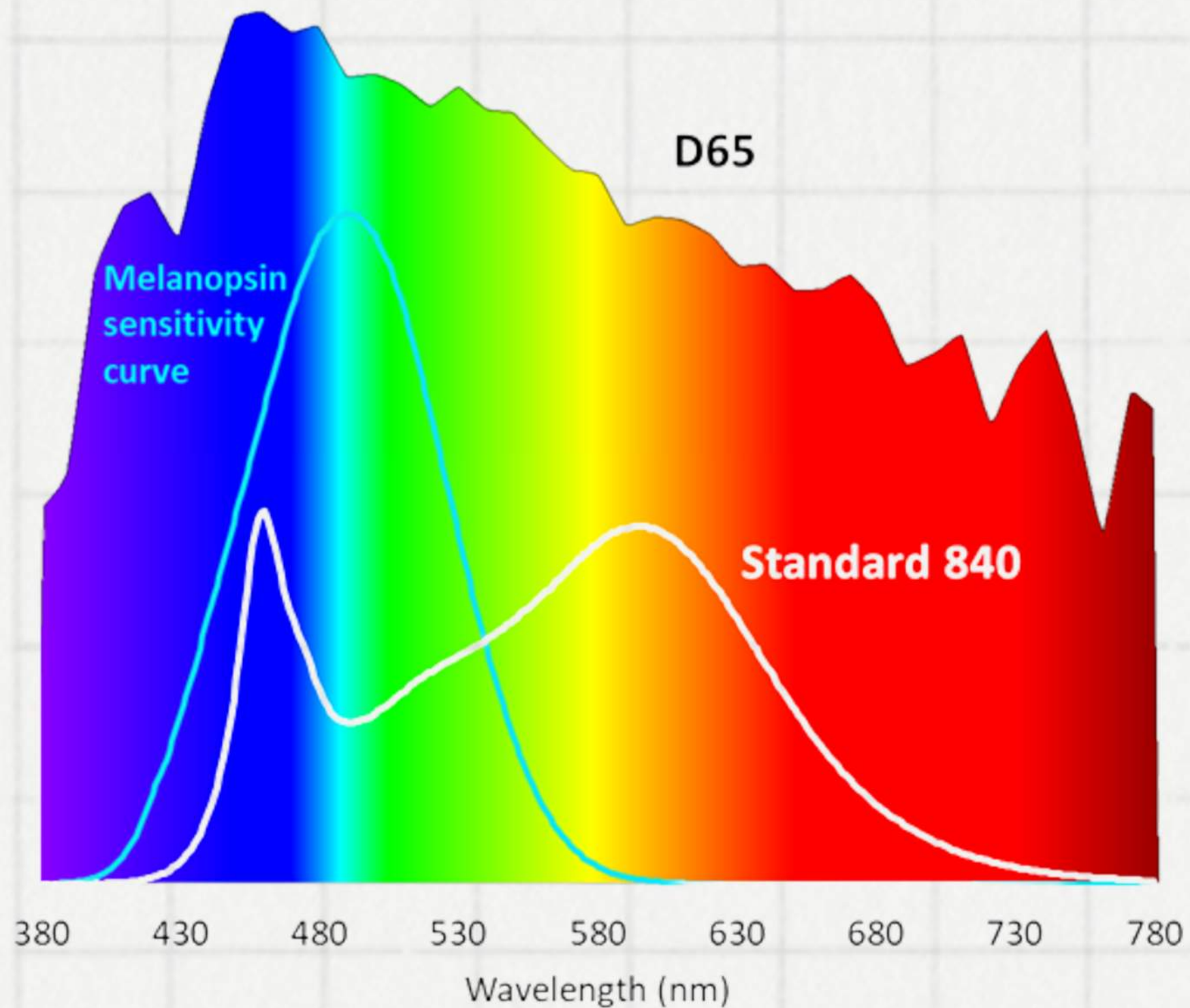
ipRGCs discovered through effects on circadian rhythm.

*Berson et al., 2002*

Lights Should Support Circadian Rhythms: Evidence-Based Scientific Consensus

*248 scientists and 2697 peer-reviewed papers, Frontiers in Photonics, 2023*

# Spectrum

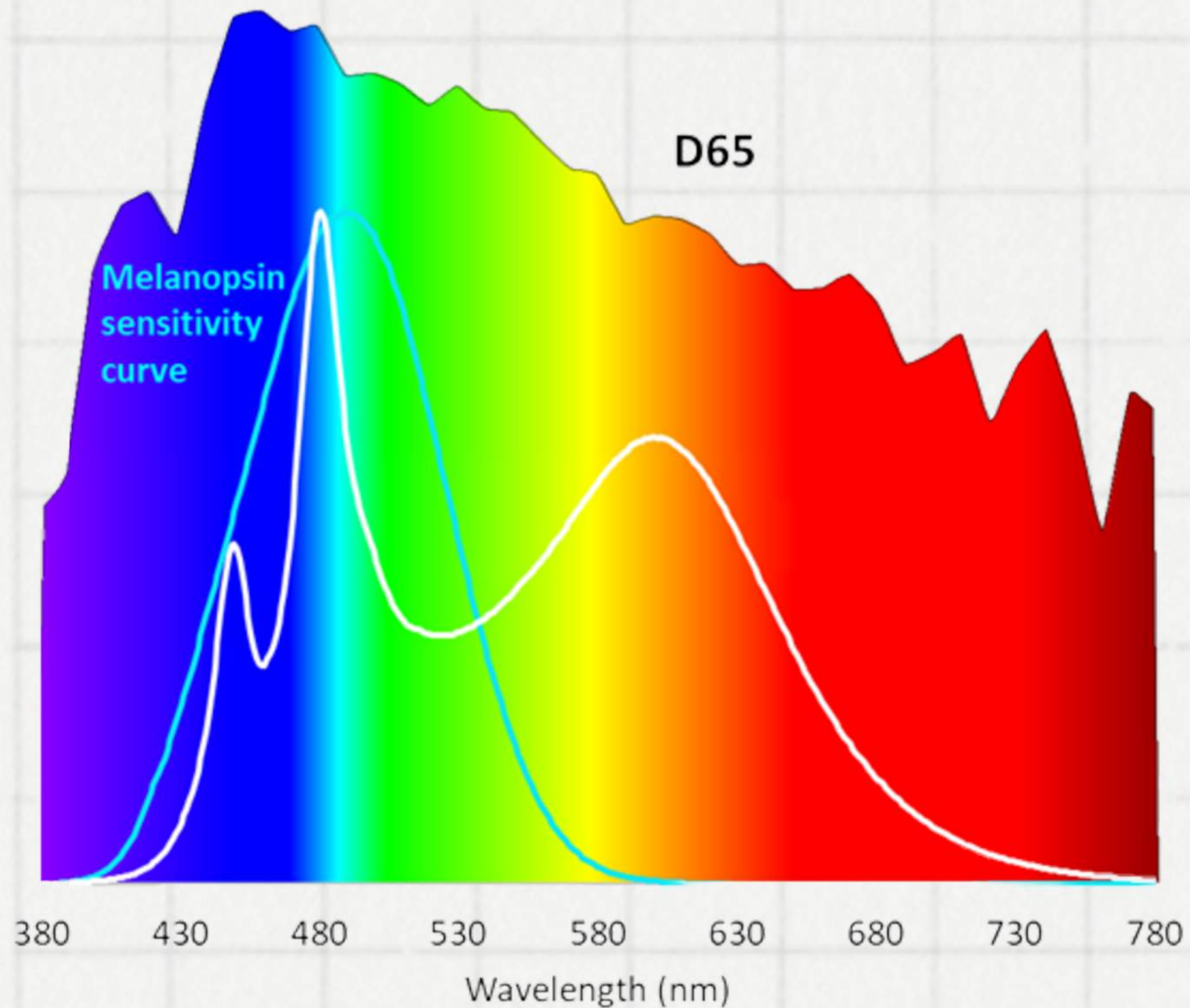


Daylight spectral power distribution (SPD) at 6500K - D65

Melanopic Equivalent Daylight Illuminance - mEDI (LUX)

Melanopic Daylight Equivalency Ratio - mDER

# Spectrum

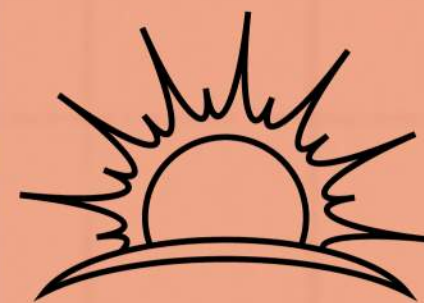
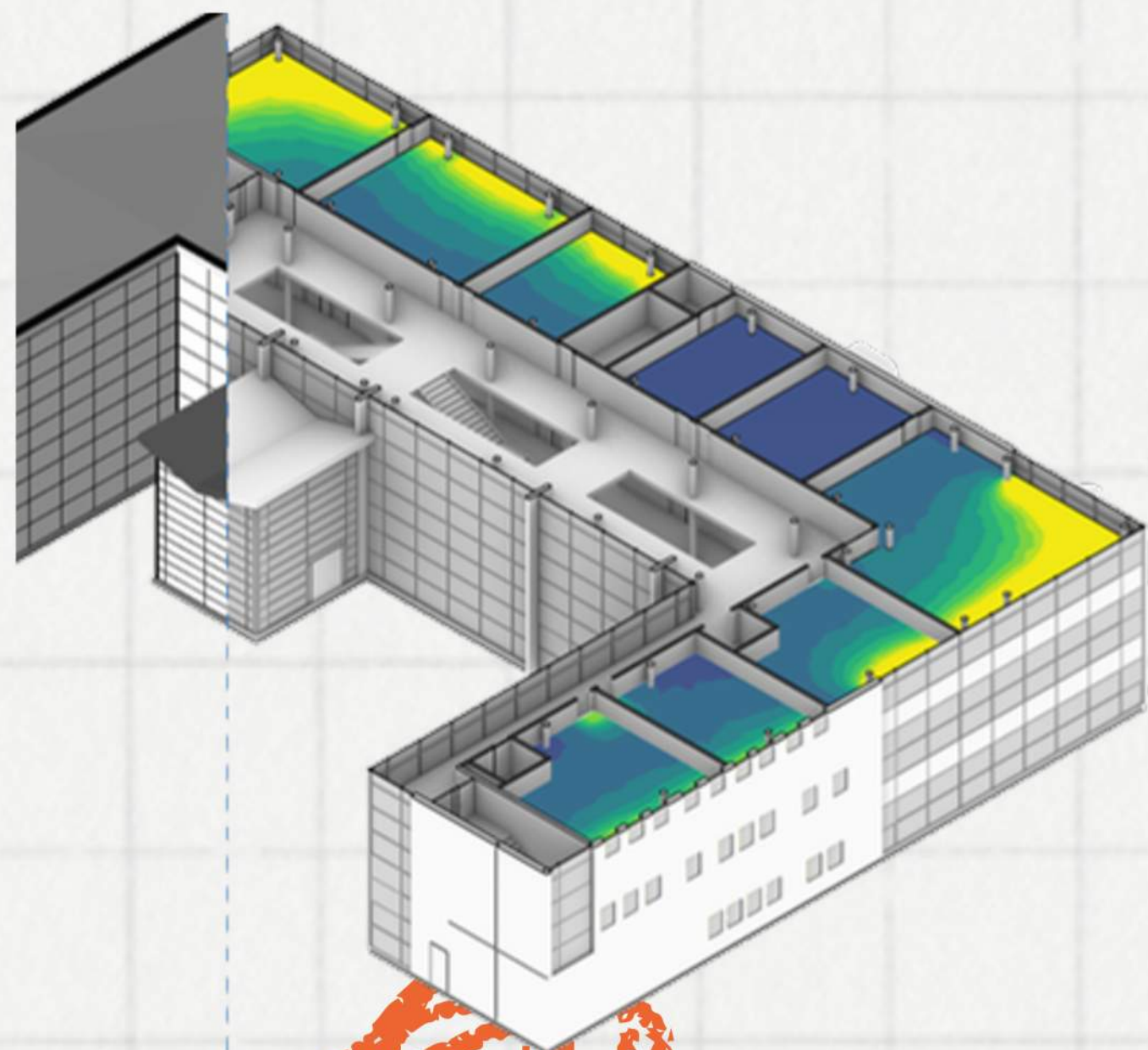


Daylight spectral power  
distribution (SPD) at 6500K -  
D65

Melanopic Equivalent Daylight  
Illuminance - mEDI  
(LUX)

Melanopic Daylight Equivalency  
Ratio - mDER

# Melanopic EDI



**Daylight**

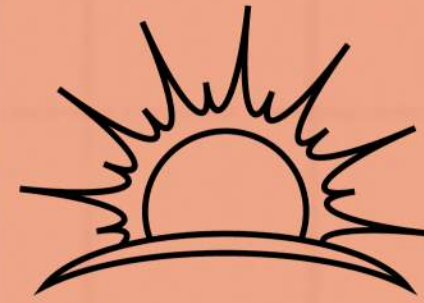
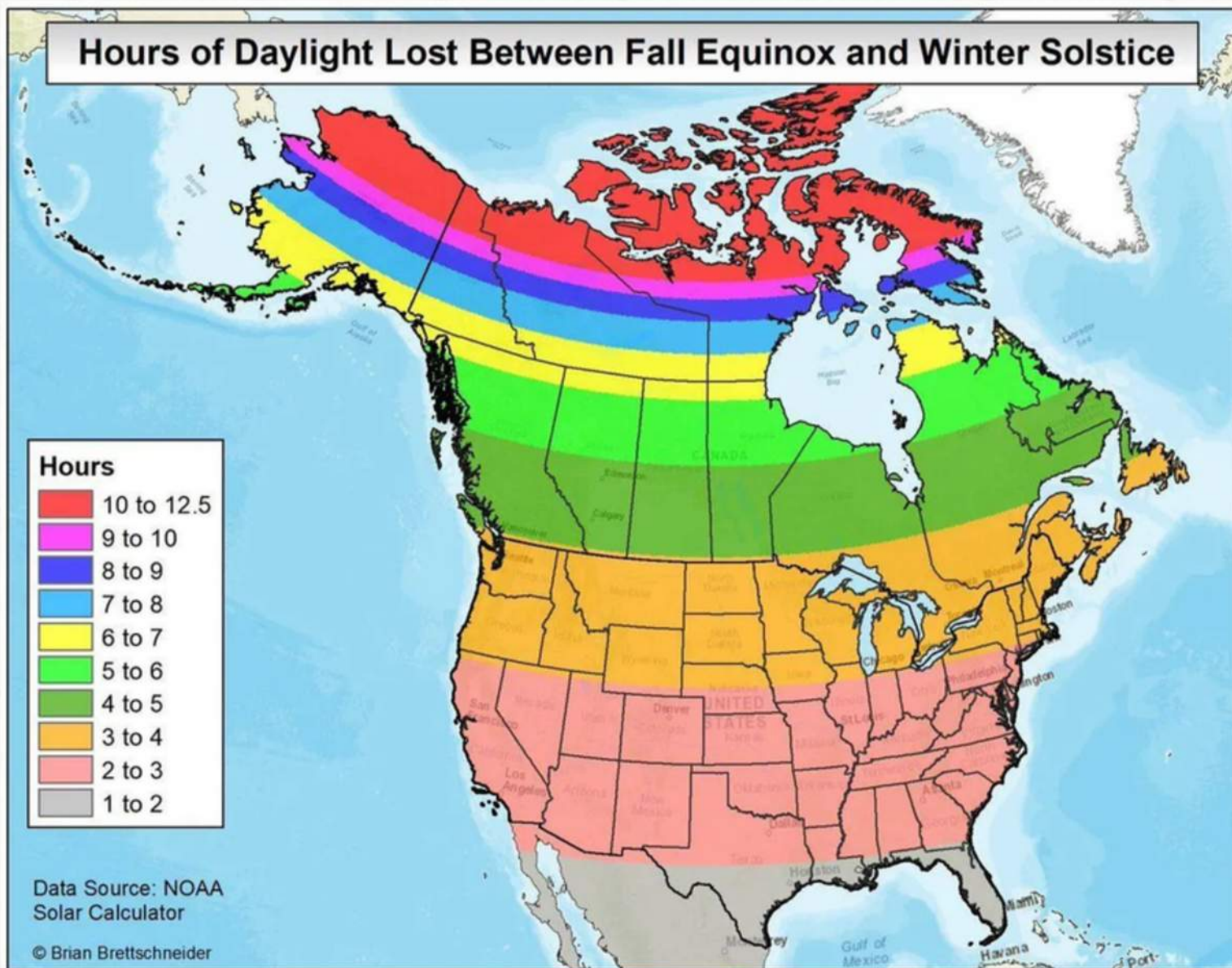


**Artificial light**



**SPD change**

# Melanopic EDI



Daylight



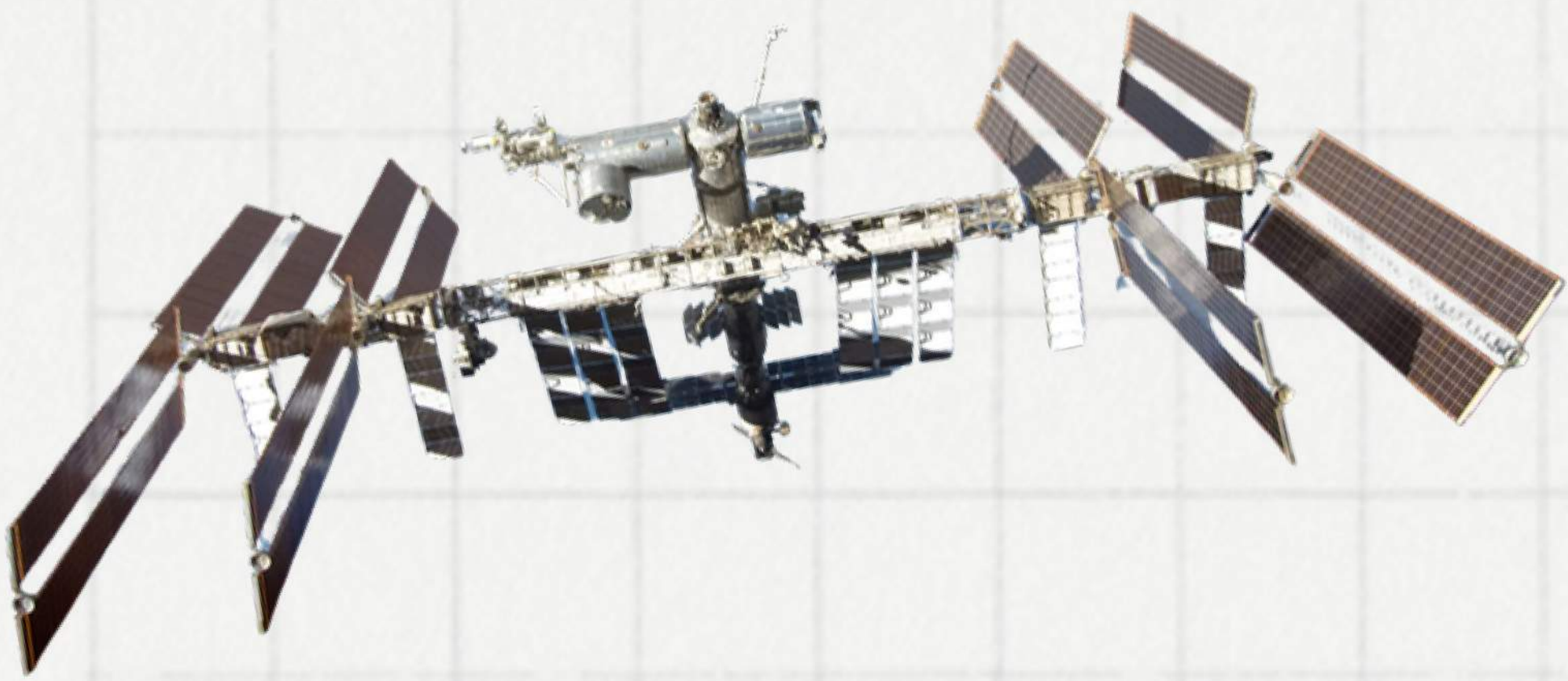
Artificial light



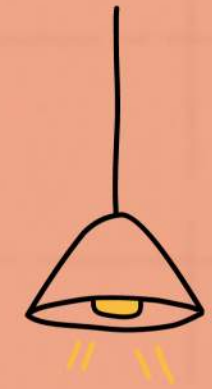
SPD change



# Melanopic EDI



Daylight



Artificial light




SPD change



# Melanopic EDI



Daylight



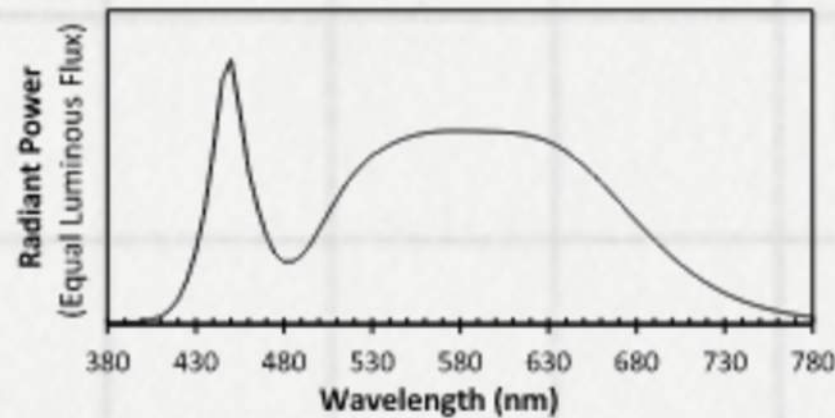
Artificial light



SPD change

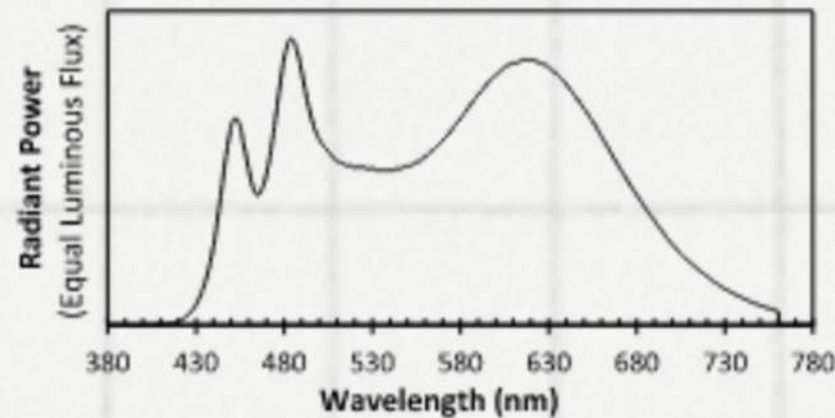
# SPD change

SPD B



CCT (K)	4268
mDER	0.65
CRI R <sub>a</sub>	88
R <sub>f</sub>	85
R <sub>g</sub>	102
R <sub>cs-h1</sub>	-6%

SPD C



CCT (K)	3782
mDER	0.82
CRI R <sub>a</sub>	84
R <sub>f</sub>	84
R <sub>g</sub>	95
R <sub>cs-h1</sub>	0%

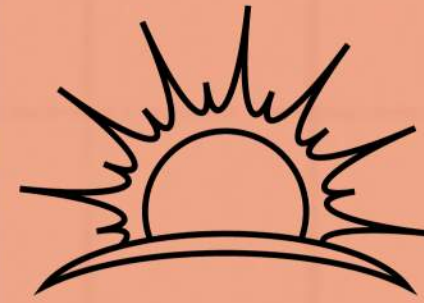


Color tuning  
≠  
circadian lighting

Circadian lighting still  
can impact CCT

More spectrum in  
460-520nm region

# Melanopic EDI



Daylight

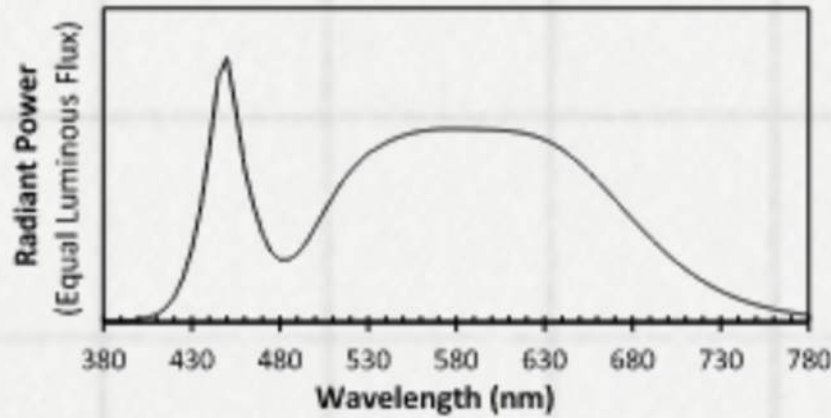


Artificial light



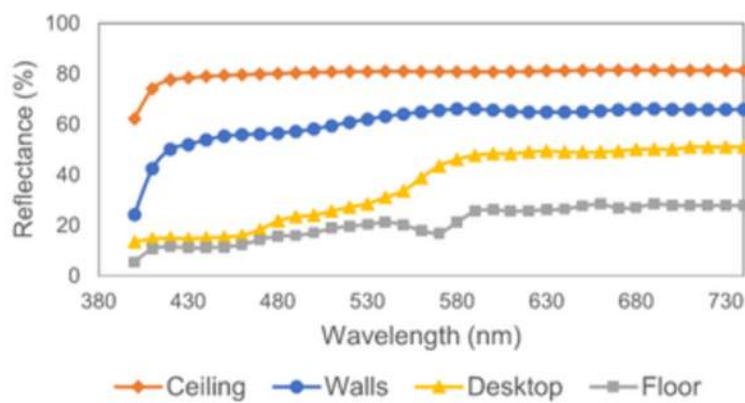
SPD change

SPD B



CCT (K)	4268
mDER	0.65
CRI $R_a$	88
$R_f$	85
$R_g$	102
$R_{cs-h1}$	-6%

Surface Reflectance Distribution - Measured SRDs



Surface	Description	Avg. (%)	Image
Ceiling	White ceiling	80	
Walls	White paint	60	
Desktop	Blonde wood	36	
Floor	Grey carpet	20	

Figure A-2. Reflectance values of the major surfaces in the model space. (SRD: spectral reflectance distribution)  
(Courtesy of Jessica Collier, PNNL)

# Why schools?

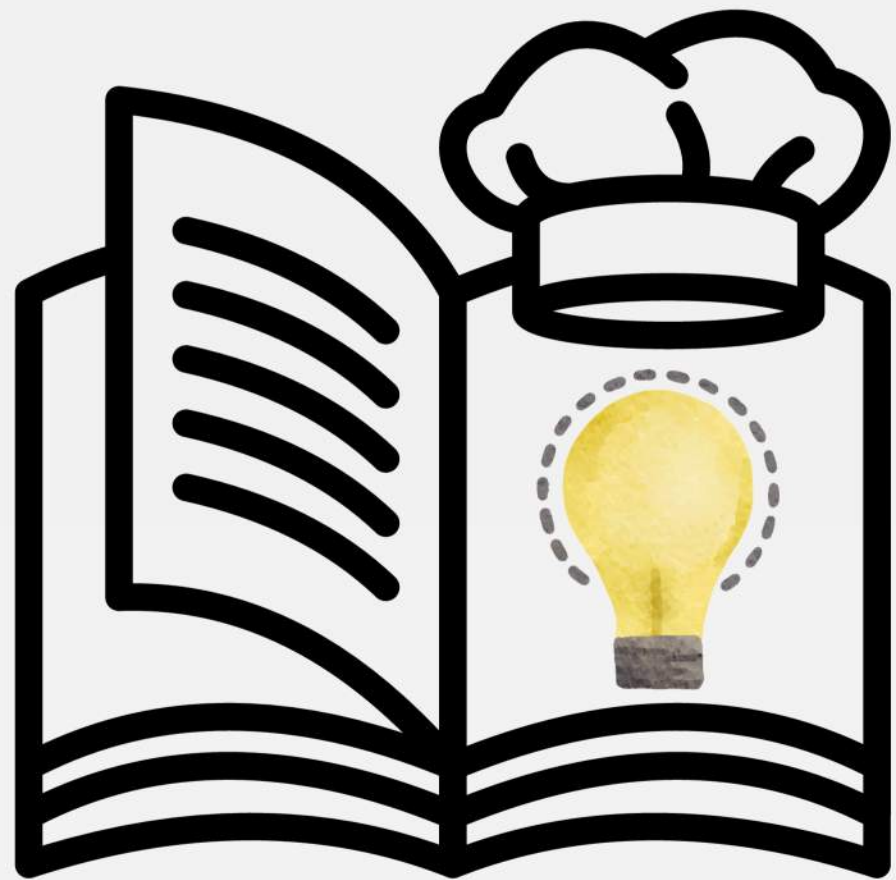


**School hours do not match daylight hours**

**Kids are less alert in winter**

**Kids have less exposure to screens**

# Design Recipe

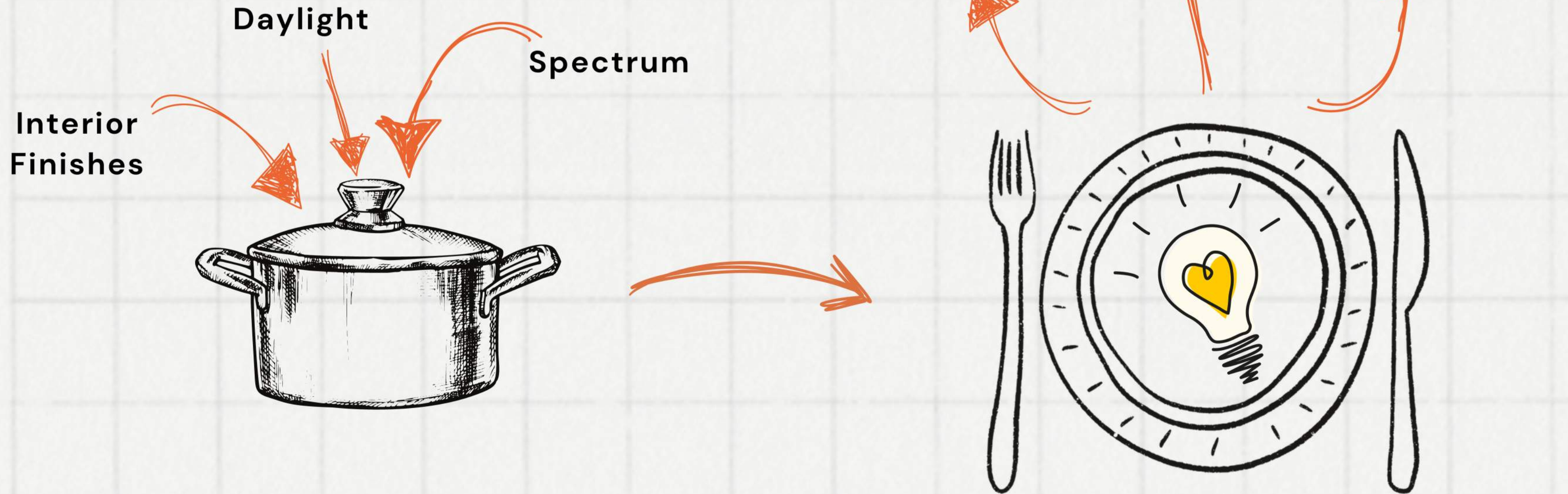


**Daytime mEDI  
250lux minimum**

**Evening mEDI  
10lux maximum  
(3 hours before sleep)**

**Measured at  
1.2m (4') AFF in  
VERTICAL plane (Ev)**

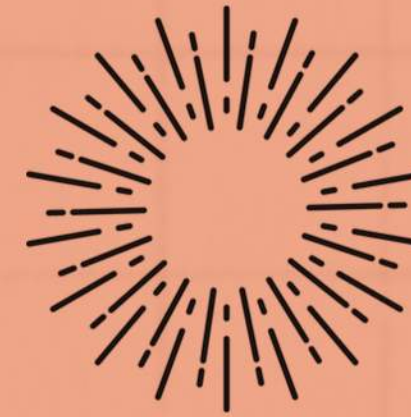
# Design Recipe



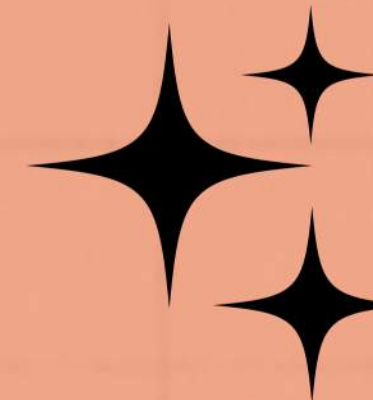
# Visual comfort



**Brightness**



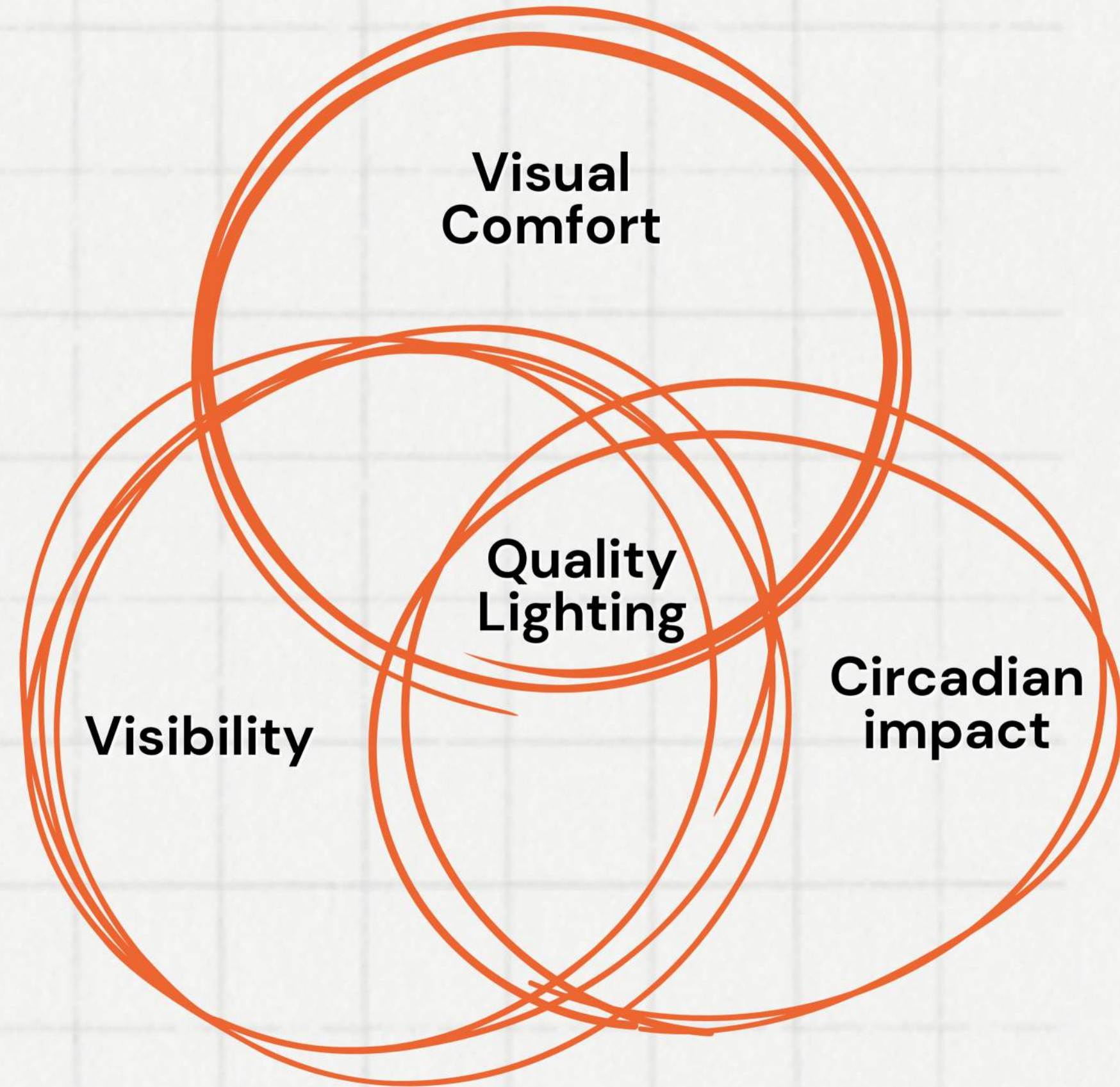
**Glare**



**Flicker**

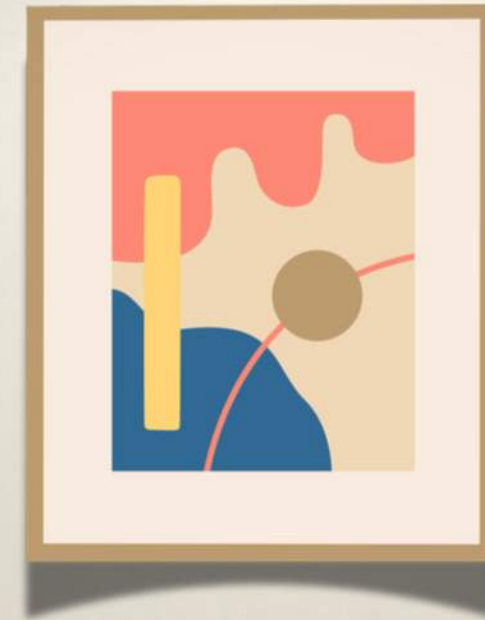
# Quality Lighting

- Visibility
- Visual Comfort
- Circadian Impact



# Creating visual interest

- Guide observers
- Highlights draw attention
- Place objects in the spotlight



# Speaker lighting

- Facial features
- Lip-reading
- Eye-contact



# Controls

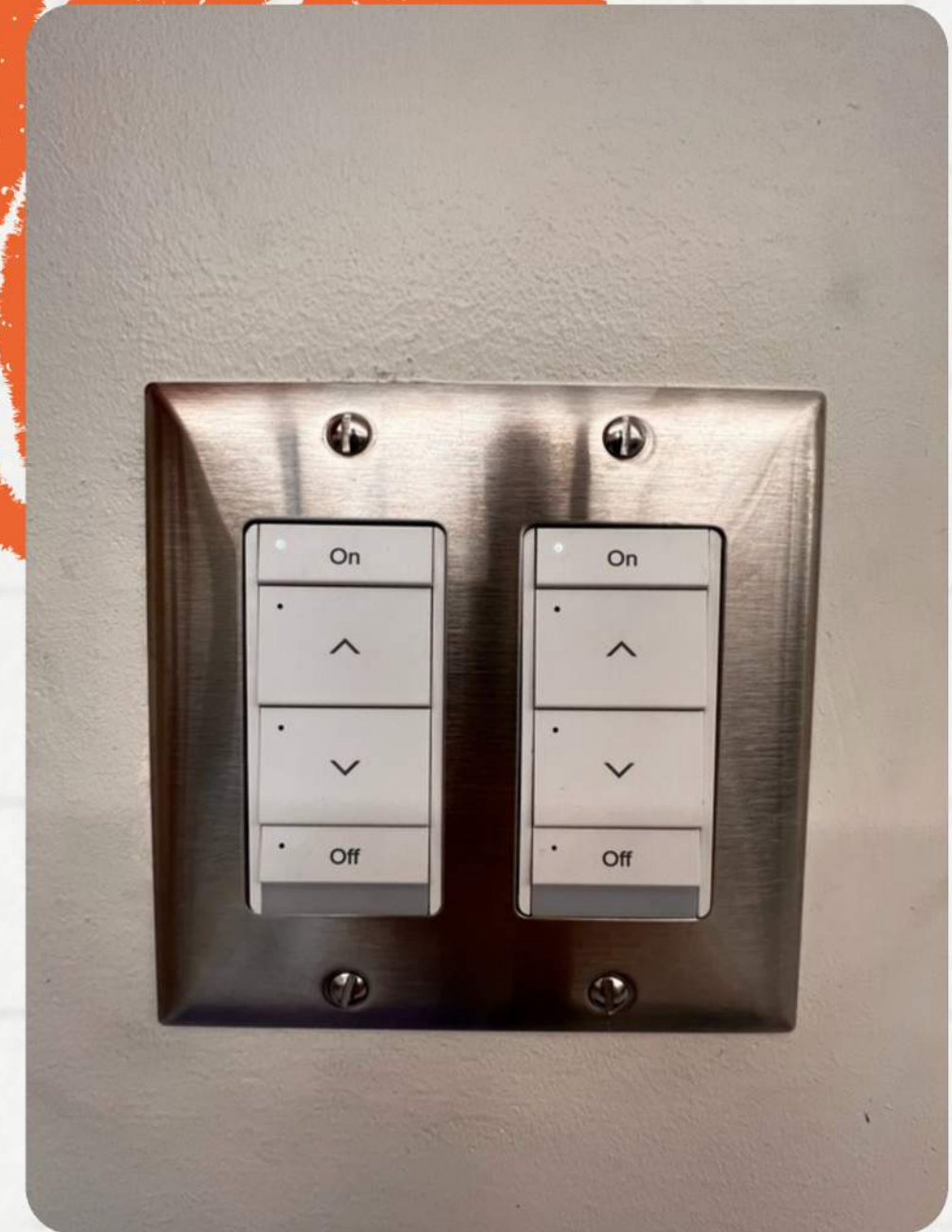
- Building Code
- NECB
- ASHRAE 90.1
- Automated controls
- Daylight harvesting
- Multi-zone



# Controls

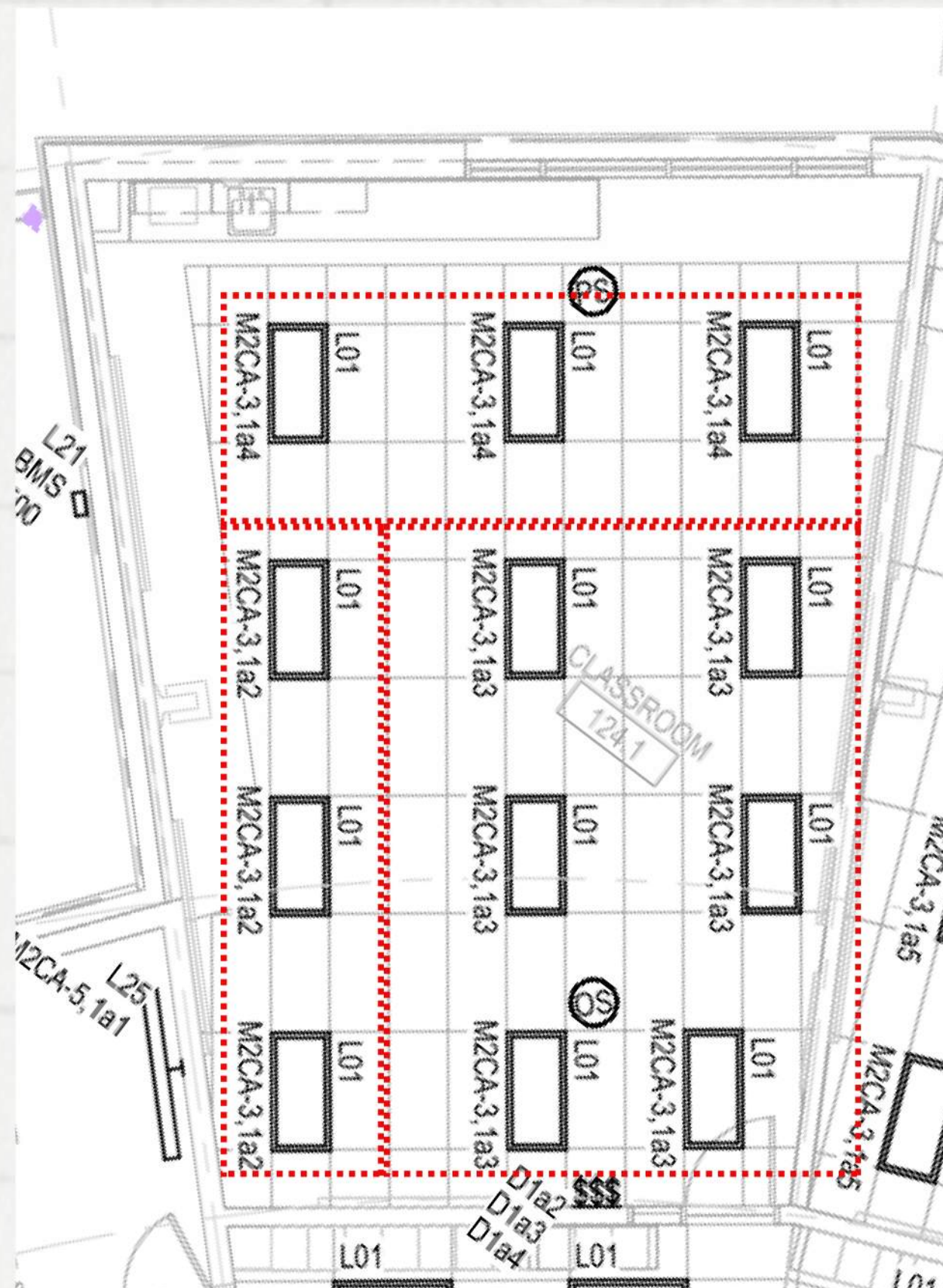
- Building Code
- ASHRAE 90.1
- Automated controls
- Daylight harvesting
- Multi-zone

**0-10V**



# General Purpose Classrooms

- A variety of activities
- Presentation equipment
- Whiteboards



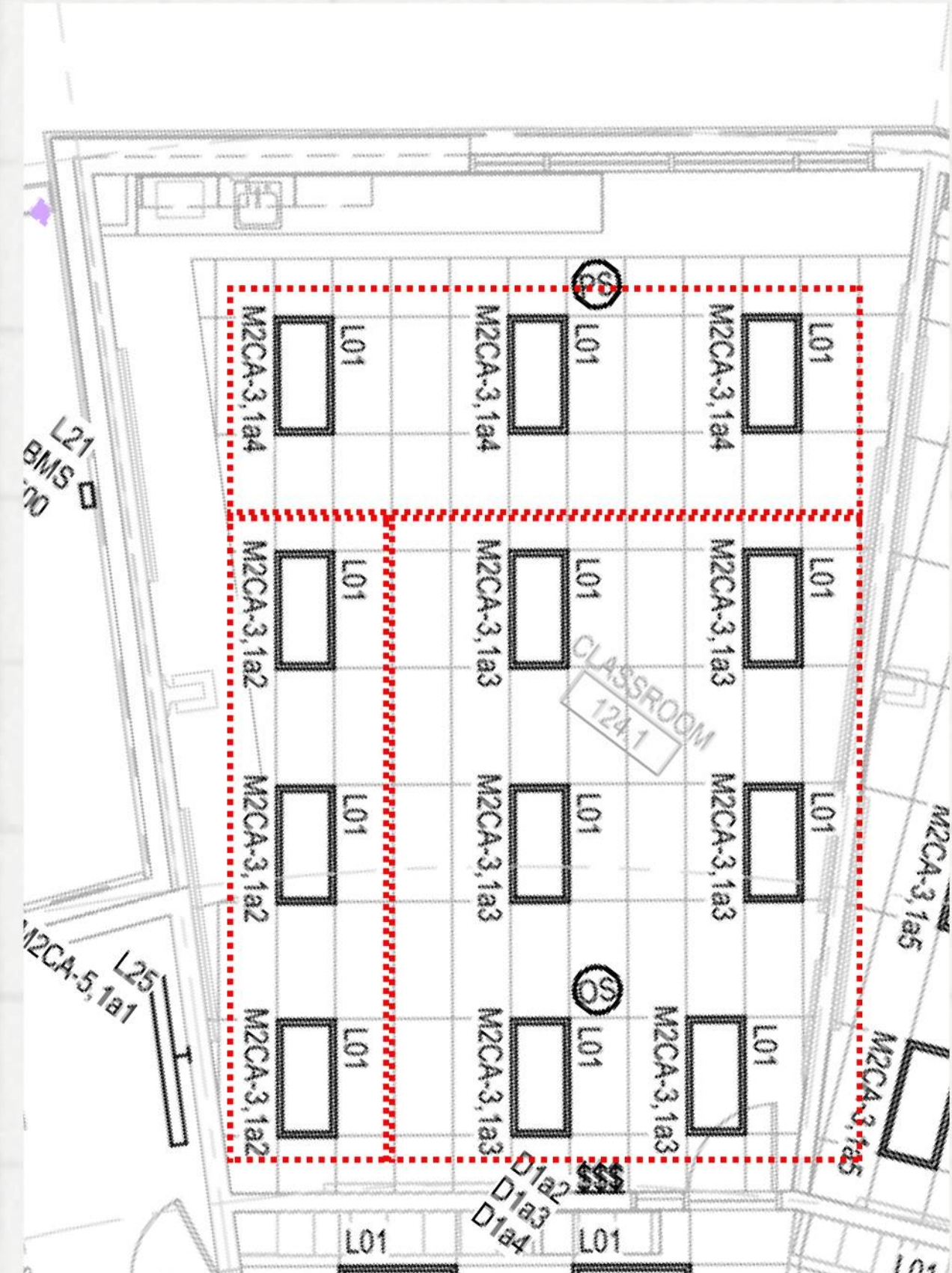
# General Purpose Classrooms

- A variety of activities
- Presentation equipment
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# General Purpose Classrooms

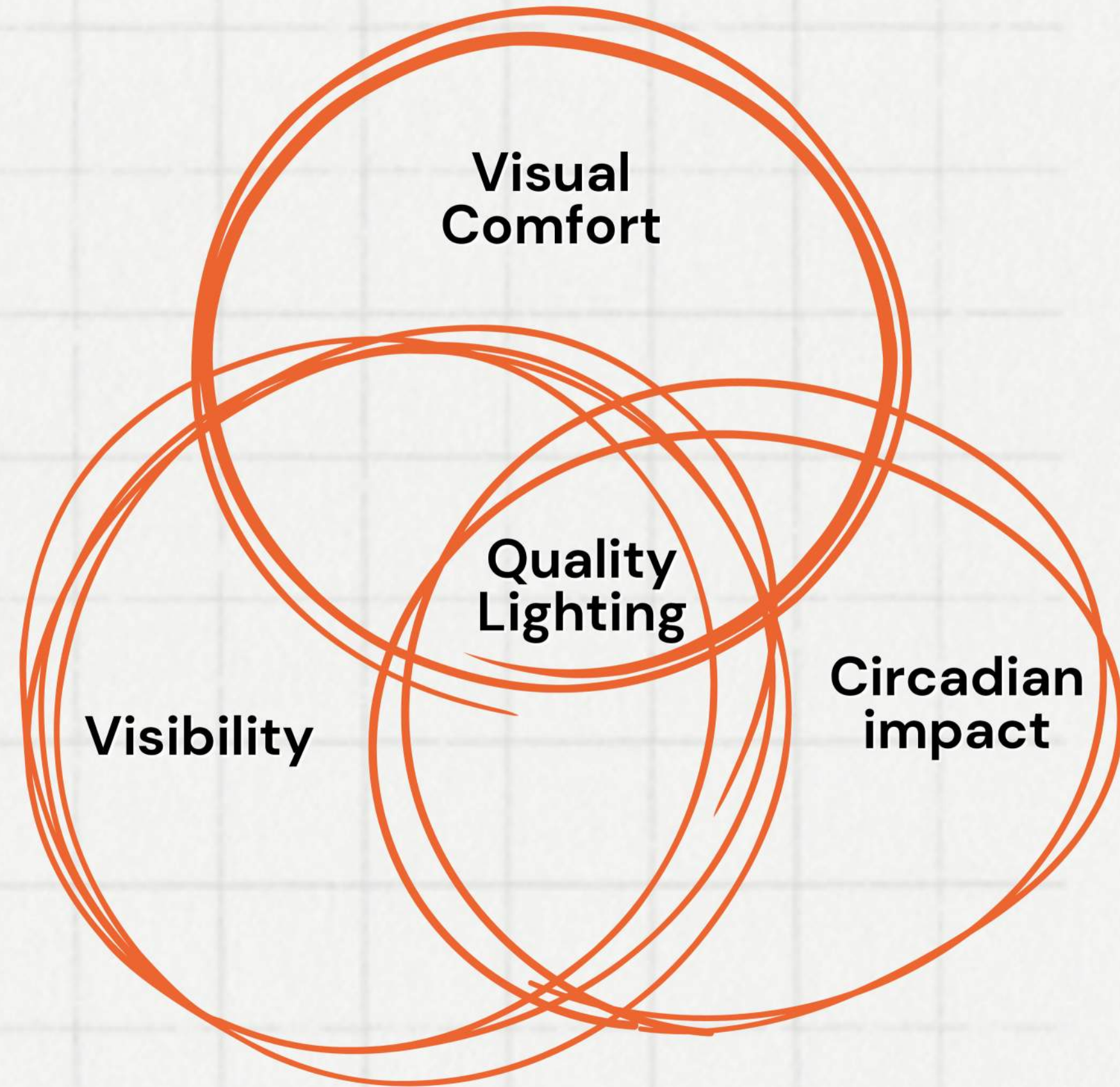
- Maximize daylight exposure
- Horizontal illuminance 300-400lux
- mEDI > 250lux
- Uniformity (2:1)
- Multi-zone controls (3 zones min)






# Quality Lighting

- Visibility
- Visual Comfort
- Circadian Impact



The background is a light gray grid. It is decorated with various hand-drawn orange scribbles and shapes, including loops, swirls, and zig-zags, primarily located along the top and bottom edges.

**Thank you  
very much!**

## References:

1. B. Brettschneider, "Fall Equinox Daylight Maps," *Forbes*, Sep. 22, 2018. Accessed: Jan. 19, 2026. [Online]. Available: <https://www.forbes.com/sites/brianbrettschneider/2018/09/22/fall-equinox-daylight-maps/>
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9. T. M. Brown et al., "Recommendations for daytime, evening, and nighttime indoor light exposure to best support physiology, sleep, and wakefulness in healthy adults," *PLOS Biology*, vol. 20, no. 3, e3001571, Mar. 2022.
10. "Phase Dimming: A Tutorial," Ozuno, Oct. 22, 2024. [Online]. Available: <https://ozuno.com/blog/phase-dimming-a-tutorial/#:~:text=Phase%20Dimming%20is%20one%20of,Dimming%20is%20still%20commonly%20used.> [Accessed: Oct. 22, 2024]
11. Solemma, "ALFA — Adaptive Lighting for Alertness," Accessed Jan. 16, 2026. [Online]. Available: <https://www.solemma.com/alfa>
12. Solemma, "ClimateStudio introduces Revit export for daylight analysis," Solemma Blog, Apr. 20, 2022. [Online]. Available: <https://www.solemma.com/blog/climatestudio-introduces-revit-to-rhino-exporter-for-daylight-simulations>

**Q&A?**