LEDucation
Trade Show and Conference

A five-step human-centric lighting design process for your next project

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Learning Objectives

At the end of this course, participants will:

1. Appreciate ways in which thoughtful lighting design balances requirements for vision and health.
2. Appreciate that Human-Centric Lighting is not a single idea with a well-defined meaning, but a spectrum of concepts that vary with user and intent.
3. Be aware of lighting recommendations that are intended to support photobiological health for day-active people.
4. Be empowered to immediately apply the core concepts to support your own photobiological and circadian health.

Outline

- Context
- Defining Human-Centric Lighting
- Principles of Human-Centric Lighting
  - Lighting Variables
  - Prioritizing Lighting Variables
  - First-Order Design Guidance
  - Quantifying Light’s Biological Potential
- Application of Human-Centric Lighting
  - Five Step Design Process

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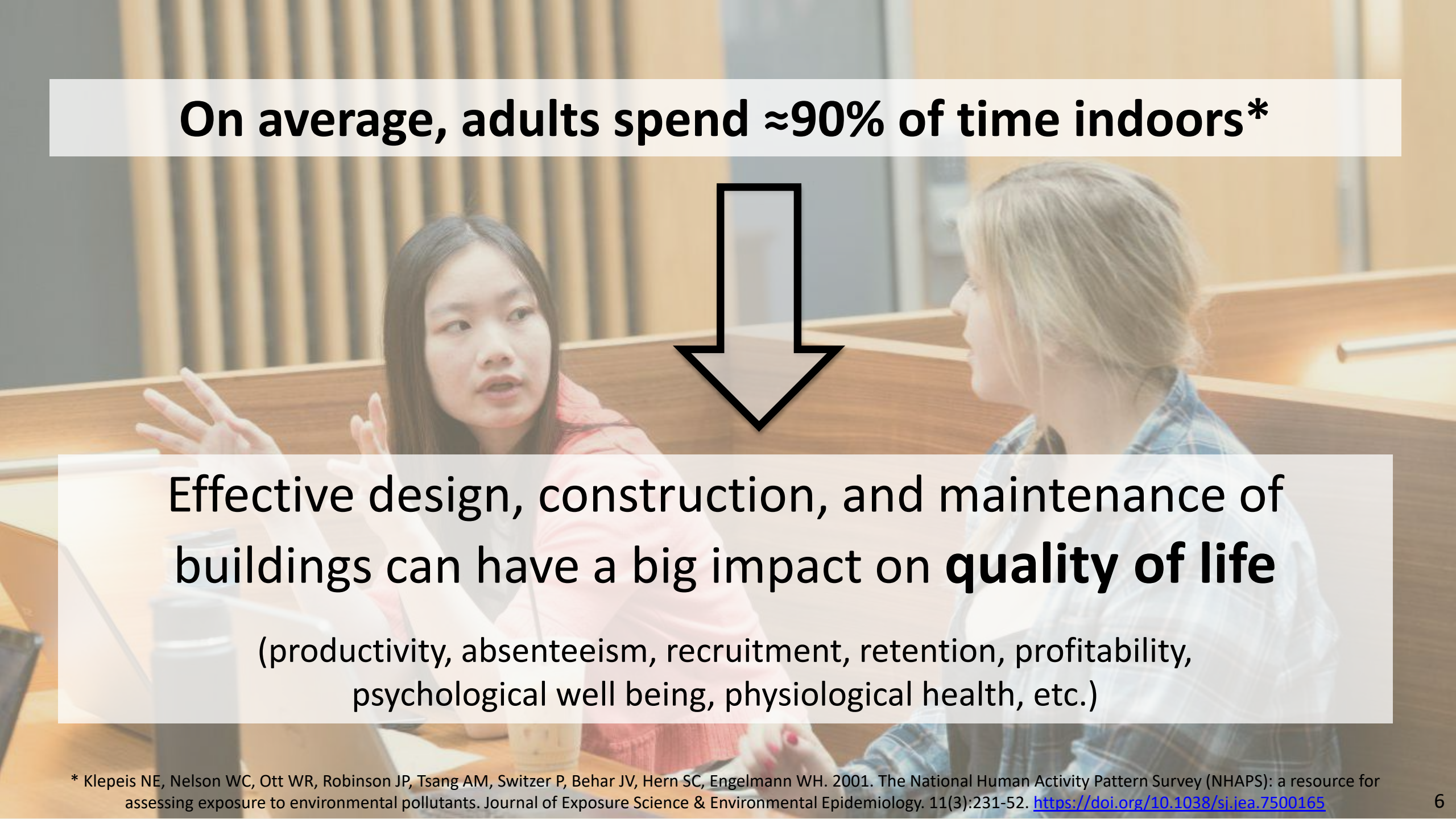

On average, adults spend ≈90% of time indoors*

Effective design, construction, and maintenance of buildings can have a big impact on **quality of life**

(productivity, absenteeism, recruitment, retention, profitability, psychological well being, physiological health, etc.)

* Klepeis NE, Nelson WC, Ott WR, Robinson JP, Tsang AM, Switzer P, Behar JV, Hern SC, Engelmann WH. 2001. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. Journal of Exposure Science & Environmental Epidemiology. 11(3):231-52. https://doi.org/10.1038/sj.jea.7500165


PLACE BAGEL
ORDER HERE
coffee

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Human-Centric Lighting is a **pseudo-scientific phrase**.

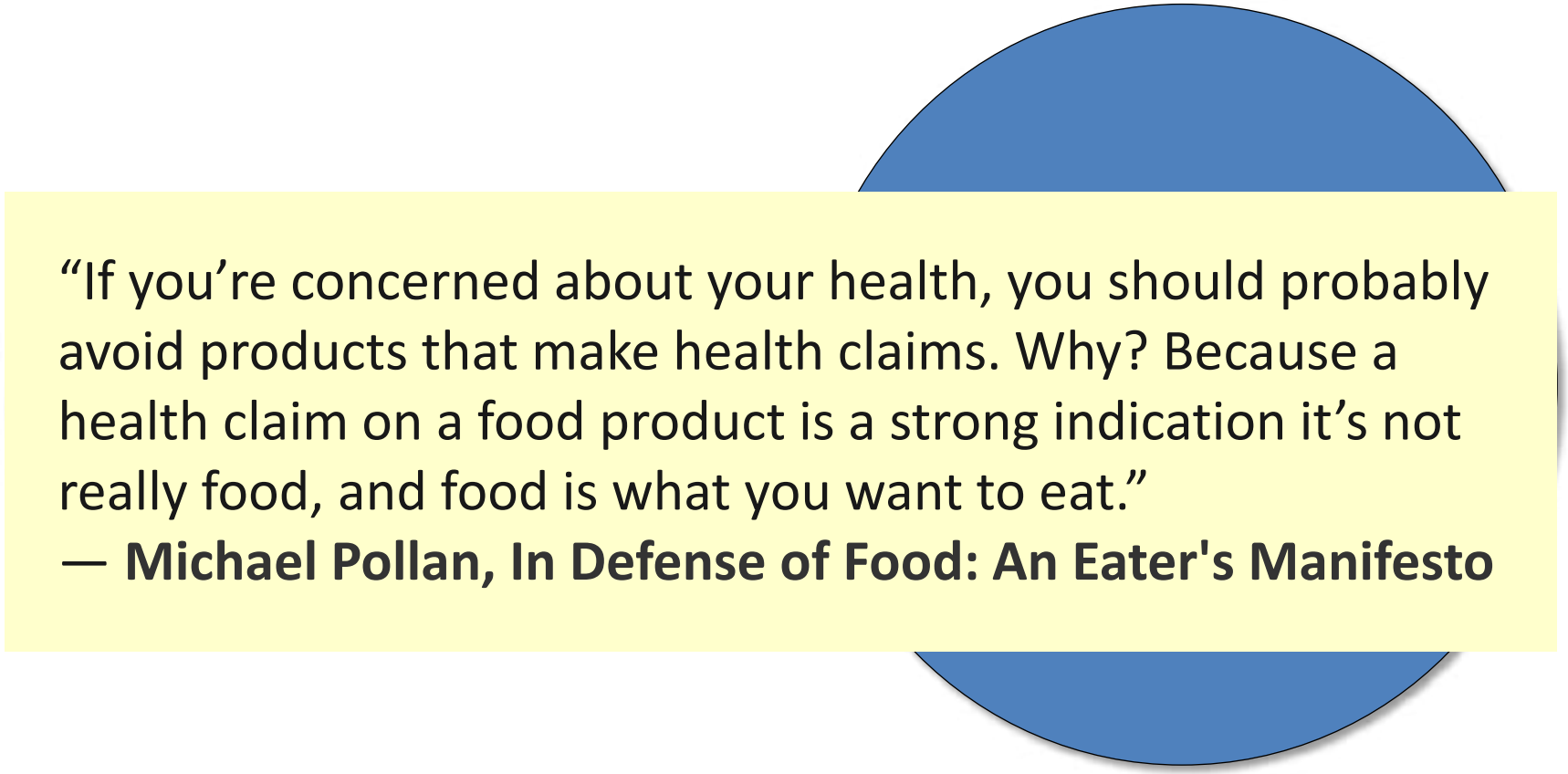
Integrative Lighting [CIE E-ILV Definition 17-29-028]*

Lighting specifically integrating both visual and non-visual effects, and producing physiological and/or psychological benefits upon humans.

Note 1: The term “integrative lighting” applies only to humans.
Note 2: Lighting primarily for therapeutic purposes (light therapy) is not included.
Note 3: The term “human centric lighting” is used with a similar meaning.

* See also: [CIE] 2019. CIE Position Statement on Non-Visual Effects of Light: Recommending Proper Light and the Proper Time. 2nd Edition. Vienna (Austria): CIE. 4 pgs. http://www.cie.co.at/publications/position-statement-non-visual-effects-light-recommending-proper-light-proper-time-2nd

Human-Centric Lighting is a **marketing phrase**.



"If you're concerned about your health, you should probably avoid products that make health claims. Why? Because a health claim on a food product is a strong indication it's not really food, and food is what you want to eat."
— **Michael Pollan, In Defense of Food: An Eater's Manifesto**

Pollan M. 2008. In Defense of Food: An Eater's Manifesto. New York (NY): Penguin Press. 256 p.

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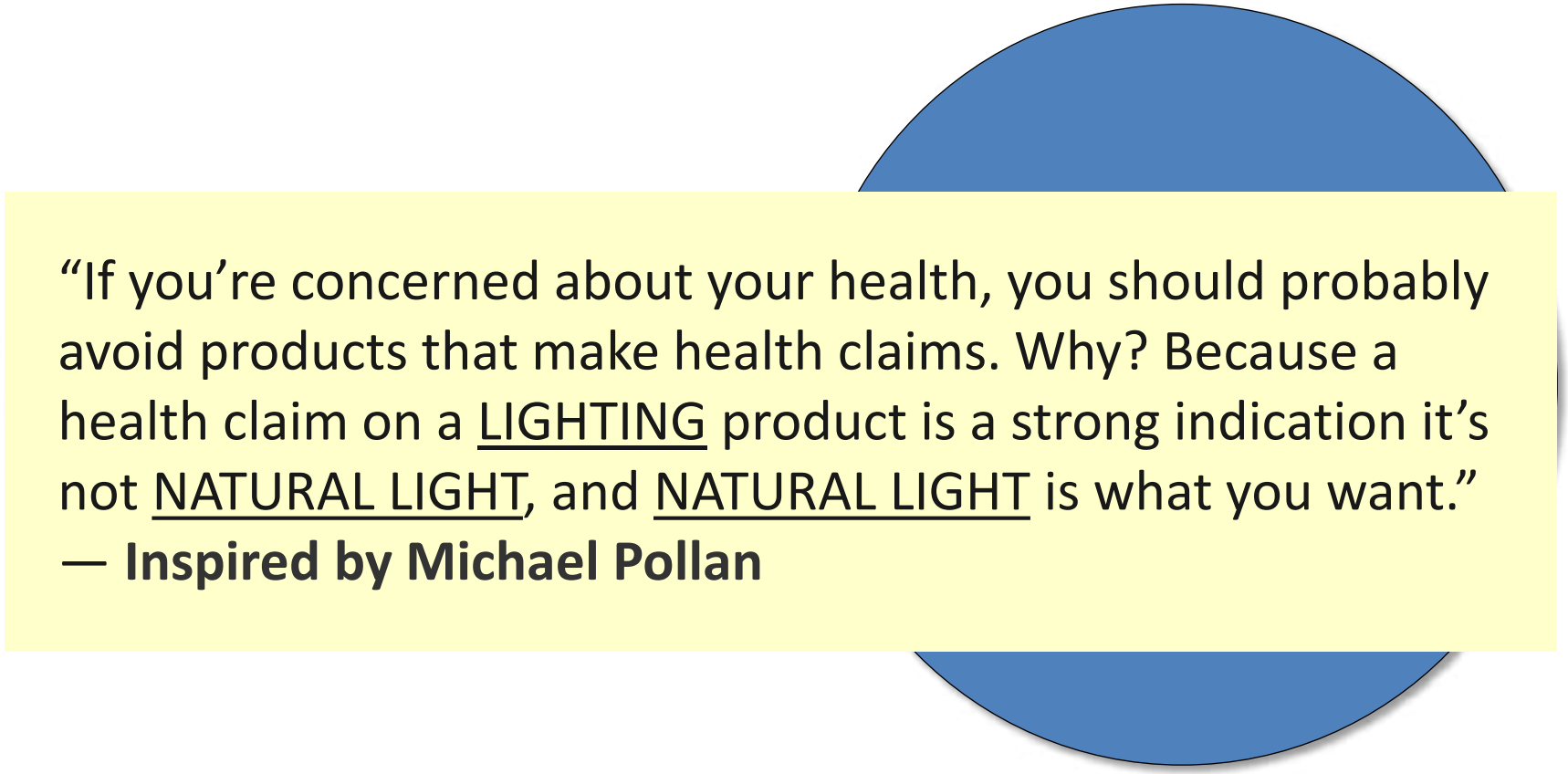

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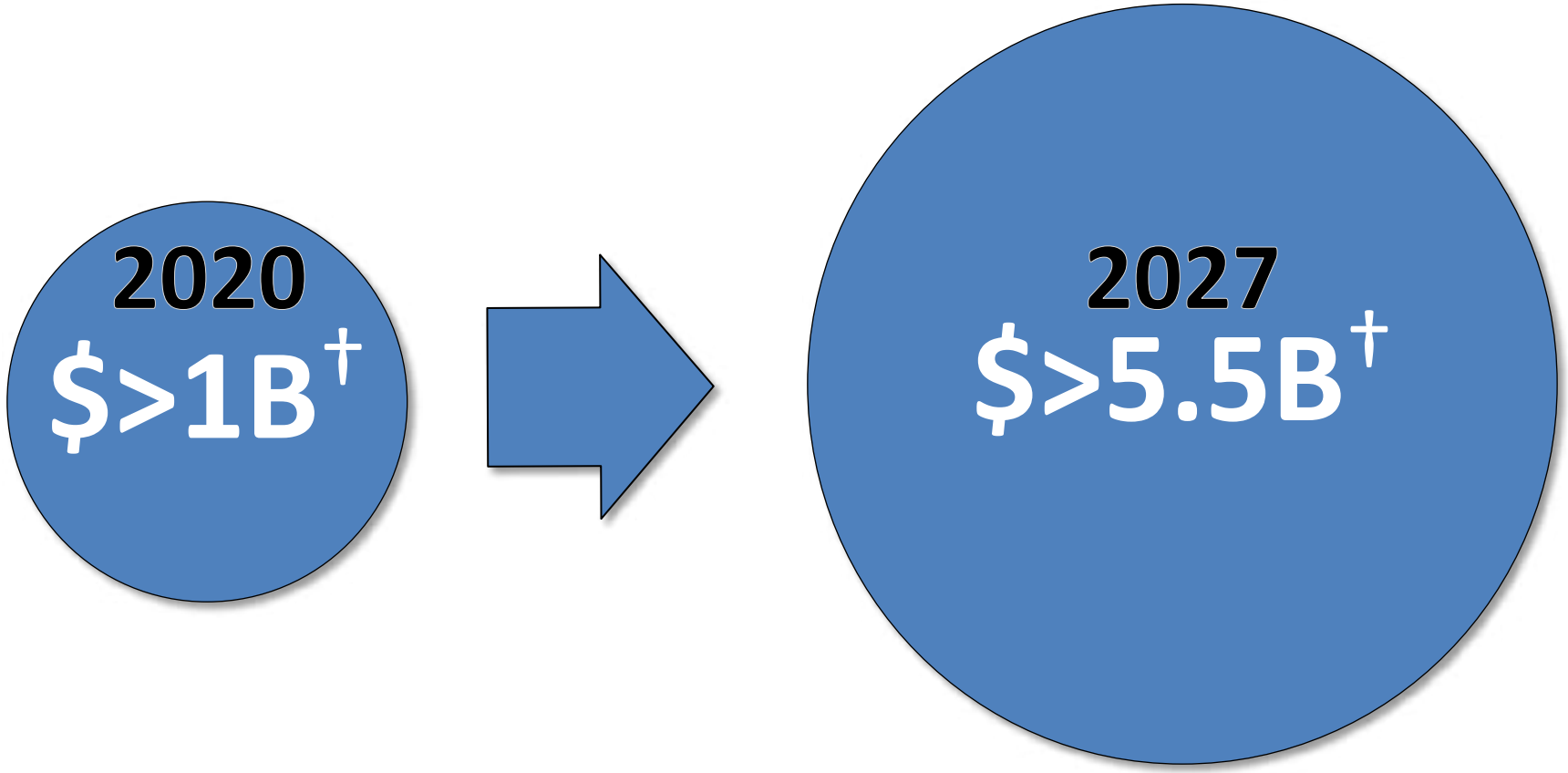

†Global Market Insights. 2021. Human Centric Lighting. https://www.gminsights.com/industry-analysis/human-centric-lighting-market

See also: AT Kearney. 2013. Market Study. Human Centric Lighting Going Beyond Energy Efficiency. Lighting Europe / ZVEI. 19 pgs. https://www.lightingeurope.org/images/publications/general/Market_Study-Human_Centric_Lighting._Final_July_2013.pdf

Human-Centric Lighting may be **misguided**.

- With lighting, especially anthropogenic light at night (ALAN), human-centricity may come with ***collateral damage***.
- ALAN exerts
  - ***Direct negative effects*** on people through circadian disruption.
  - ***Indirect negative effects*** on people by damaging earth's ecosystems.
- Holistic considerations of HCL should look ***beyond the short-term***. It is in our self-interest to persevere the ecosystems and biodiversity that support human life.

Houser KW. 2021. Ethics and Fallacies of Human-Centric Lighting and Artificial Light at Night. LEUKOS. 17(4):319-320.
https://doi.org/10.1080/15502724.2021.1951021

Human-Centric Lighting is **different things to different people**.

Circadian Lighting

Visual (dis)comfort

Planetary Health

Alertness

Sleep Quality

Task Visibility

Color Rendering

Cancer Risk

Psychology

Health

Photobiomodulation

Controls Tangibility

CCT

Light Justice

Daylight

Flicker

WELL

Physiology

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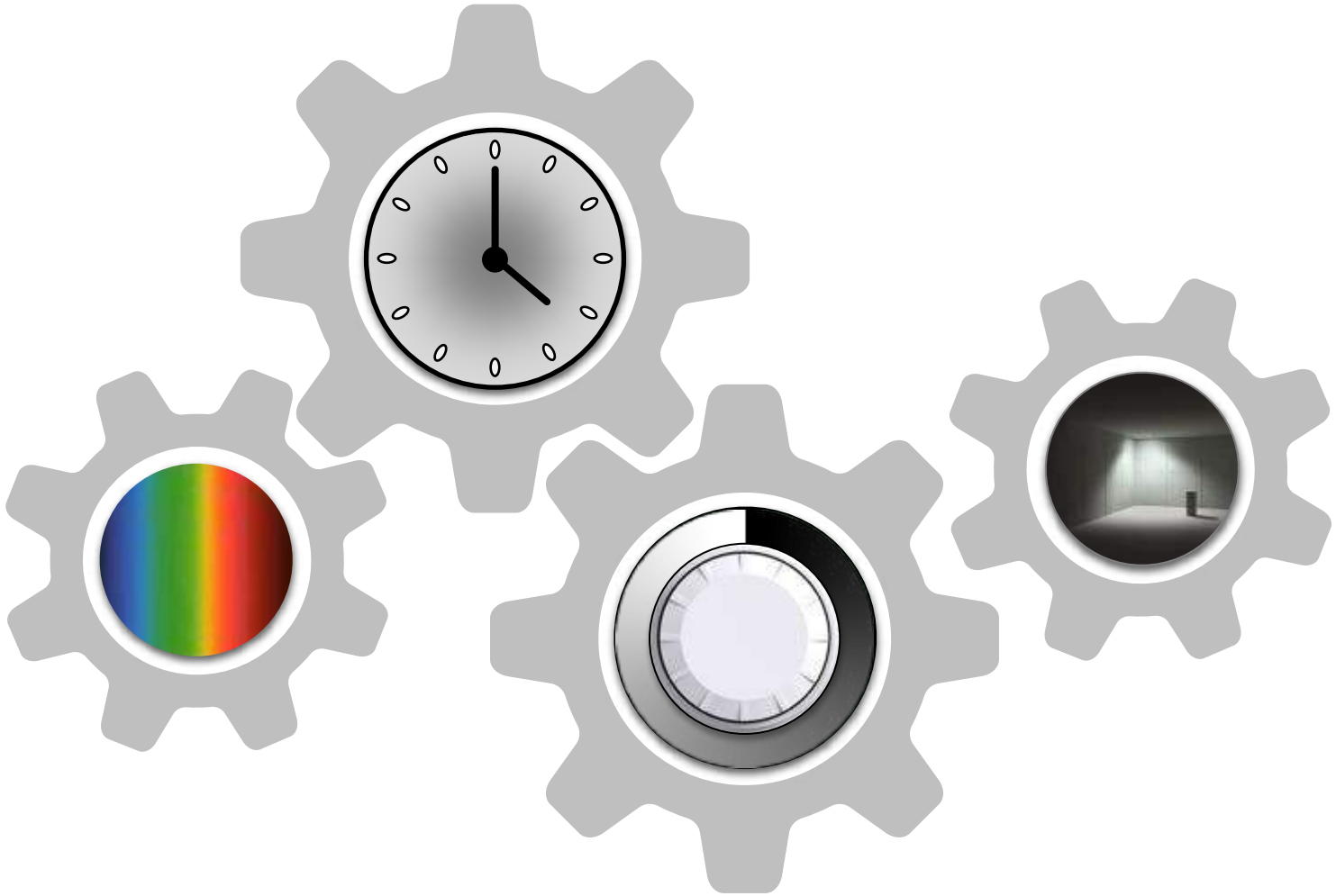
Light is a complex stimulus **that can be manipulated to affect people.**

Time
The temporal pattern (timing and duration) of exposure to light, including photic history.

Pattern
Spatial distribution of the three-dimensional light field.

Spectrum
Power as a function of wavelength—the SPD of the light stimulus.

Intensity
Quantity of light in radiometric or photometric units.



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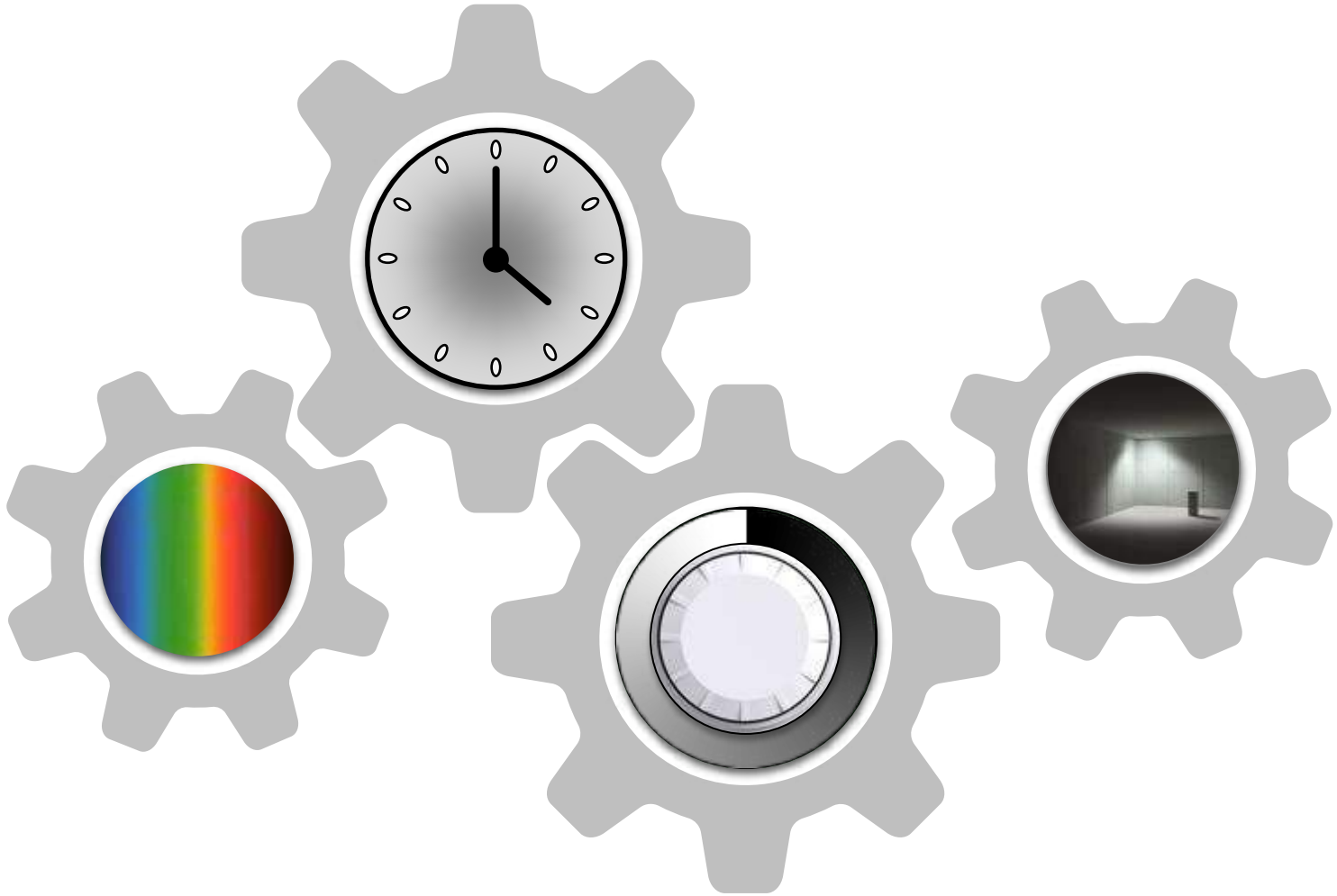
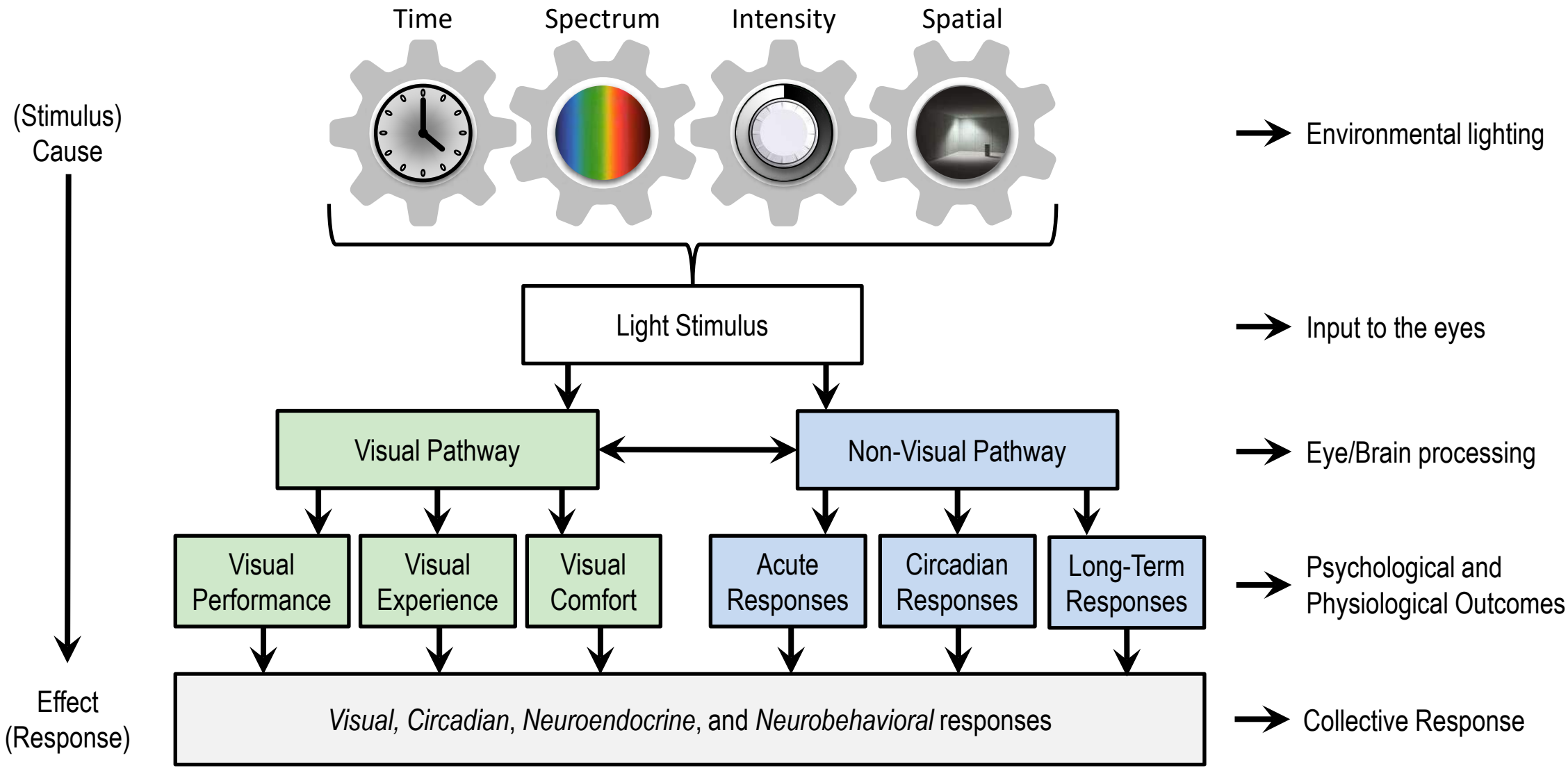


Light as a stimulus exerts responses in humans.



Houser KW, Esposito T. 2021. Human-Centric Lighting: Foundational Considerations and Five-Step Design Process. Front. Neruol. 12:630553. https://doi.org/10.3389/fneur.2021.630553

Examples of light's influence on human physiological functioning.

- Changes pupil size [1 – 3]
- Acutely suppresses melatonin [4 – 9]
- Shifts the timing of circadian rhythms [12]
- Modulates alertness, body temp, and heart rate [6, 10, 11]
- Extended periods in windowless spaces have detrimental effects on vitality, activity levels, and sleep quality [13]

Vetter C, Pattison PM, Houser K, Herf M, Phillips AJK, Wright KP, Skene DJ, Brainard GC, Boivin DB, Glickman G. 2021. **A Review of Human Physiological Responses to Light: Implications for the Development of Integrative Lighting Solutions**. LEUKOS. https://doi.org/10.1080/15502724.2021.1872383

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3. Spitschan M. 2019. Photoreceptor inputs to pupil control. Journal of Vision. 19(9):1-5. https://doi.org/10.1167/19.9.5
4. Brainard GC, Hanifin JP, Greeson JM, Byrne B, Glickman G, Gerner E, Rollag MD. 2001. Action spectrum for melatonin regulation in humans: Evidence for a novel circadian photoreceptor. J. Neurosci. 21: 6405–6412. https://doi.org/10.1523/JNEUROSCI.21-16-06405.2001
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7. Nowozin C, Wahnschaffe A, Rodenbeck A, de Zeeuw J, Hadel S, Kozakov R, Schopp H, Munch M, Kunz D. 2017. Applying Melanopic Lux to Measure Biological Light Effects on Melatonin Suppression and Subjective Sleepiness. Curr Alzheimer Res 14(10):1042-1052. https://doi.org/10.2174/1567205014666170523094526
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12. Gooley JJ, Rajaratnam SM, Brainard GC, Kronauer RE, Czeisler CA, Lockley SW. 2010. Spectral responses of the human circadian system depend on the irradiance and duration of exposure to light. Sci. Transl. Med. 2:31ra33. https://doi.org/10.1126/scitranslmed.3000741
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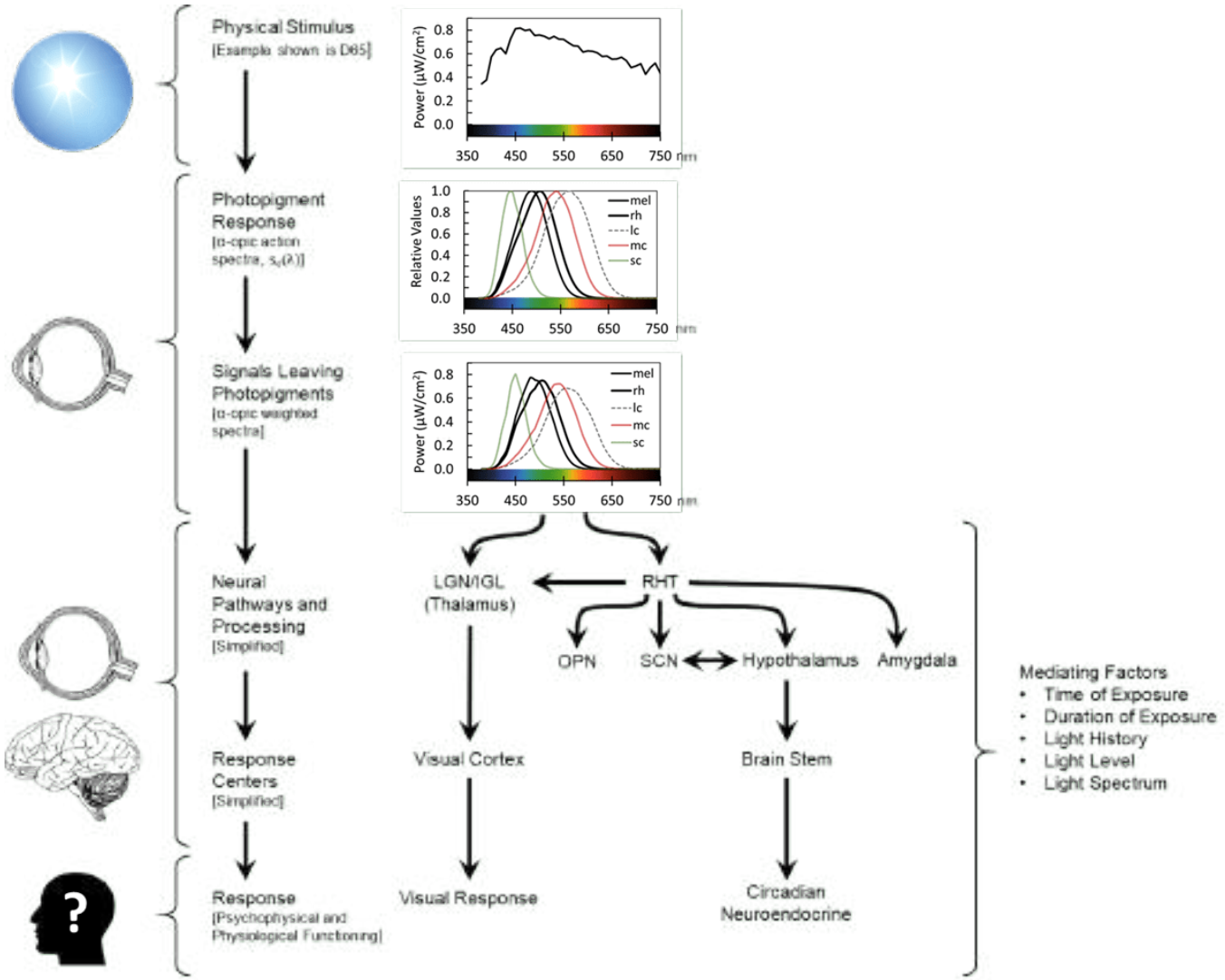
Uncertainty increases between stimulus and response **because of incomplete understandings**.

High Certainty

Low Certainty



Houser KW, Boyce PR, Zeitzer JM, Herf M. 2020. Human Centric Lighting: Myth Magic, or Metaphor? Light. Res. Technol. Online before print. https://doi.org/10.1177/1477153520958448

Uncertainty increases between stimulus and response **because of non-lighting factors**.

- Age
- Climate
- Diet
- Disease
- Exercise
- Genetics
- Medications
- Mental health
- Pregnancy
- Sleep habits
- Stress
- Travel

There are salient open questions about the applicability of lab studies to daily life.

Uncertainty increases between stimulus and response **because of the time delay.**

	Psychophysical	**Physiological**
Immediate (seconds or minutes)	• Brightness perception • Visual amenity • Visual discomfort • Attention response	• Pupil size • Acute melatonin suppression • Luminance adaptation • Short-term chromatic adaptation
Delayed (hours, days, or weeks)	• Mood • Cognition • Motivation	• Circadian phase shift • Sleep quality • Long-term chromatic adaptation
Long-Term (months or years)	• Productivity • Depression	• Stress • Poor health • Seasonal affective disorder • Depression

Every item in this table is subject to influence by non-lighting factors. The longer the delay between the stimulus and the response, the more opportunity there is for other factors to influence the response.

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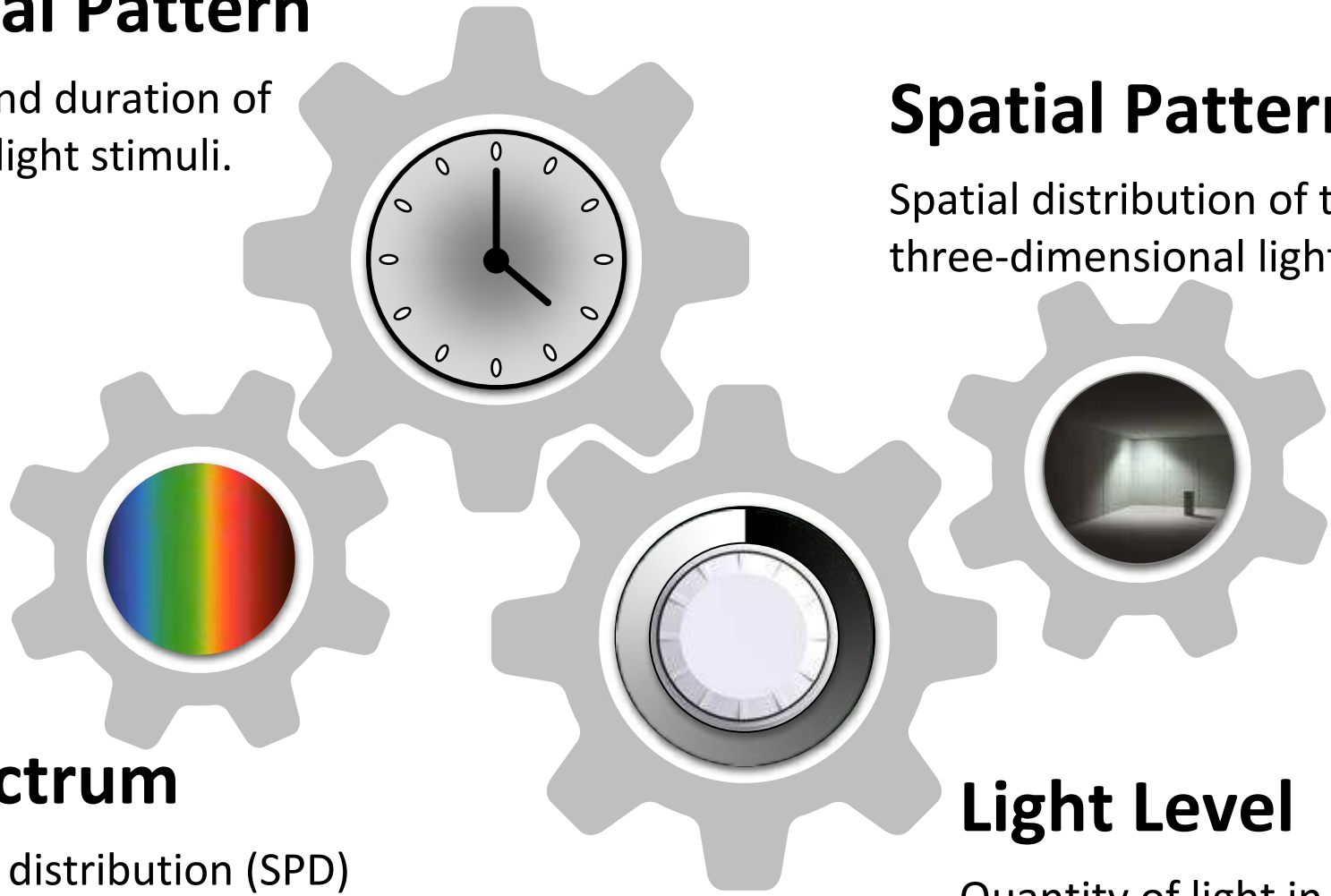
When lighting for non-visual responses, the variables are still **time**, **intensity**, **spectrum**, and **spatial pattern**, but they likely prioritize differently.

Temporal Pattern

The timing and duration of exposure to light stimuli.

Spatial Pattern

Spatial distribution of the three-dimensional light field



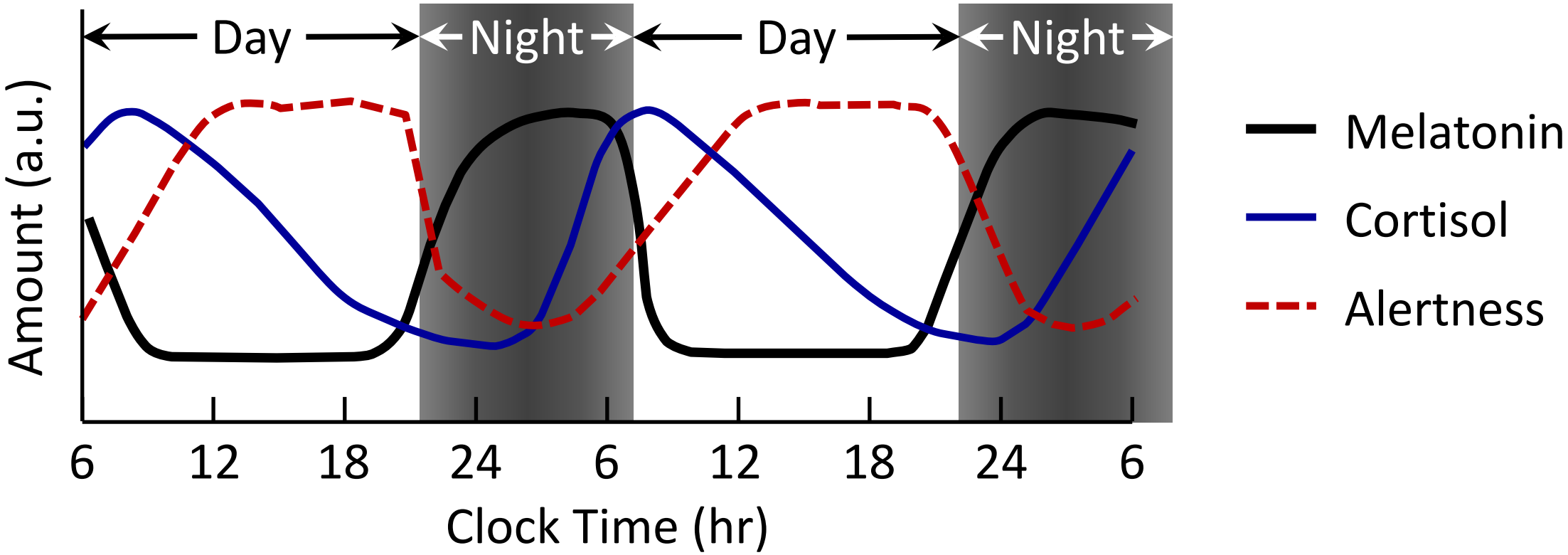
Light Spectrum

Spectral power distribution (SPD) that governs color qualities.

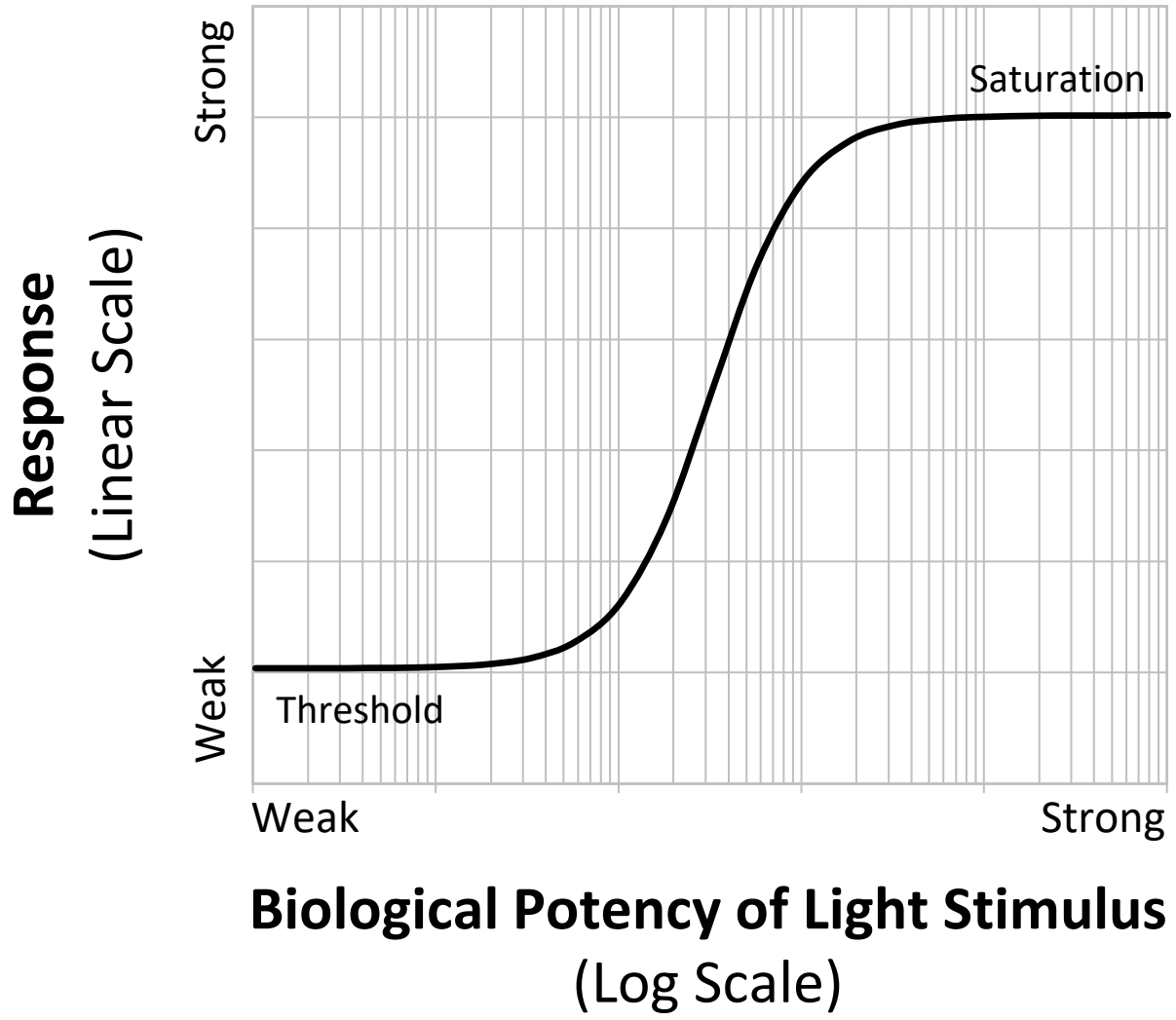
Light Level

Quantity of light in radiometric or photometric units.

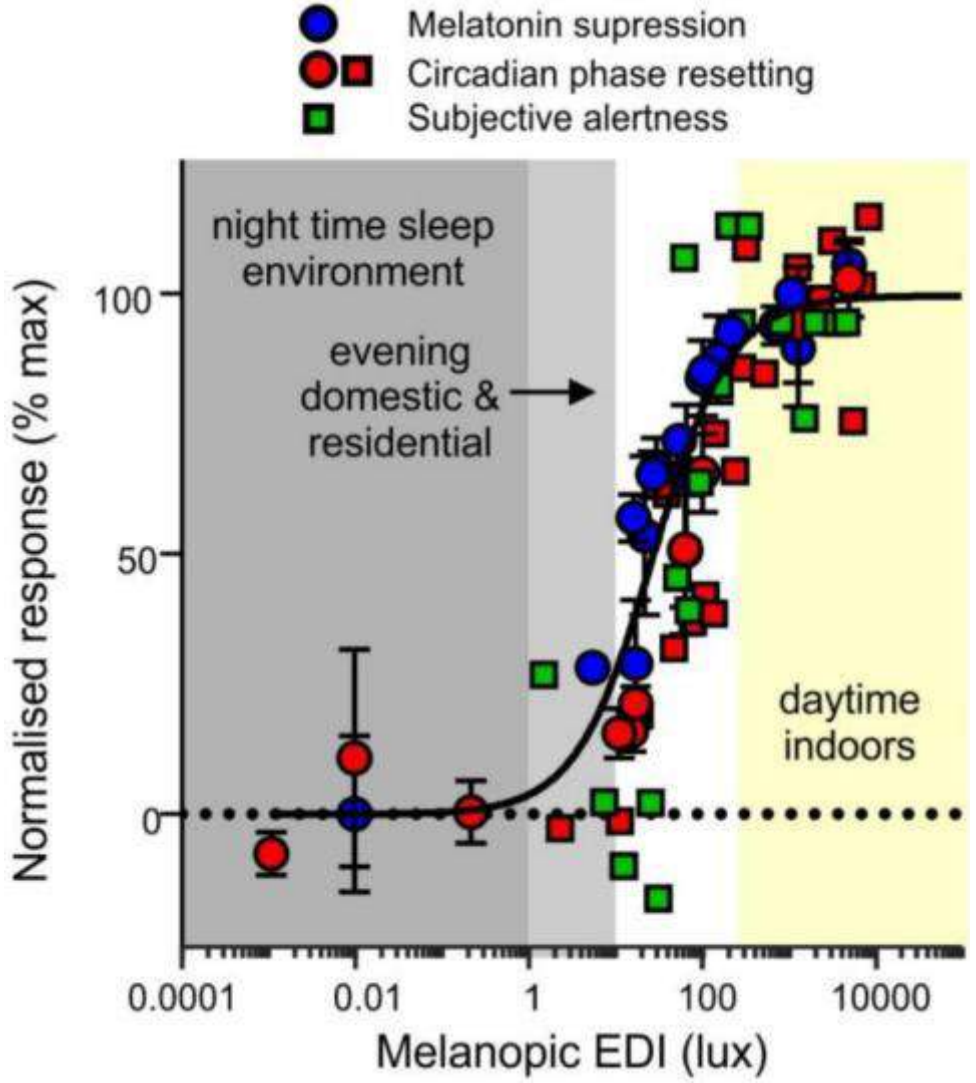
Temporal Pattern is the #1 influence on health related aspects of light.



To understand the role of **Light Level** and **Spectrum,** it is important to understand a generic **logistic sigmoid function**.

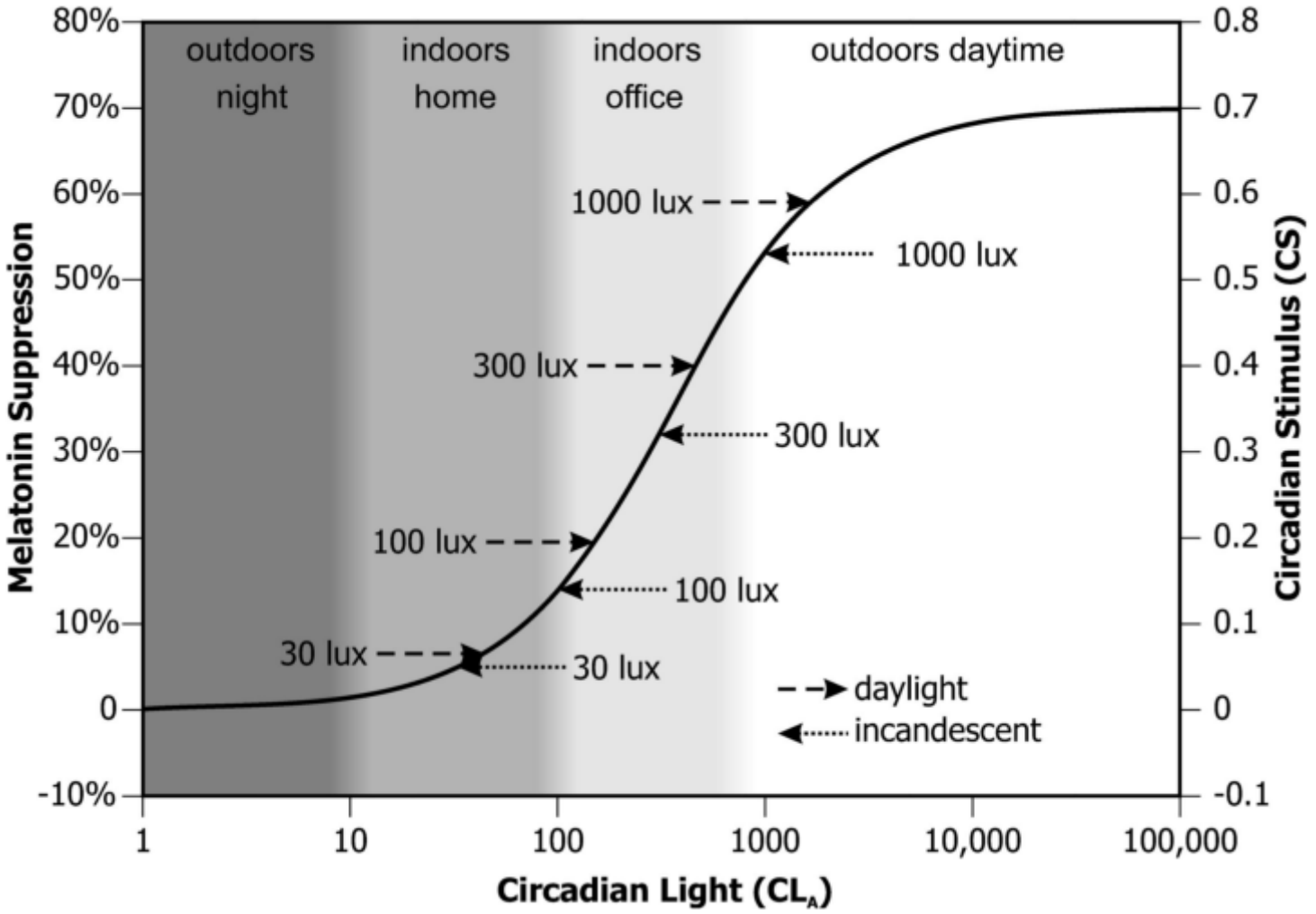


Light Level is the #2 influence.



Brown TM, Brainard GC, Cajochen C, Czeisler CA, Hanifin JP, Lockley SW, Lucas RJ, Munch M, O'Hagan JB, Peirson SN, Price LLA, Roenneberg T, Schlangen LJM, Skene DJ, Spitschan M, Vetter C, Zee PC, Wright KP. 2020. Recommendations for Healthy Daytime, Evening, and Night-Time Indoor Light Exposure. Preprints 2020. https://dx.doi.org/10.20944/preprints202012.0037.v1

Spectrum is the #3 influence.



Figueiro MG. 2017. Disruption of Circadian Rhythms by Light During Day and Night. Current Sleep Medicine Reports. 3(2):76-84. https://doi.org/10.1007/s40675-017-0069-0

Spatial Pattern should be considered with **Quantity** and **Spectrum**.

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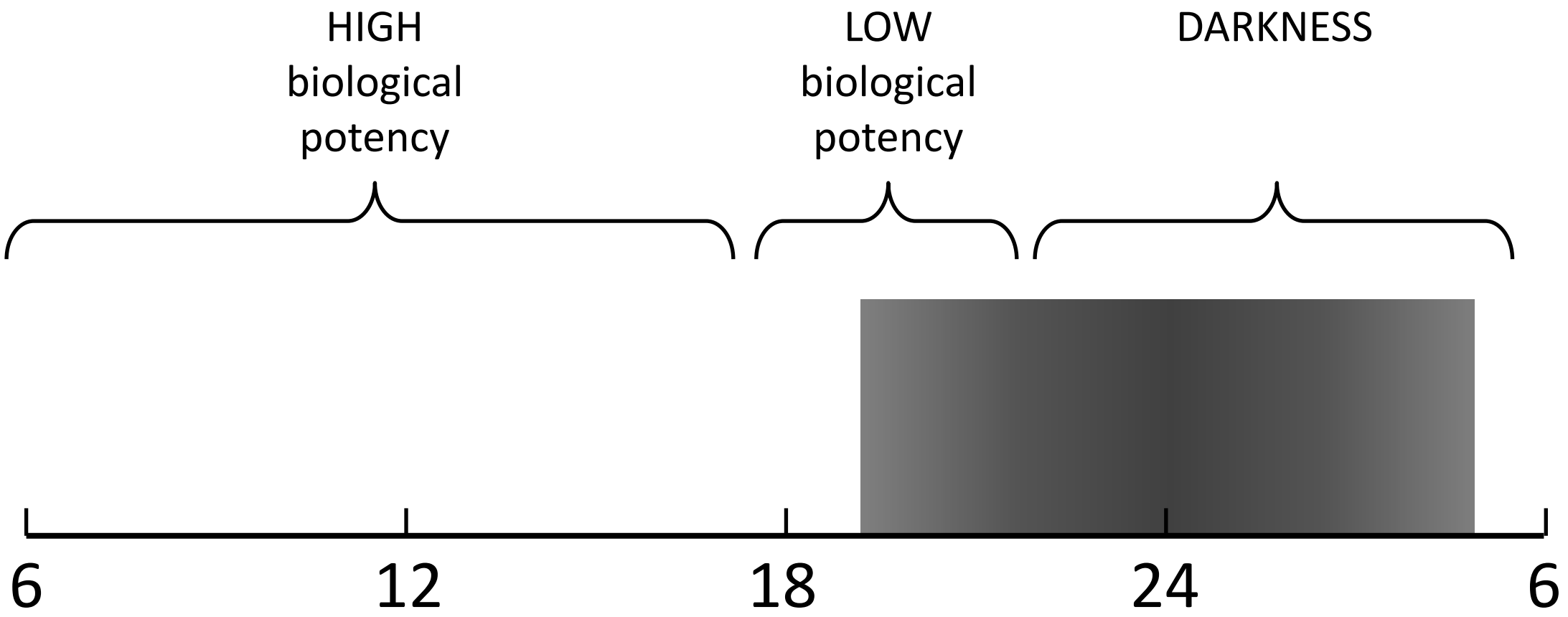
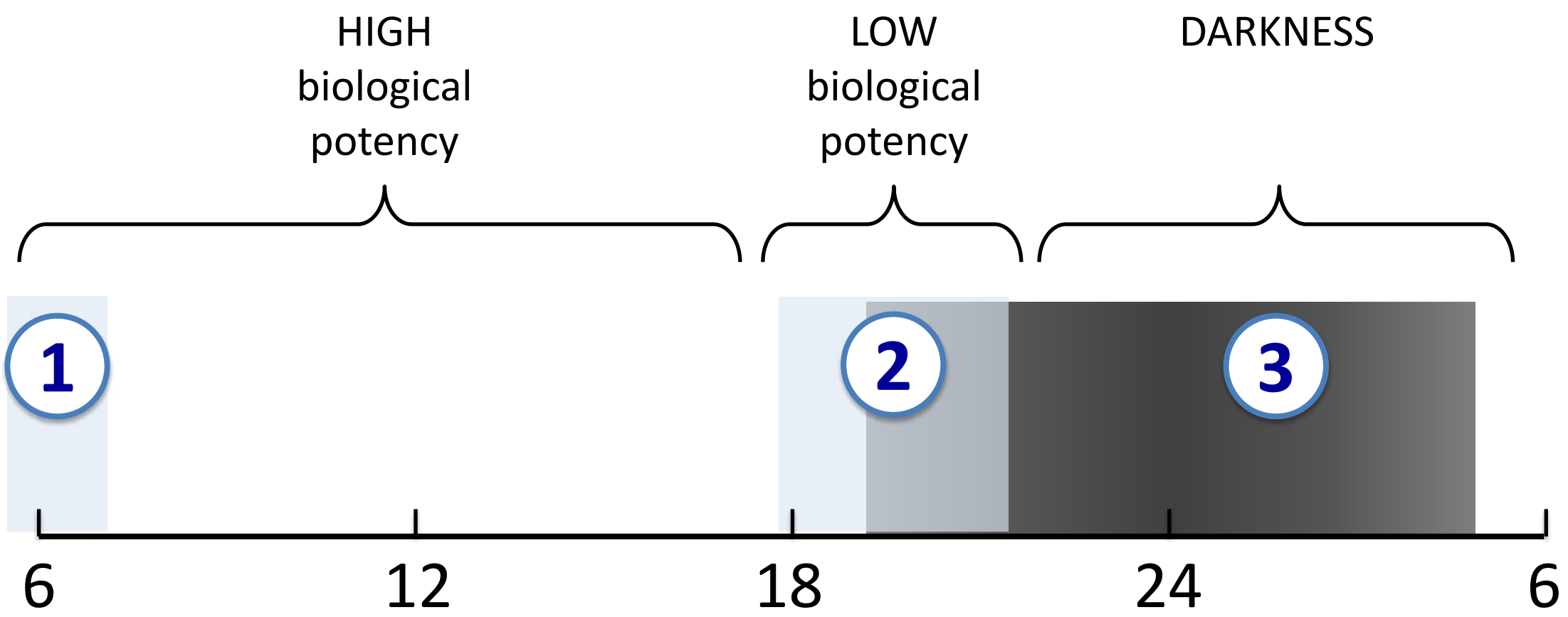
What then, is “human-centric lighting”? *

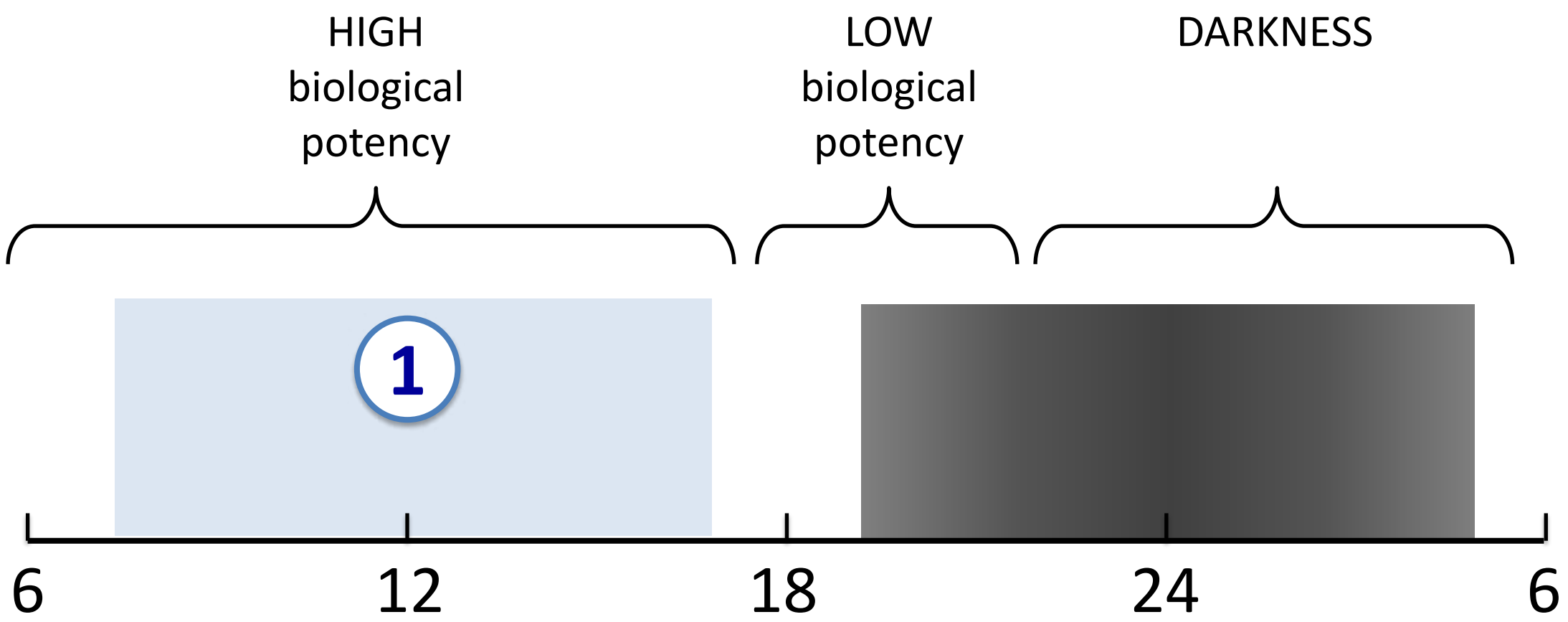
* For day active people!



Buildings where people **sleep** require **three** lighting conditions (for circadian health).



Building where people **work/learn** require **one** static lighting condition (for circadian health).



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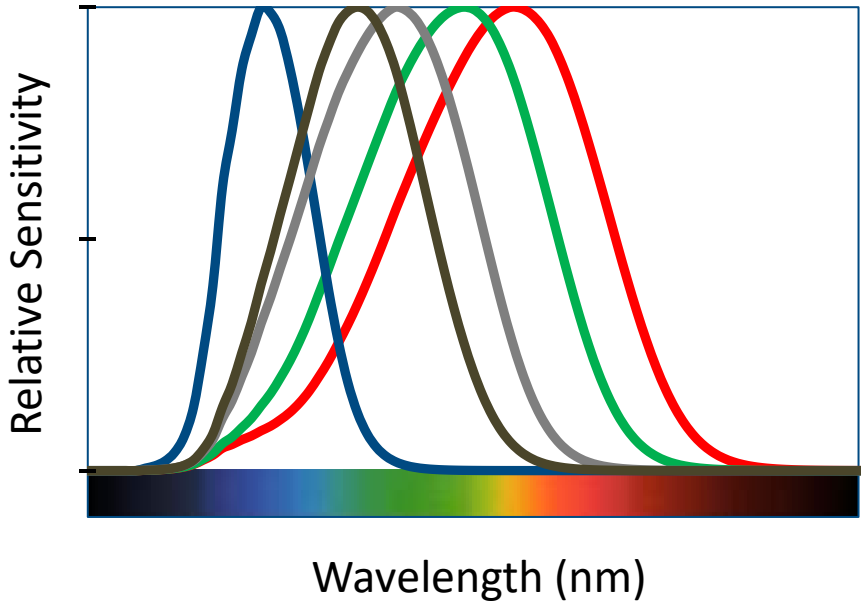
There is not yet agreement for how to quantify the **Biological Potential** of light.

Two Methods

1. Based on the spectral response of the photopigments in the rods, cones, and ipRGCs
2. Based on nocturnal suppression of the hormone melatonin

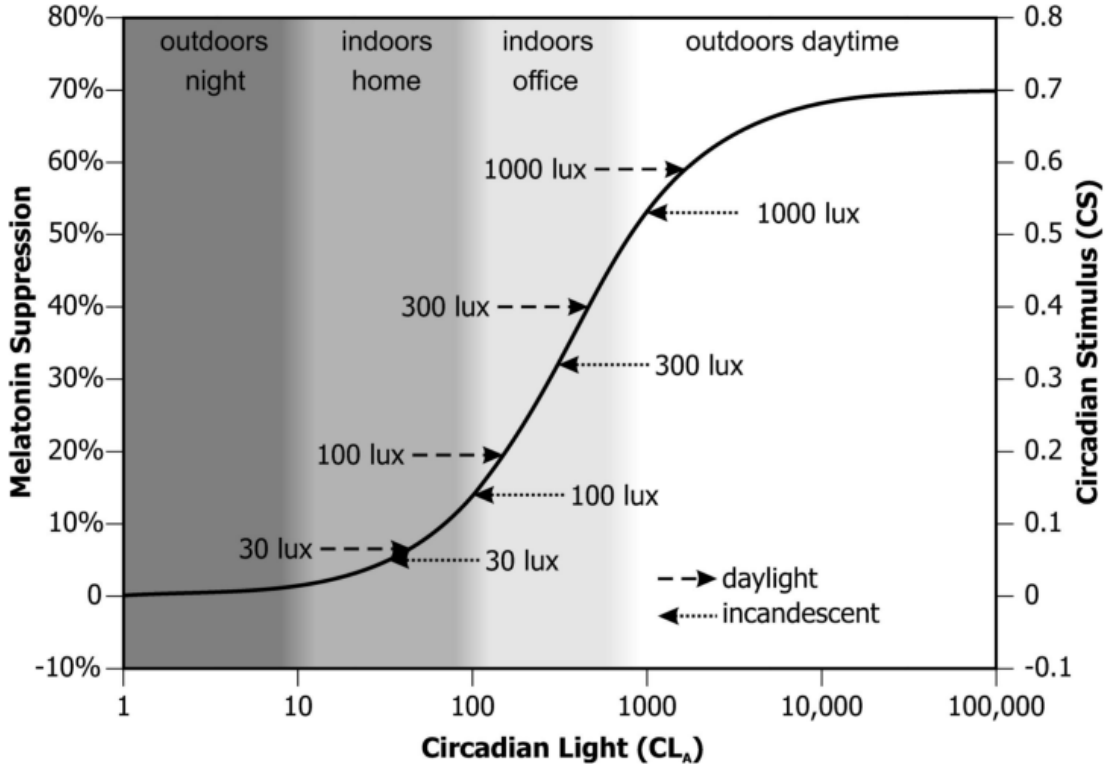
METHOD 1: Based on spectral response of photopigments in the rods, cones and ipRGCs.

- Adopted by CIE and the only method with international consensus
  [CIE S 026:2018]
- One quantity is Melanopic Equivalent Daylight Illuminance (***melanopic EDI***), which can be employed to determine compliance with WELL and UL.
  [Note: Equivalent Melanopic Lux (EML) is similar, and used by WELL, but proscribed by CIE.]



METHOD 2: Based on nocturnal suppression of the hormone melatonin after 1 hr exposure.

- Developed by the Lighting Research Center
- One quantity is Circadian Stimulus (**CS**), which can be employed to determine compliance with UL and some aspects of WELL.



Summary of **Circadian Lighting*** Principles

Day-active people:

- Look to nature: Bright days and dark nights.
- In principal, visual and non-visual outcomes can be simultaneously addressed.
- Energy use constraints may be a challenge.

Night-active people:

- Visual and non-visual needs usually conflict.
- It is a challenge that demands prioritization and consideration of tradeoffs.

* Important: *Circadian Lighting* is not equal to *Human-Centric Lighting*!

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  - **Five Step Design Process**

Step 1

Step 2

Step 3

Step 4

Step 5

Step 1 **Operational goals**

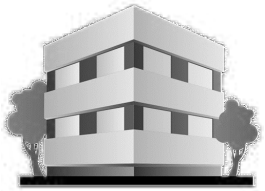
Step 2

Step 3

Step 4

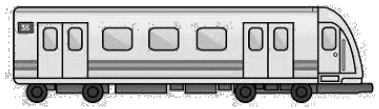
Step 5

Step 1: *Characterize the lighting application*

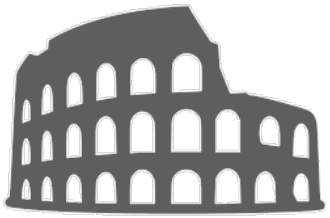

Corporate


Education


Entertainment


Transportation


Healthcare


Historic

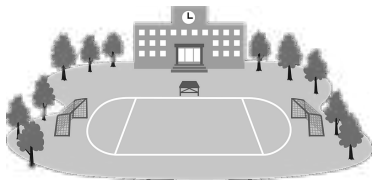

Dining


Residential


Hospitality


Retail


Worship


Public Spaces

Healthcare Example

Characterization:

Healthcare environments are typified by the intent to prevent, cure, or treat illness.

Likely operational goals:

- Safety
- Save lives
- Improve patients' quality of life
- Minimize suffering

Step 1	Operational goals
Step 2	**Occupants' sleep-wake cycles**
Step 3	
Step 4	
Step 5	

Step 2: *Establish likely occupant sleep-wake cycles*

Day-Active
(Night-Inactive)

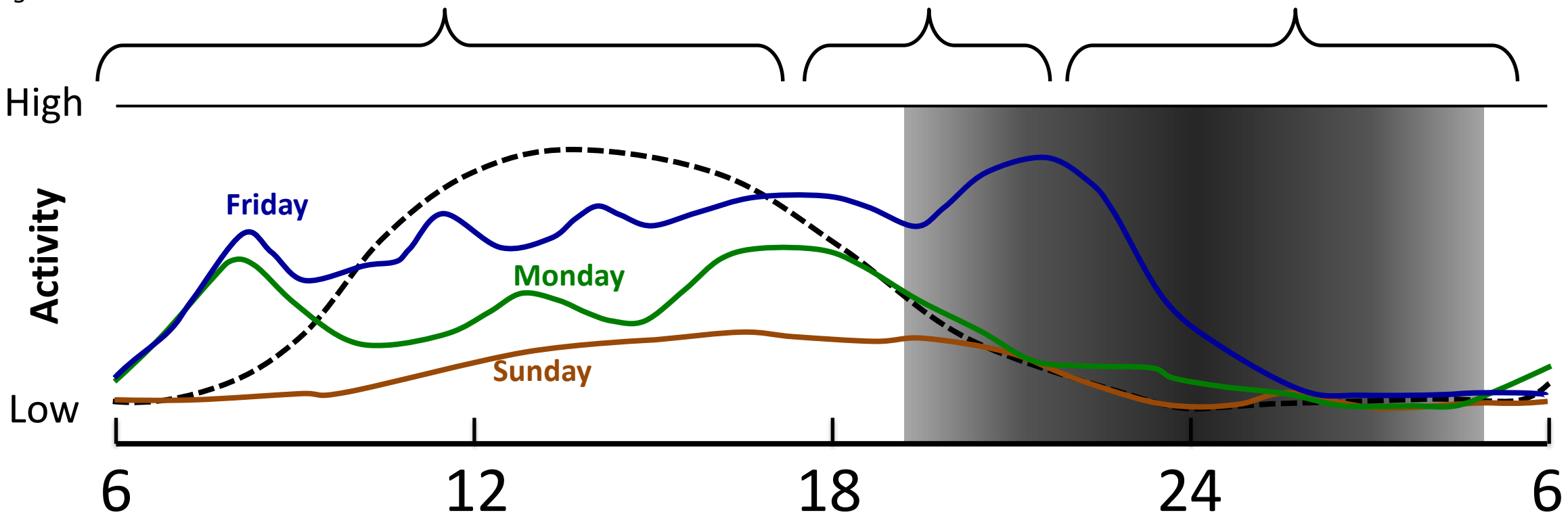
synchronous

Wake: *morning*
Work: *day*
Sleep: *night*

Light that is high in melanopic content

Light that is low in melanopic content

Darkness



Activity profiles adapted from Ihler and Smith 2006

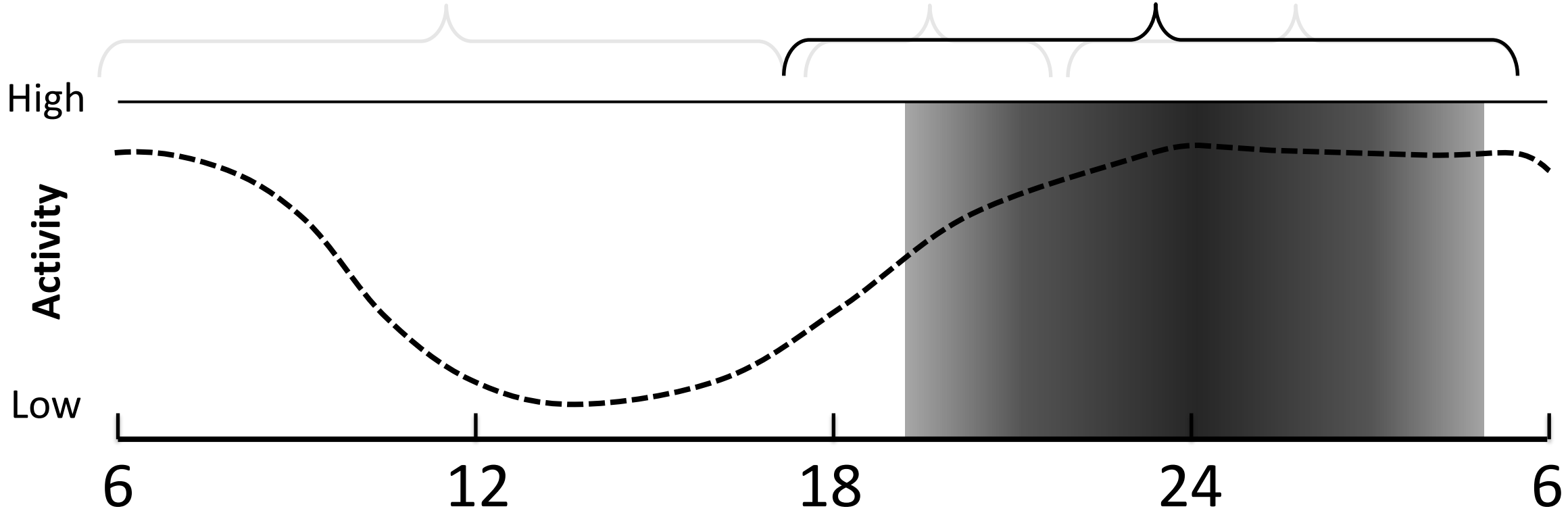
Step 2: *Establish likely occupant sleep-wake cycles*

Night-Active
(Day-Inactive)

asynchronous

Wake: *evening*
Work: *night*
Sleep: *morning*

Nighttime illumination to adequately and safely perform personal or professional tasks



Activity profiles adapted from Ihler and Smith 2006

Step 2: *Establish likely occupant sleep-wake cycles*

Day-Active

synchronous

Wake: *morning*
Work: *day*
Sleep: *night*

Night-Active

asynchronous

Wake: *evening*
Work: *night*
Sleep: *morning*

Healthcare Example

Caregivers

- Can be **day-active** or **night-active** depending on shift, which changes throughout the day

Patients

- Can be **day-active** or **night-active**

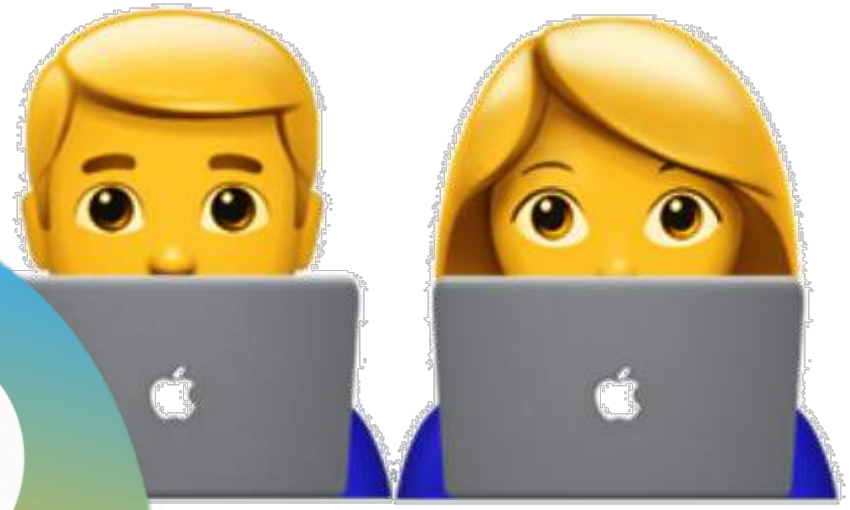
Step 1	Operational goals
Step 2	Occupants’ sleep-wake cycles
Step 3	**Occupant sleep requirements**
Step 4	
Step 5	

Step 3: *Characterize occupant sleep needs*

SLEEPING

OR

Working



OR

Both

Healthcare Example

Caregivers 

- Will be working (not sleeping, hopefully!)

Patients 

- No sleep requirements (outpatient)
- Sleep requirements (inpatient)

Step 1	Operational goals
Step 2	Occupants’ sleep-wake cycles
Step 3	Occupant sleep requirements
Step 4	**Published HCL guidance**
Step 5	

Step 4: *Review published HCL guidance*

FREE, Web (the document, not certification)

https://v2.wellcertified.com/v/en/light/feature/3

FREE, Web (the document, not certification)

https://v2.wellcertified.com/v/en/light/feature/3

Equivalent Melanopic Lux (**EML**) and *Melanopic Ratio* (**R**)
melanopic Equivalent Daylight Illuminance (**melanopic EDI**) and the *Daylight Efficacy Ratio* (**DER**)

FREE, Web or $75 PDF download (no certification)

https://www.shopulstandards.com/ProductDetail.aspx?productId=UL24480_1_D_20191219

Circadian Stimulus (**CS**), with WELL and *Illuminance* (**E**) alternate compliance paths

Sidebar: Computing EML of WELL v2.0

$$EML = E * R$$

Illuminance

Melanopic Ratio

$$EML = 100\ lux * 0.45$$

$$= 45\ m\text{-}lux$$

Melanopic Ratio (R)

$$R = \frac{\text{Light source's melanopic content (scaled)}}{\text{Light source's photopic content (scaled)}}$$

R is a simple ratio (scaled so the theoretical Equal Energy illuminant has a value of 1.0). It depends only spectrum.

How to determine it:

Request from manufacturer

OR use WELL calculator to compute:

https://standard.wellcertified.com/sites/default/files/Melanopic%20Ratio.xlsx

Sidebar: Computing mel-EDI of CIE S 026

mel-EDI = E * DER

Illuminance

Daylight Efficacy Ratio

mel-EDI = 100 lux * 0.45

= 45 lux

Daylight Efficacy Ratio (DER)

$$\text{DER} = \frac{\text{Light source's melanopic efficacy of luminous radiation}}{\text{Daylight (D65)'s melanopic efficacy of luminous radiation}}$$

DER is a ratio of ratios. It depends only on spectrum.

How to determine it:

Request from manufacturer

OR use CIE S026 toolbox to calculate

https://bit.ly/33YM9Rh

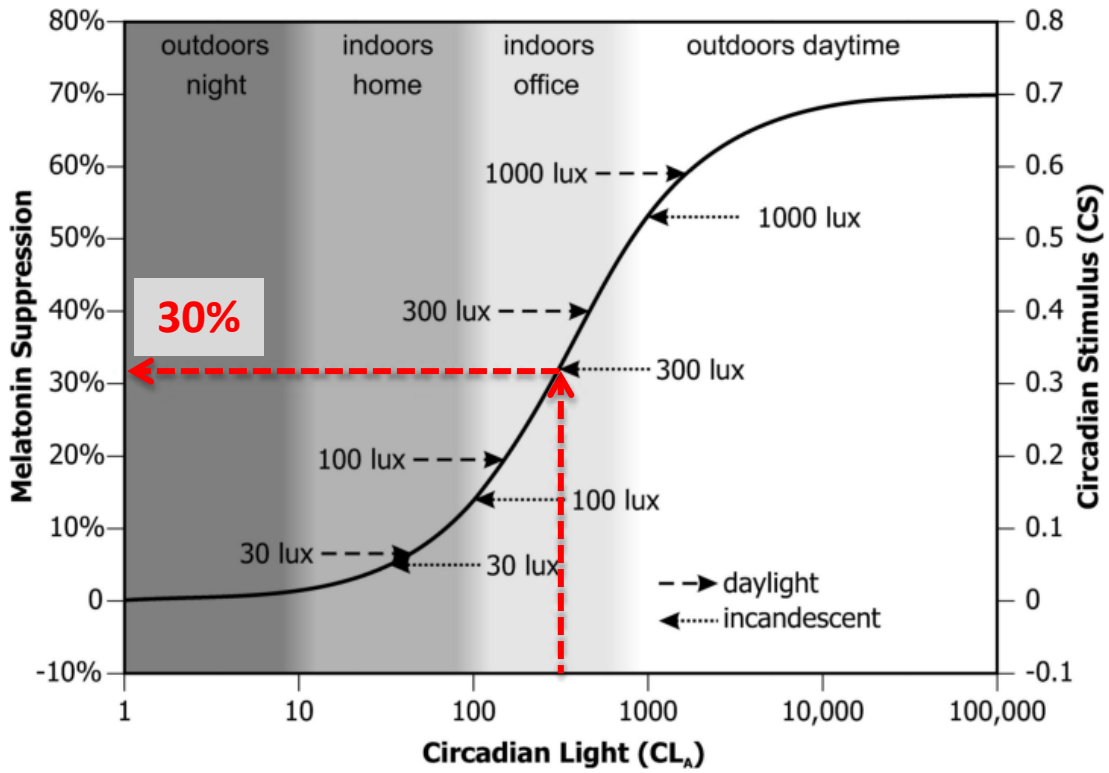
Sidebar: EML and mel-EDI are related by a constant

melanopic EDI = **0.91** EML

1.10 melanopic EDI = EML

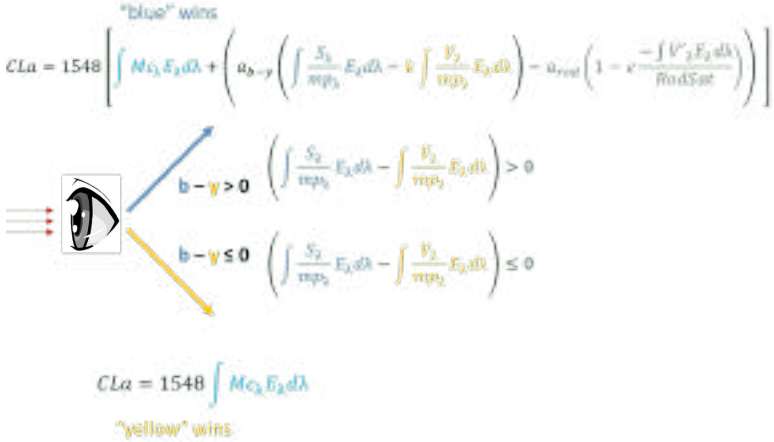
Sidebar: Computing Circadian Stimulus

CS is a measure of human nocturnal melatonin suppression



CL$_a$ is similar to EML or mel-EDI and depends on both spectrum and intensity

Circadian Light (CL$_a$)



CL$_a$ is a non-linear model built on a "blue"-"yellow" spectral opponency. CL$_a$ depends on both spectrum and intensity.

How to determine it:

Request from manufacturer (specify illuminance!)

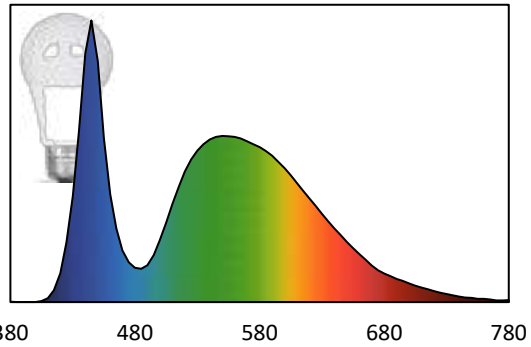
OR use LRC calculators

https://www.lrc.rpi.edu/cscalculator/

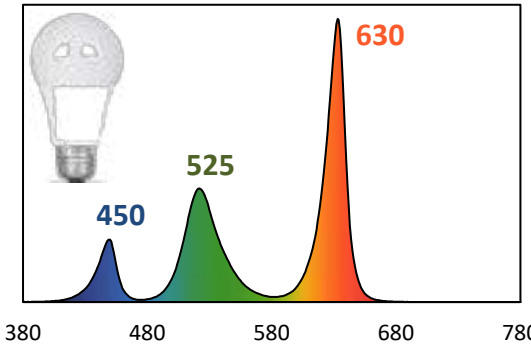
http://www.lrc.rpi.edu/resources/CSCalculator_2017_10_03_Mac.xlsm

Sidebar: performance of familiar light sources

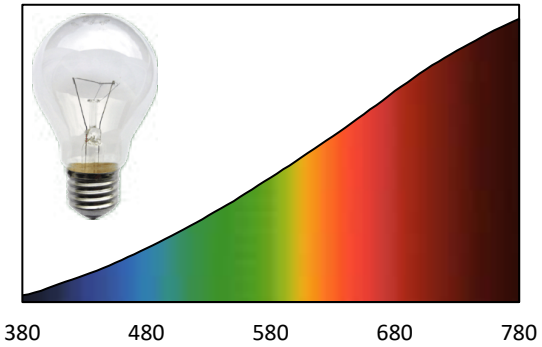
PC LED – 5600 K



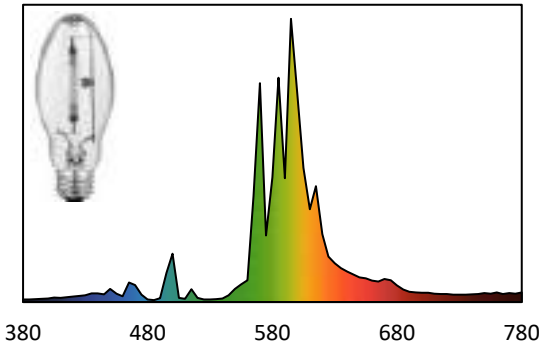
RGB LED 1 – 3500 K



Incandescent – 2700 K

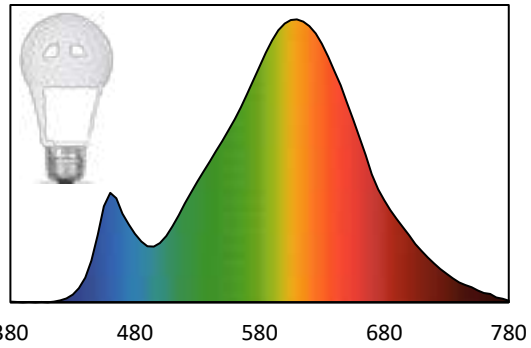


HPS – 2000 K

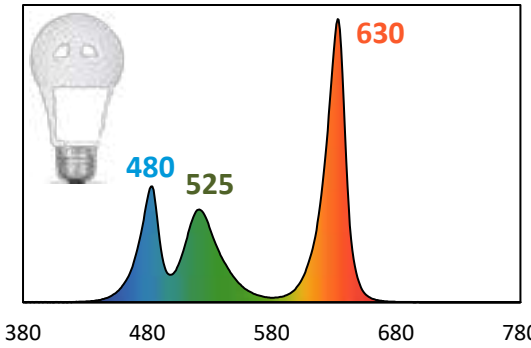


R:	0.75	0.77	0.55	0.19
mel-DER:	0.68	0.70	0.50	0.17
CS (@200 lx):	14%	18%	14%	5.2%

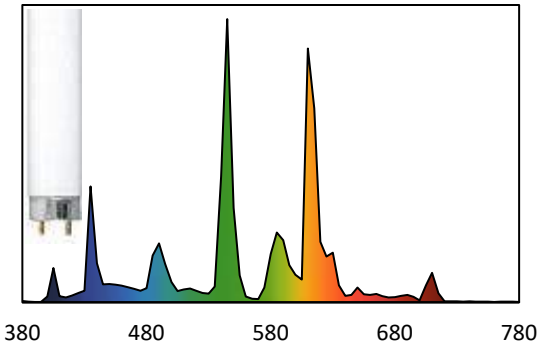
PC LED – 2600 K



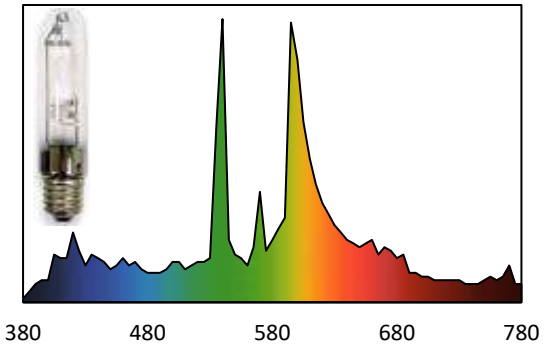
RGB LED 2 – 3500 K



F32T8/835 – 3500 K



CDM 830 – 3000 K



R:	0.45	1.10	0.55	0.75
mel-DER:	0.41	1.01	0.49	0.68
CS (@200 lx):	11%	24%	14%	11%

Sidebar: Do not use CCT to predict bio potency

www.nature.com/scientificreports

scientific reports

Check for updates

OPEN

Correlated color temperature is not a suitable proxy for the biological potency of light

Tony Esposito[1]✉ & Kevin Houser[2,3]

Using a simulation based on a real, five-channel tunable LED lighting system, we show that Correlated Color Temperature (CCT) is not a reasonable predictor of the biological potency of light, whether characterized with CIE melanopic Equivalent Daylight Illuminance (mel-EDI), Equivalent Melanopic Lux (EML) (a scalar multiple of mel-EDI), or Circadian Stimulus (CS). At a photopic corneal illuminance of 300 lx and $R_f \geq 70$, spectra can vary in CS from 17 to 41% across CCTs from 2500 to 6000 K, and up to 23% at a single CCT, due to the choice of spectrum alone. The CS range is largest, and notably discontinuous, at a CCT of 3500 K, the location of the inflection point of the CS model. At a photopic corneal illuminance of 300 lx and $R_f \geq 70$, mel-EDI can vary from 123 to 354 lx across CCTs from 2500 to 6000 K and can vary by up to 123 lx at a fixed CCT (e.g., 196 to 319 lx at 5000 K). The range of achievable mel-EDI increases as CCT increases and, on average, decreases as color

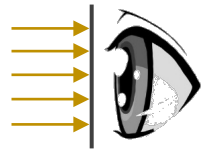
Sidebar: Do not use CCT to predict bio potency

"Using a simulation based on a real, five-channel tunable LED lighting system, **we show that Correlated Color Temperature (CCT) is not a reasonable predictor of the biological potency of light**, whether characterized with CIE melanopic Equivalent Daylight Illuminance (mel-EDI), Equivalent Melanopic Lux (EML) (a scalar multiple of mel-EDI), or Circadian Stimulus (CS)."

Step 4: *Review published HCL guidance*

* If electric light only

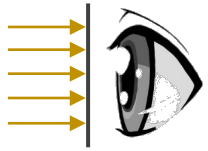
** From electric light, if certain daylight criteria are met

	Temporal Pattern	Light Spectrum		Light Level		Spatial Pattern
		CS [% Mel Suppr.]	EML [m-lux]	mel-EDI [Lux]	Illuminance [Lux]	
Well v2 1 points	**Min 4 Hours Exposure** At least 9 AM – 1 PM	**N/A**	**≥ 150** * or **≥ 120** **	**≥ 136** * or **≥ 109** **	**N/A**	*Not Specified* Measured on vertical plane @ Eye level
Well v2 3 points	**Min 4 Hours Exposure** At least 9 AM – 1 PM	**N/A**	**≥ 275** * or **≥ 180** **	**≥ 250** * or **≥ 163** **	**N/A**	*Not Specified* Measured on vertical plane @ Eye level
Underwriters Lab DG 24480	7 AM – 4 PM (min 2 hrs) 5 PM – 7 PM (all) After 8 PM (all)	**≥ 0.30** **≤ 0.20** **≤ 0.10**	Comply with WELL	**N/A** **N/A** **N/A**	**≥ 500** **N/A** **N/A**	*Not Specified* Measured on vertical plane @ Eye level

Step 4: *Review published HCL guidance*

Spatial Pattern

Quantities are vertical at the plane of the eye, not horizontal workplace illuminances!



Well v2
1 points

Intensity

Spectrum

EML ≥ 150 m-lx
mel-EDI ≥ 136 lx

" … light levels may be lowered …"

Time

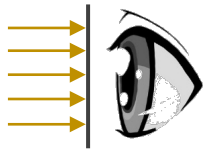
Values shown are from electric light only. WELL permits lower targets if specific daylight criteria are met. See WELL v2.0 https://v2.wellcertified.com/v/en/light/feature/3

Step 4: *Review published HCL guidance*

Well v2
3 points

Spatial Pattern

Quantities are vertical at the plane of the eye, not horizontal workplace illuminances!



Intensity

Spectrum

EML ≥ 275 m-lx

mel-EDI ≥ 250 lx

" … light levels may be lowered …"

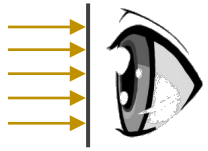
Time

Values shown are from electric light only. WELL permits lower targets if specific daylight criteria are met. See WELL v2.0 https://v2.wellcertified.com/v/en/light/feature/3

Step 4: *Review published HCL guidance*

Spatial Pattern

Quantities are vertical at the plane of the eye, not horizontal workplace illuminances!



Underwriters Lab
DG 24480

Intensity

Spectrum

CS ≥ 30% (or 500 lx)

CS ≤ 20%

CS ≤ 10%

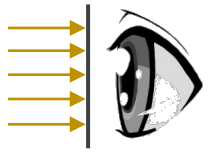
Time

Underwriters Laboratory. 2019. Design Guidelines for Promoting Circadian Entrainment with Light for Day-Active People. UL Design Guideline 24480. Edition 1. Northbrook, IL: UL.

Step 4: *Review published HCL guidance*

Spatial Pattern

Vertical plane at 1.2 m height



Intensity

Spectrum

mel-EDI ≥ 250 lx

mel-EDI ≤ 10 lx

mel-EDI ≤ 1 lx

Time

Timing & Duration
Throughout Daytime

Timing & Duration
3 hrs before bedtime

Timing & Duration
During Sleep

6 12 18 24 6

Brown TM, Brainard GC, Cajochen C, Czeisler CA, Hanifin JP, Lockley SW, Lucas RJ, Munch M, O'Hagan JB, Peirson SN, Price LLA, Roenneberg T, Schlangen LJM, Skene DJ, Spitschan M, Vetter C, Zee PC, Wright KP. 2022. Recommendations for daytime, evening, and nighttime indoor light exposure to best support physiology, sleep, and wakefulness in healthy adults. Plos Biology. https://doi.org/10.1371/journal.pbio.3001571

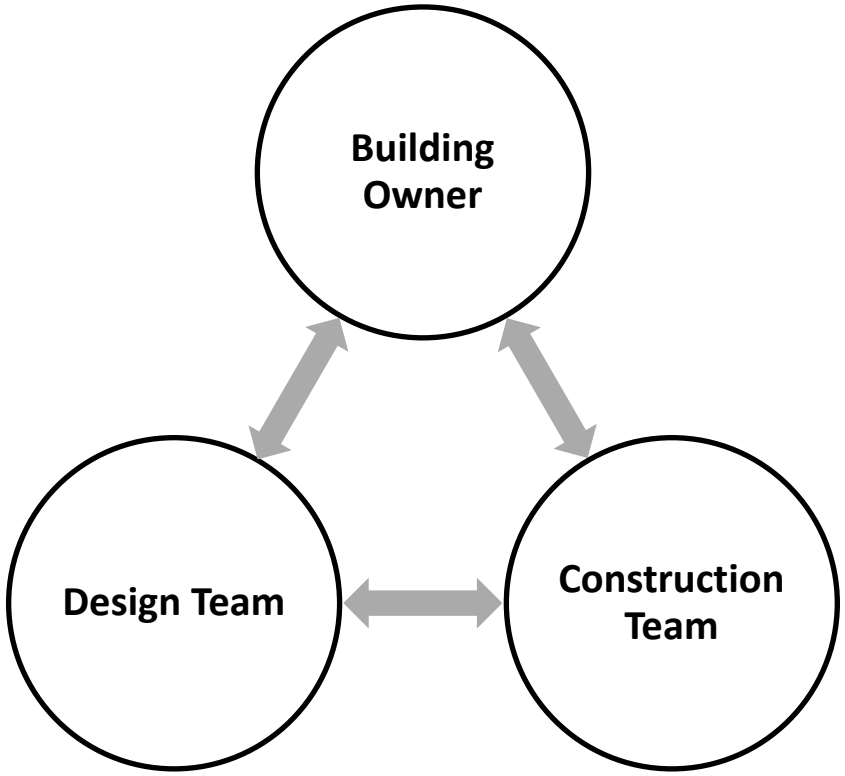
Step 1	Operational goals
Step 2	Occupants’ sleep-wake cycles
Step 3	Occupant sleep requirements
Step 4	Published HCL guidance
Step 5	**Specify numerical criteria**

Step 5: *Put it together*

Step 1	Operational goals
Step 2	Occupants’ sleep-wake cycles
Step 3	Occupant sleep requirements
Step 4	Published HCL guidance
Step 5	**Specify numerical criteria**

Step 5: *Put it together*

Step 1	Operational goals
Step 2	Occupants' sleep-wake cycles
Step 3	Occupant sleep requirements
Step 4	Published HCL guidance
Step 5	Specify numerical criteria



Resources

Human Centric Lighting and Semantic Drift
https://doi.org/10.1080/15502724.2018.1501234 [OPEN ACCESS]
This LEUKOS editorial traces the rise of the phrase “Human Centric Lighting” and comments on the lack of clarity about what the phrase could mean and might mean to different people.

Human-Centric Lighting: Myth, Magic, or Metaphor?
https://doi.org/10.1177/1477153520958448
This LR&T article unpacks the concept of HCL. What is old? What is new? What is known? What is unknown? What are the varied roles of different constituencies?

A Review of Human Physiological Responses to Light: Implications for the Development of Integrative Lighting Solutions
https://doi.org/10.1080/15502724.2021.1872383 [OPEN ACCESS]
This LEUKOS article is a comprehensive review intended to be a one-stop scientific article for those that are trying to understand how light influences biology and physiology. It is written for the scientific community as much as it is for the design community.

Human-Centric Lighting: Foundational Considerations and a Five-Step Design Process
https://doi.org/10.3389/fneur.2021.630553 [OPEN ACCESS]
This articles supports specifiers. They are the ones that are tasked with designing light for people, yet the information they need to make good decisions is fragmented and inconsistent. This article provies order to the complexity of information that is out there, offering actionable guidance.

Melanopsin Vision: Sensation and Perception through Intrinsically Photosensitive Retinal Ganglion Cells
https://doi.org/10.1017/9781009029865
This brief book in the *Cambridge Elements in Perception* series integrates new knowledge and perspectives from visual neuroscience, psychology, sleep science, and architecture to discuss how melanopsin-mediated ipRGC circuits can be manipulated with light.

Ethics and Fallacies of Human-Centric Lighting and Artificial Light at Night
https://doi.org/10.1080/15502724.2021.1951021 [OPEN ACCESS]
This LEUKOS editorial comments on the intrinsic problems with human centricity. Lighting causes collateral damage to people and non-human life. Does the lighting community have the collective will to do better?

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LEDucation
Trade Show and Conference

This concludes The American Institute of Architects Continuing Education Systems Course

leducation.org