

Be Careful When Selecting LEDs

Find the Right Lamp for Your Application



Use Them Aptly & Responsibly

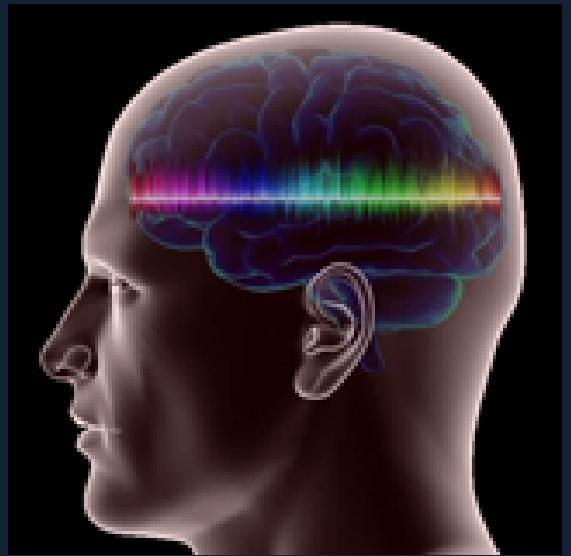
Incandescent Lamps	Fluorescent Lamps	Metal Halide Lamps	LED Lamps
No Harmful Effect	Negligible Harm	Less Harm	Harmful to Humans
Poor Efficiency	High Efficiency	Roads & Stadiums	Best Efficiency
No Flexibility	Better Flexibility	Roads & Stadiums	More Opportunities
		Retail & Facades	Easy to Repair



LED Lamps: Harmful When Misused!

- ✓ Can Cause Eye Strain & Sleep Disruption
- ✓ Handle Glare & Color Temperature Carefully
- ✓ Choose LEDs with Proper Dimming Controls
- ✓ Avoid Overly Intense or Cool White LEDs

Choose the Right Lighting for a
Safe and Productive Environment



THE PHYSIOLOGY OF ILLUMINATION

LIGHT, BODY & CLOCK

How illumination meets vision, sleep and circadian rhythm in the built environment.

GIRISH BHARDWAJ

For the people who shape spaces

For a developer, owner or end user, colour is experienced before a lighting specification is read. It determines whether food looks inviting, merchandise looks true to its materials, art retains its character, and a room feels coherent from one area to the next.

For architects, interior designers, lighting designers, engineers and procurement teams, those experiences must become decisions that can be specified, tested and repeated. A familiar number such as CRI helps, but it cannot describe every change a light source makes to the colours in a space.

This short book begins with the eye and the spectrum, then explains colour fidelity, gamut and the TM-30 graphics. It uses images from my presentation to connect the measurements with design decisions. The aim is to help the project team ask better questions of a luminaire sample and its data sheet.

When a finish, fabric or product matters, view the actual material under the proposed light. Ask for the spectral power distribution and the full colour rendition report. Compare samples at the intended light level, with the intended dimmer and optics. The right source is the one that serves the space and its occupants.

Girish Bhardwaj

From appearance to physiology

The foreword is shared with the companion volume, *Colour Beyond CRI*. This volume extends the conversation from how a room looks to how light reaches the eye and helps synchronize daily physiology.

Each source slide appears intact on its own page, including its original pictures and wording. A short editorial note below the slide explains the idea and identifies statements that need care. This format preserves the presentation while giving end users and specifiers a more reliable reading path.

A lighting design still needs task visibility, visual comfort and safety. Timing, spectrum, exposure at the eye and individual circumstances also matter when discussing circadian effects. No single lamp, colour temperature or “wellness” label can establish a medical outcome.

Wellumination

"WELLNESS IS A STATE OF BEING PHYSIOLOGICALLY STABLE & PSYCHOLOGICALLY SOUND."

Wellumination™ is the amalgam of lighting and wellness *(Girish Bhardwaj)*

Let's Understand Light.

Complete Guide To Understand The Relationship Between Physiology And Light

Diagram illustrating the relationship between light and wellness:

- Basics Of Light
- Lighting Design
- Concepts And Application Of Light
- Lighting Controls
- Physiology And Light
- Plants And Light
- Wellbeing and Light

www.girishbh.com

WHAT THIS SLIDE SHOWS

The opening frames wellness as the purpose of the work. "Wellumination" is the author's term joining lighting and wellness.

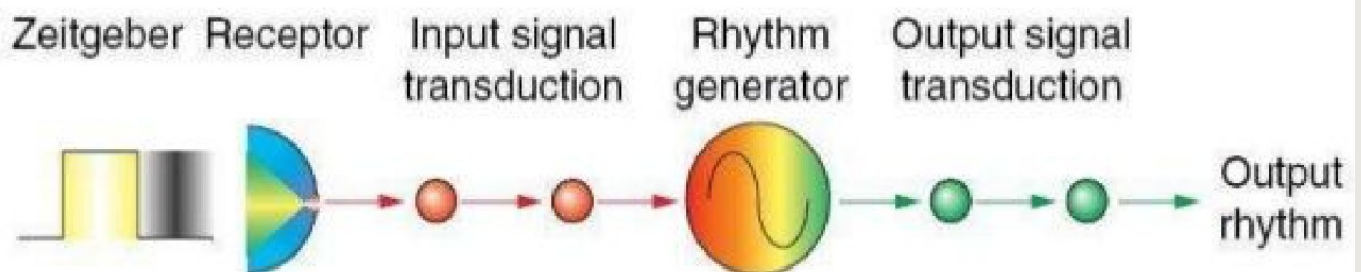
EDITORIAL NOTE

Use this as a design question: what exposure does the space actually create for its occupants?

The brain and its signals



1. The brain is the body's most complex organ.
2. Neurons communicate using both electrical and chemical signals.
3. Genetically determined circuits are the foundation of the nervous system.
4. Life experiences change the nervous system.
5. Intelligence arises as the brain reasons, plans, and solves problems.
6. The brain makes it possible to communicate knowledge through language.
7. The human brain endows us with a natural curiosity to understand how the world works.
8. Fundamental discoveries promote healthy living and treatment of disease.



WHAT THIS SLIDE SHOWS

The brain receives and processes visual and environmental signals. Light is a powerful time cue for the circadian system.

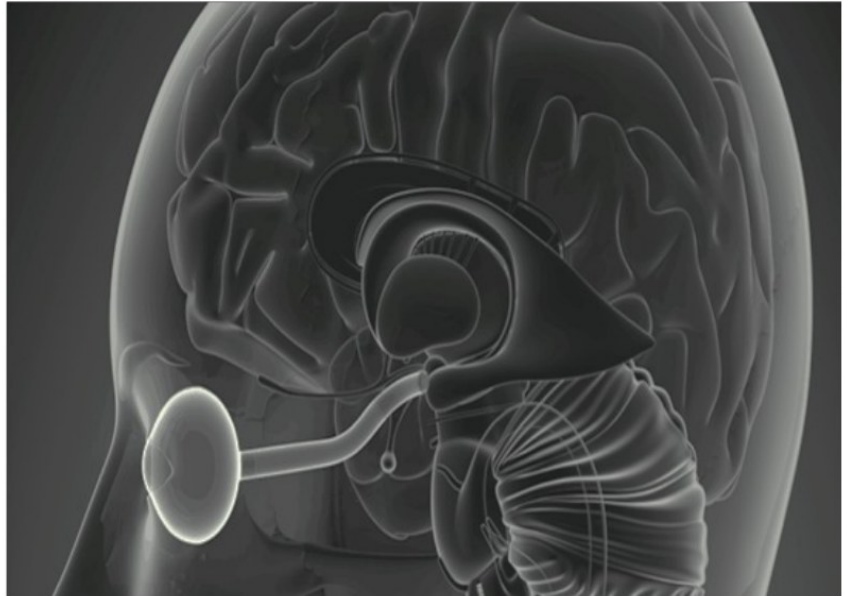
EDITORIAL NOTE

The slide is a broad introduction; avoid treating the diagram as a complete map of brain function.

Visual and nonvisual effects

Visual & non visual impact

Retinal damage
Brain fatigue
Stress
Migraine
Insomnia
EFD
Cancer
Obesity
Age related Macular disorder



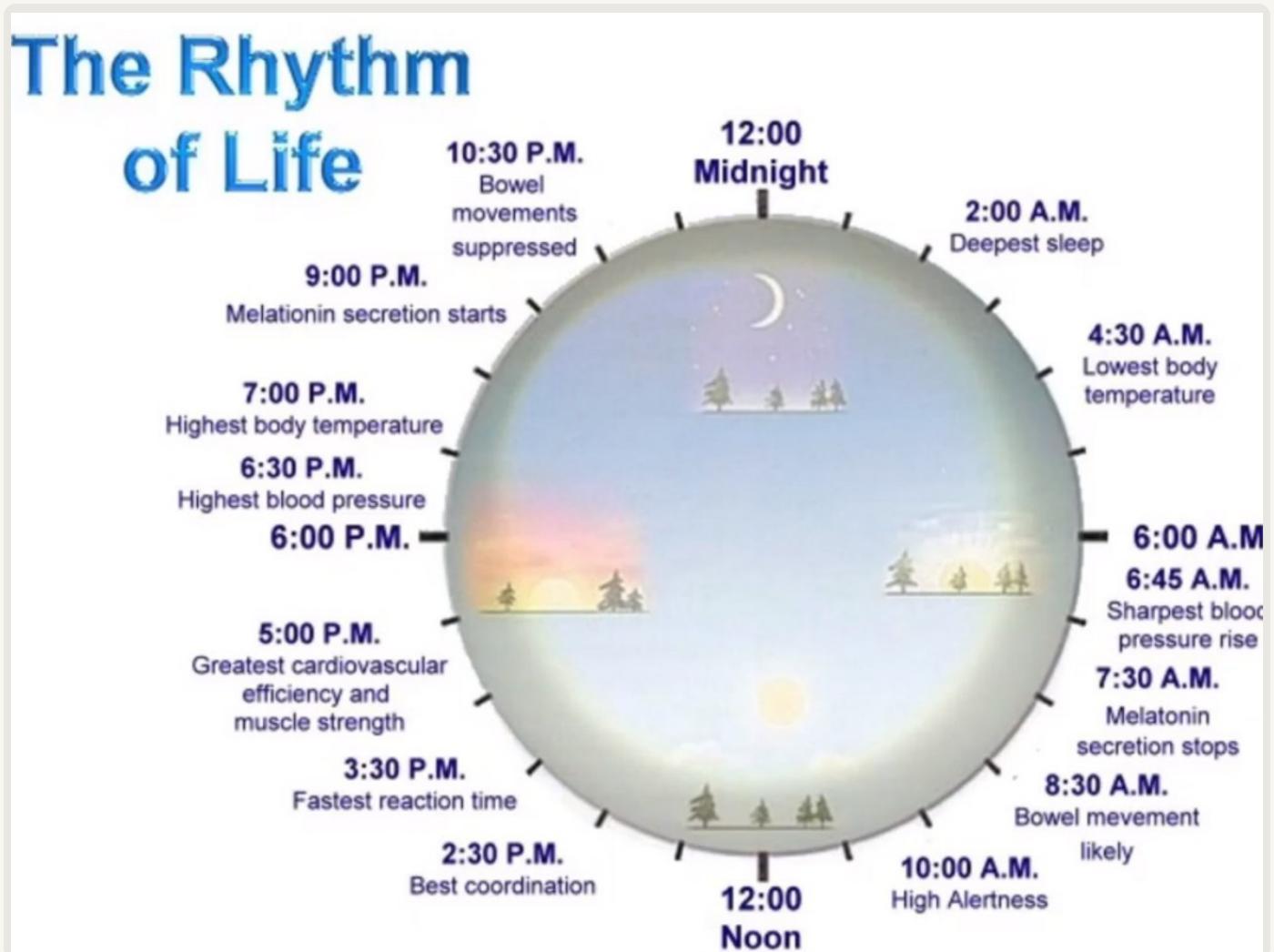
WHAT THIS SLIDE SHOWS

Light supports vision and also contributes to circadian timing. The list on the source slide combines established effects, associations and proposed risks.

EDITORIAL NOTE

Do not infer that ordinary electric light directly causes each listed illness. Evaluate each claim against its own evidence.

The daily rhythm



WHAT THIS SLIDE SHOWS

Circadian rhythms follow an approximately 24-hour pattern. Light and darkness help align internal timing with the day.

EDITORIAL NOTE

The displayed times are illustrative; schedules and phase vary among people.

Living against the clock



Consequences of living against the clock

Emotional responses	Cognitive responses	Somatic responses
Exhaustion	Reduction in Concentration	Drowsiness
Increased irritability	Reduction in Performance	Microsleeps
Mood fluctuations	Reduction in Attention	Unintended sleep
Anxiety	Reduction in Memory	Sensations of pain
Depressed mood	Reduction in Recall of events	Sensations of cold
Frustration	Reduction in Multitasking	Cardiovascular disease
Anger	Reduction in Decision making	Risk of cancer
Increased impulsivity	Reduction in Creativity	Metabolic abnormalities
Decreased motor skills	Reduction in Productivity	Weight gain
Increased stimulant use	Reduction in Socialisation	Risk of diabetes II
Increased sedative use	Reduction in Communication	Reduced immunity
Alcohol use/misuse		Disorders of the HPA

Based on data from Pritchett D, Wulff K, Oliver PL, et al. as published in J Neural Transm., 2012

WHAT THIS SLIDE SHOWS

Sleep timing and work schedules can affect mood, alertness and performance. The slide collects many possible consequences.

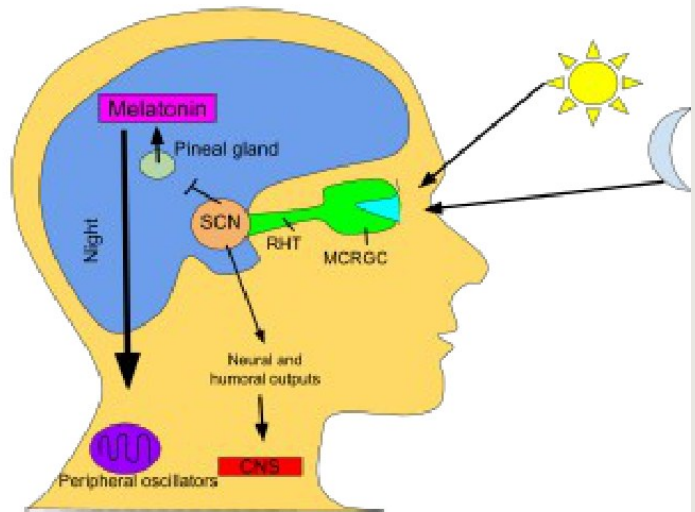
EDITORIAL NOTE

These outcomes are multifactorial. The diagram should not be read as a diagnosis or a quantified effect of lighting.

Melatonin at night

MELATONIN- A HORMONE OF DUSK TO DAWN

1. Defined as, the hormone responsible for sleep.
2. It increases the cells regeneration.
3. Acts as a antioxidant.
4. Stimulates the immune system- making it stronger
5. It is the essential hormone for chronobiological adaptation.
6. The SCN-activated thru Pineal gland, light-inhibited production of melatonin conveys the message of darkness to the clock and induces night-state physiological functions like sleep/wake blood pressure and metabolism



WHAT THIS SLIDE SHOWS

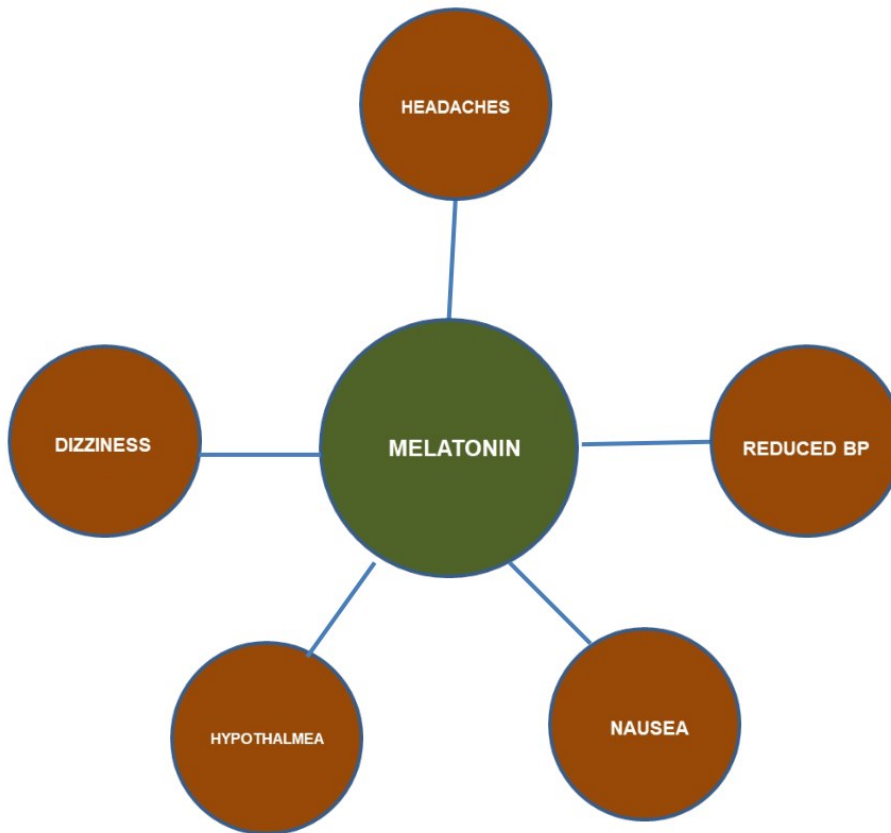
Melatonin is a hormone associated with biological night. The circadian system regulates its timing, and light exposure can suppress it depending on dose and timing.

EDITORIAL NOTE

Melatonin has several biological roles; a design should not promise immune or cell-regeneration benefits.

When melatonin is disrupted

MELATONIN- ADVERSE EFFECTS



WHAT THIS SLIDE SHOWS

This visual groups symptoms often discussed alongside sleep disruption. It works as a prompt to ask about nocturnal light exposure.

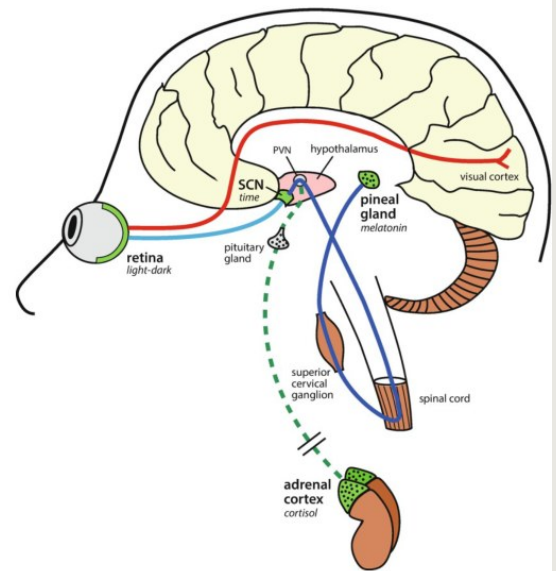
EDITORIAL NOTE

A symptom wheel does not establish that a particular symptom was caused by melatonin or by a luminaire.

Cortisol across the day

CORTISOL- A STEROID HORMONE

1. Defined as, the Steroid hormone responsible for the alertness
2. It triggers thru the Pituitary gland to take control of our alertness activities. It is released with the pattern that recurs every 24 hours (Diurnal cycle).
3. Boost energy levels
4. Manages Carbohydrates, proteins & fat.
5. Regulates blood pressure.
6. Aligning itself with certain parts of brain like hypothalamus & pituitary gland it controls fear, mood & motivation.



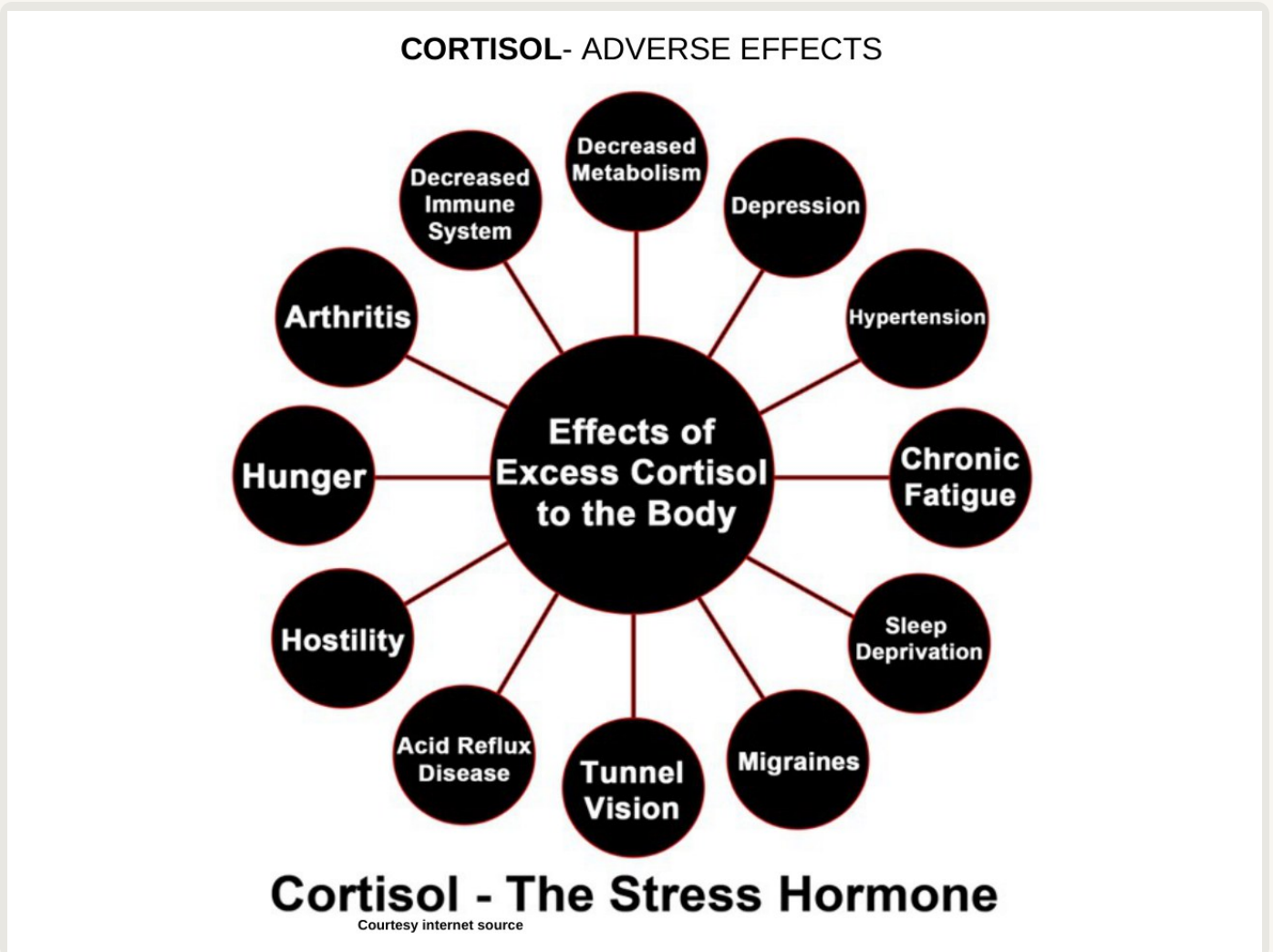
WHAT THIS SLIDE SHOWS

Cortisol participates in metabolism and stress responses and typically follows a daily pattern. It is controlled by a wider hormonal system.

EDITORIAL NOTE

The pituitary gland is part of the pathway; lighting does not directly “set” cortisol to a chosen level.

Excess cortisol claims



WHAT THIS SLIDE SHOWS

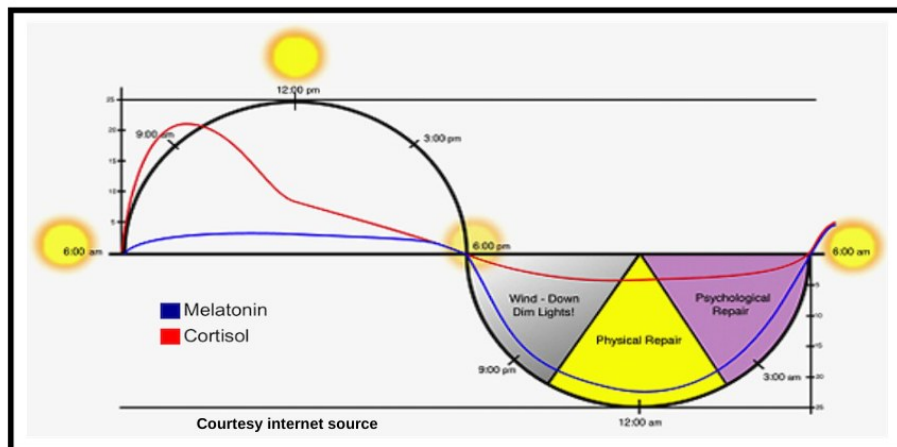
The slide lists conditions associated with stress and altered cortisol. Some relationships are complex or bidirectional.

EDITORIAL NOTE

Avoid using this wheel to infer individual medical risk from a lighting condition.

How the clock aligns

Lets understand Circadian Rhythm



“Sleep is the form of payback towards the fatigue & we certainly have to repay this towards the proper functioning of our body and the brain.”

A scenario:

In today's world, the nights are days and the days are nights for many of us.

We are exposed to the phenomenon known as **ELECTROLUMINESCENCE**.

Humans receiving **high CS during the entire workday**, exhibited **reduced depression and better sleep quality** compared to those receiving low CS.

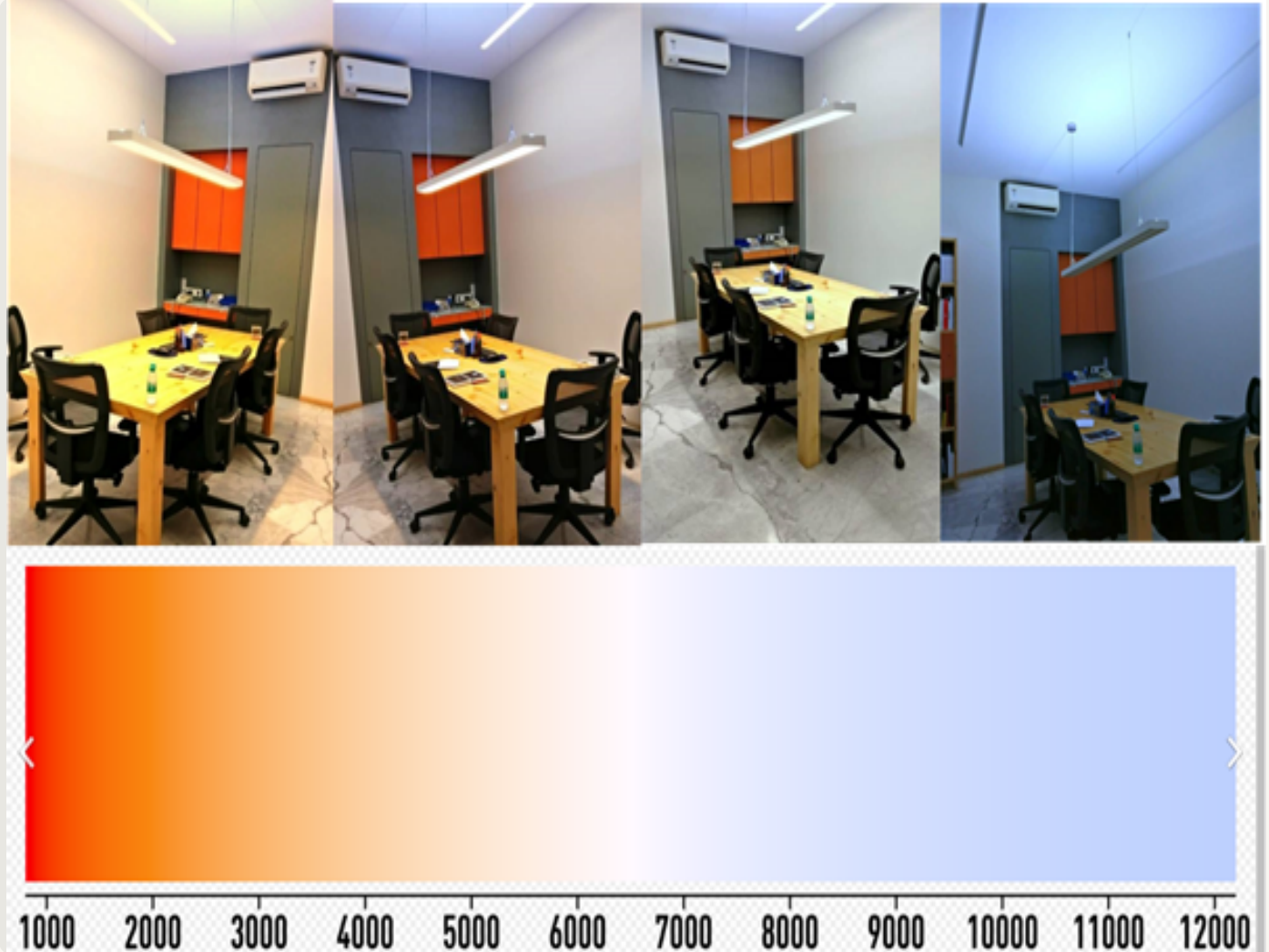
WHAT THIS SLIDE SHOWS

Light is a zeitgeber, or time cue. Morning and evening exposures can have different effects on circadian phase.

EDITORIAL NOTE

The illustration is conceptual. It does not prescribe one exposure schedule for every person.

Light across the workday



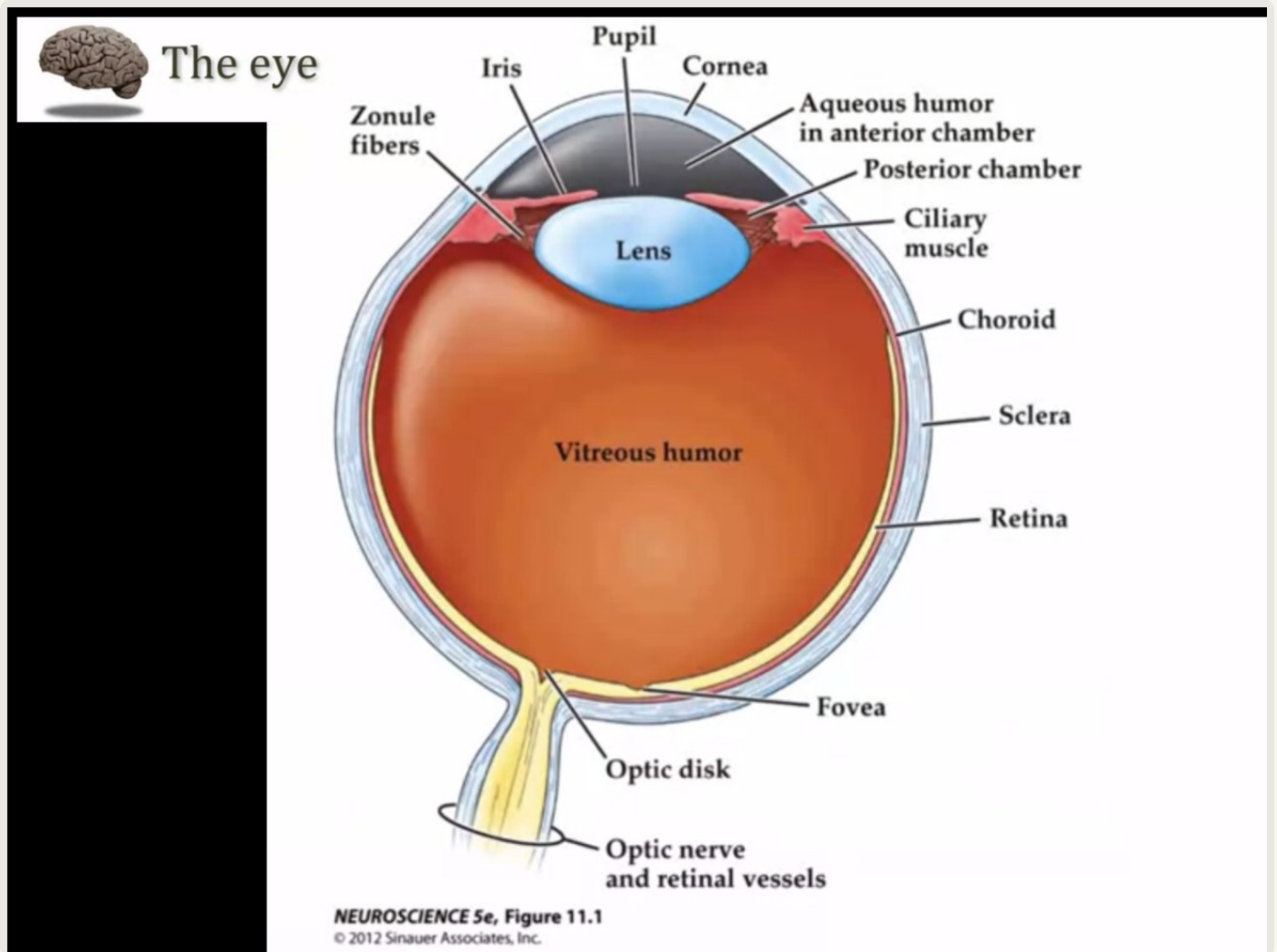
WHAT THIS SLIDE SHOWS

The slide connects outdoor daylight, time of day and electric lighting in an office. All can contribute to the eye's exposure.

EDITORIAL NOTE

Measure vertical light at eye level and document occupancy and timing before comparing design options.

The optical route



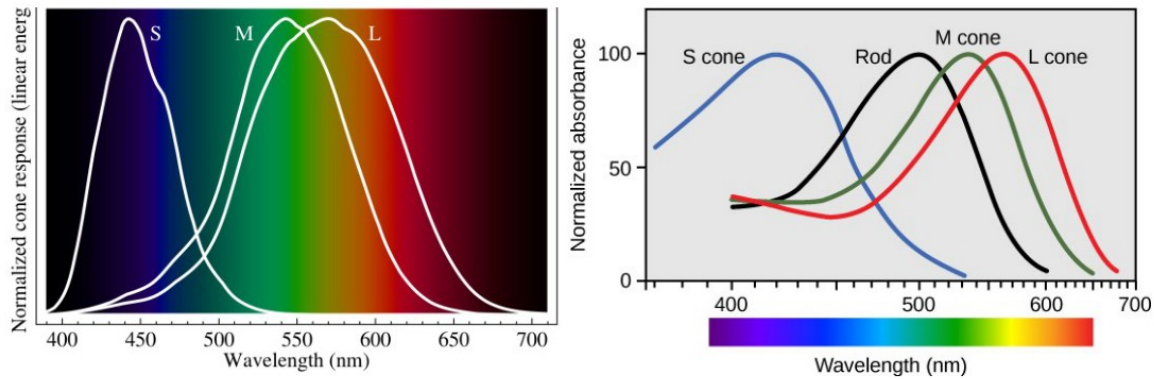
WHAT THIS SLIDE SHOWS

Light passes through the cornea and lens before reaching the retina, where photoreceptors begin visual processing.

EDITORIAL NOTE

The eye diagram gives anatomy; actual retinal exposure also depends on source size, brightness and viewing geometry.

Rods, cones and wavelength



It is known that the **rod cells** are more suited to **scotopic vision** and **cone cells** to **photopic vision** and that they differ in their sensitivity to different wavelengths of light.

It has been established that **the maximum spectral sensitivity of the human eye under daylight conditions** is at a wavelength of **555 nm**, while at night the peak shifts to **507 nm**.

In visual neuroscience, spectral sensitivity is used to describe the different characteristics of the photo pigments in the rod cells and cone cells in the retina of the eye. It is known that the rod cells are more suited to scotopic vision and cone cells to photopic vision, and that they differ in their sensitivity to different wavelengths of light. It has been established that the maximum spectral sensitivity of the human eye under daylight conditions is at a wavelength of 555 nm, while at night the peak shifts to 507 nm.

Courtesy internet sources

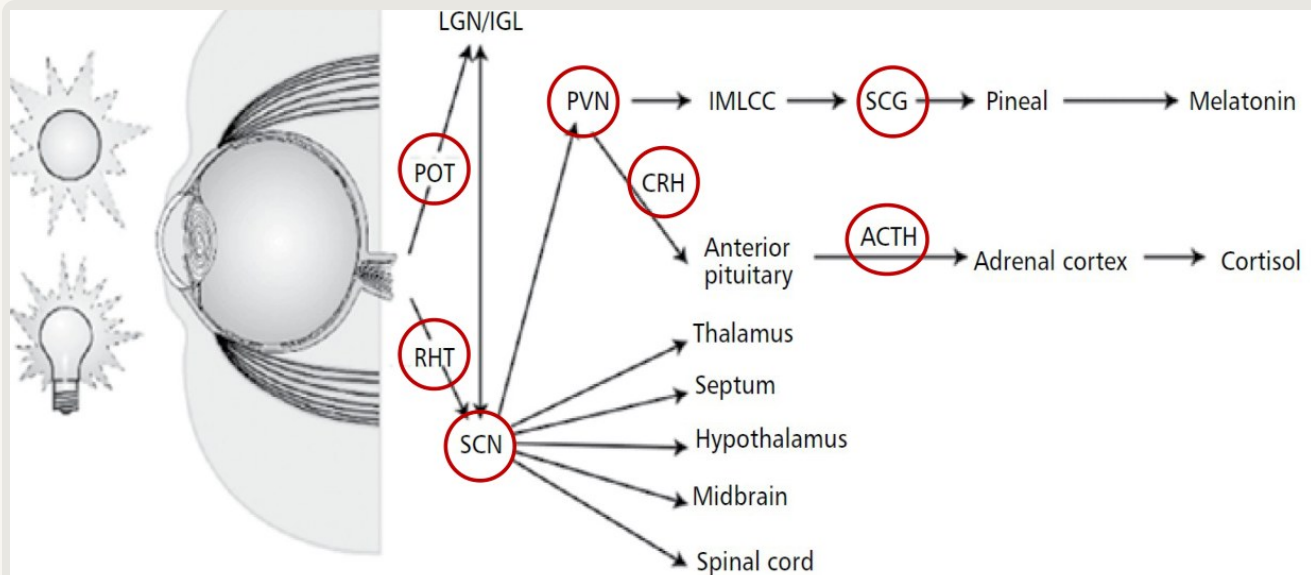
WHAT THIS SLIDE SHOWS

Photopic sensitivity peaks near 555 nm and scotopic sensitivity near 507 nm. Rod and cone contributions change with adaptation level.

EDITORIAL NOTE

These peaks describe luminous efficiency functions, not the complete response of every retinal pathway.

The clock pathway



CIBSE for the sole use of the pe

POT	: Primary optic tract
RHT	: Retino-hypothalamic tract.
SCN	: Suprachiasmatic nucleus
PVN	: Paraventricular nucleus
SCG	: Superior cervical ganglion
CRH	: Corticotrophic-releasing Hormone
ACTH	: Adrenocorticotropic Hormone

The SCN drives the circadian rhythm in pineal melatonin production (that is, high melatonin levels at night and low melatonin levels during the day) via a **multisynaptic pathway** that projects to the Paraventricular nucleus of the hypothalamus (**PVN**)

The superior cervical ganglion (SCG) . Core body temperature (CBT) and the pineal hormone melatonin are the most commonly used phase markers of this rhythm.

Melatonin is used more often since it is not subject to as many masking influences as it **can be measured non-invasively**.

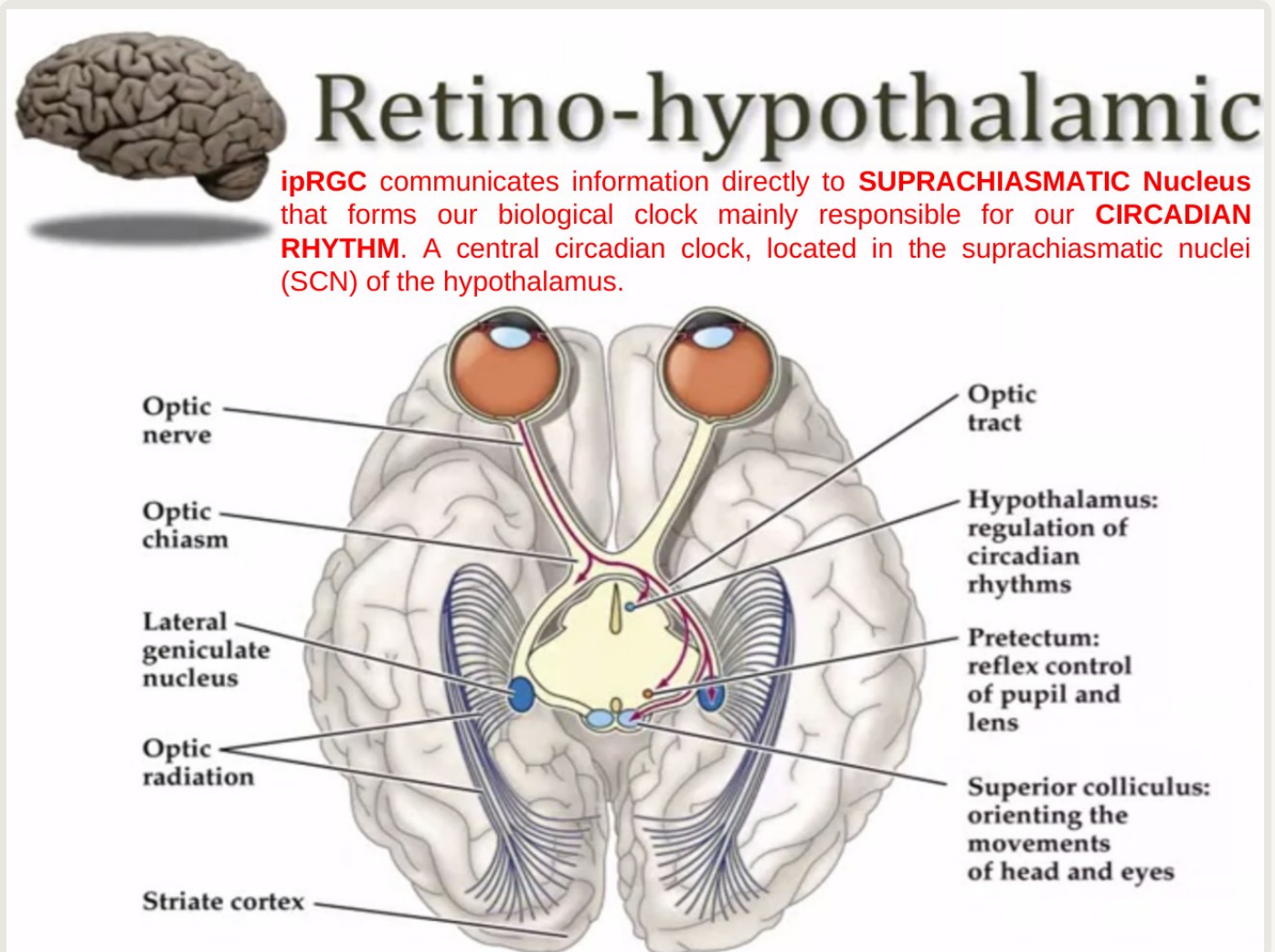
WHAT THIS SLIDE SHOWS

Retinal input reaches the suprachiasmatic nuclei via a neural pathway. Downstream signaling contributes to daily melatonin timing.

EDITORIAL NOTE

The SCN, pineal gland and stress-hormone pathways have distinct roles; the arrows simplify a complex system.

ipRGCs and the SCN



WHAT THIS SLIDE SHOWS

Intrinsically photosensitive retinal ganglion cells contain melanopsin and help carry light information to the circadian clock.

EDITORIAL NOTE

Rods and cones can also contribute to nonvisual responses. A single wavelength does not explain the full effect.

Three cone classes

Pigmentation & wavelengths

Cyanolabe: Pigment in the retinal cones that is more sensitive to the blue portion of the spectrum.

Chlorolabe: Pigment in the retinal cones that is more sensitive to the green portion of the spectrum.

Erythrolabe: Pigment in the retinal cones that is more sensitive to the red portion of the spectrum.

Firing patterns:

S = Small Wavelength Receptor, M = Medium Wavelength Receptor, & L = Long Wavelength Receptor

Blue: A large response in the S receptor, a smaller response in the M receptor, and an even smaller response in the L receptor.

Green: A large response to the M receptor, while the S & L receptors have a smaller response.

Red: A large response to the L receptor, a smaller response to the M receptor, and an even smaller response to the S receptor.

Yellow: A large response to M & L receptors, while the S receptor has a smaller response.

White: A large response to all three receptors S, M, & L

WHAT THIS SLIDE SHOWS

S, M and L cones have overlapping spectral sensitivities. Colour vision arises from comparing their responses through neural circuits.

EDITORIAL NOTE

The older pigment labels on the slide are historical shorthand; cones are not exclusively “blue,” “green” and “red” sensors.

Three visual regimes

Photopic Vision

This operating state of the visual system occurs at luminances higher than approximately 10 cd/m². For these luminances, the visual response is dominated by the cone photoreceptors.

This means that color is perceived and fine detail can be resolved in the fovea.

The visual system in this state of adaptation exhibits a spectral sensitivity to monochromatic optical radiation that is defined by the Standard Photopic Luminous Efficiency Function of Wavelength of Photopic Luminous Efficiency.

Scotopic Vision

This operating state of the visual system occurs at luminances less than approximately 0.001 cd/m². For these luminances only the large receptive fields consisting of rod photoreceptors respond to stimulation

There is no perception of color

The visual system in this state of adaptation exhibits a spectral sensitivity to monochromatic optical radiation that is defined by the Standard Scotopic Luminous Efficiency Function of Wavelength of the Luminous Efficiency.

Mesopic Vision

This operating state of the visual system is intermediate between the photopic and scotopic states. In the mesopic state both cones and rod photoreceptors are active.

The fovea maintains photopic spectral sensitivity through the mesopic region until vision fails because it contains only cone photoreceptors.

Luminances below approximately 10 cd/m² and above approximately 0.001 cd/m² produce this state of adaptation.

WHAT THIS SLIDE SHOWS

Photopic vision is cone dominated, scotopic vision rod dominated, and mesopic vision involves both. This changes visual sensitivity in dim settings.

EDITORIAL NOTE

The numerical boundaries on the slide are approximate and depend on the task and method.

Age and retinal exposure

Color transmissions & the age

The huge variation w.r.t. the sensitivity in the **spectral transmission of the human crystalline lens** exists between the ages of 40 and 59 years & the age of 60 and older.

The decrement in transmittance between these two age groups varies from 40% for 420 nm to 18% for 580 nm.

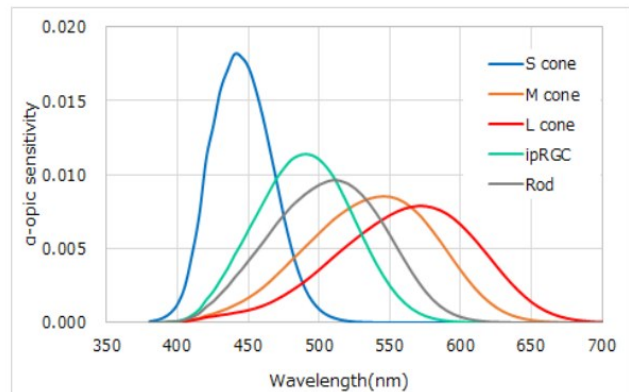
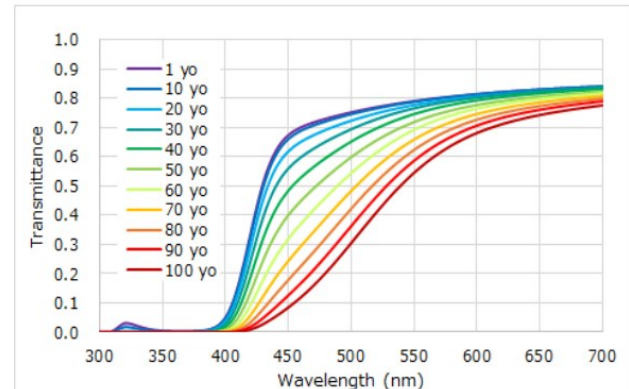
Though age is not the only parameter affecting crystalline transmission. **Moreover, the light transmitted decreases with age.**

This total transmission of light is similar to or lower than the amount that the different intraocular lenses transmit, even with a yellow or orange filter. The color of the human lens becomes yellowish and saturated with age.

Melanopsin's are the photopigments used by Retinal Ganglion Cells.

The spectral sensitivity differs from that of rods and cones making established photometric measures inappropriate for quantifying effective light exposure for this new photoreceptor.

The solution to this problem in which 'Melanopic' illuminance (m-lux) is estimated by weighting irradiance at each wavelength according to a sensitivity function



WHAT THIS SLIDE SHOWS

The eye's lens changes with age, often reducing transmission of shorter wavelengths. Individual lenses and ocular conditions vary.

EDITORIAL NOTE

Consider age, glare and available daylight when designing for mixed-age occupants; do not infer a single correction factor.

Blue light and context

Some of the main **concerns** revolve around risks associated with the **440 to 460nm blue peak** typical of nearly all white LEDs applied for general lighting, as exposed in numerous papers published over the last 15 years (e.g. ANSES 2010).

Specifically, these risks can lead to potential circadian rhythm disruption **(melanopic NIF influence)** and result in **retinal damage due to oxidative photodegradation** (so-called “*blue light hazard*” centered at 450nm) with possible links to age-related macular degeneration (ARMD).

There has lately been a strong rebuttal from the LED industry, citing publications such as the “True Colours” 2014 report from the *US Department of Energy* (DOE 2014) denoting that the **debate** should not be about LEDs, but rather about the **CCT of lighting** .

Other authoritative reports from the *International Energy Agency* (IEA 2014) and the *Scientific Committee on Emerging and Newly Identified Health Risks of the EC* (SCENIHR 2012)

WHAT THIS SLIDE SHOWS

Short wavelengths matter to both circadian response and retinal safety assessment. Timing and exposure conditions matter.

EDITORIAL NOTE

Blue-light hazard depends on radiance, duration and geometry. Typical white LED lighting is not automatically a retinal injury risk.

A colour perception exercise

**LET'S PLAY A GAME RELATED TO
COLOUR, PIGMENTATION & PHYSIOLOGY**

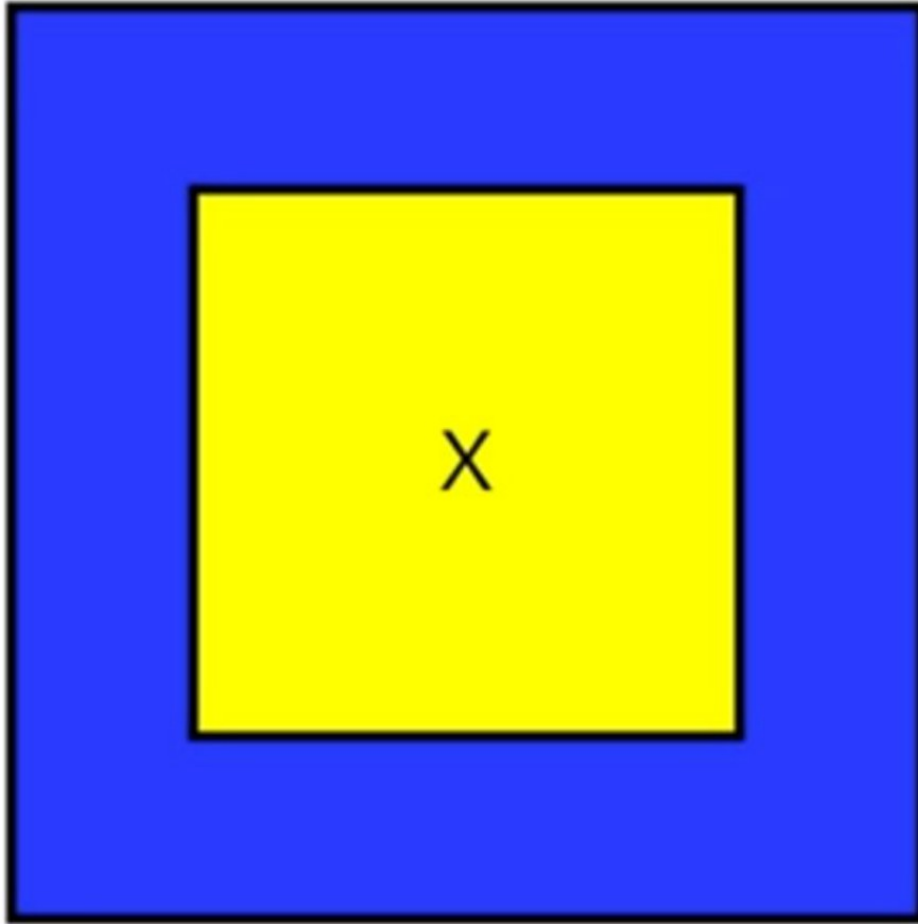
WHAT THIS SLIDE SHOWS

The slide introduces a short demonstration. The following pages preserve both versions of a coloured surround.

EDITORIAL NOTE

Compare the centre region before reading the explanation of opponent processing.

Coloured surround



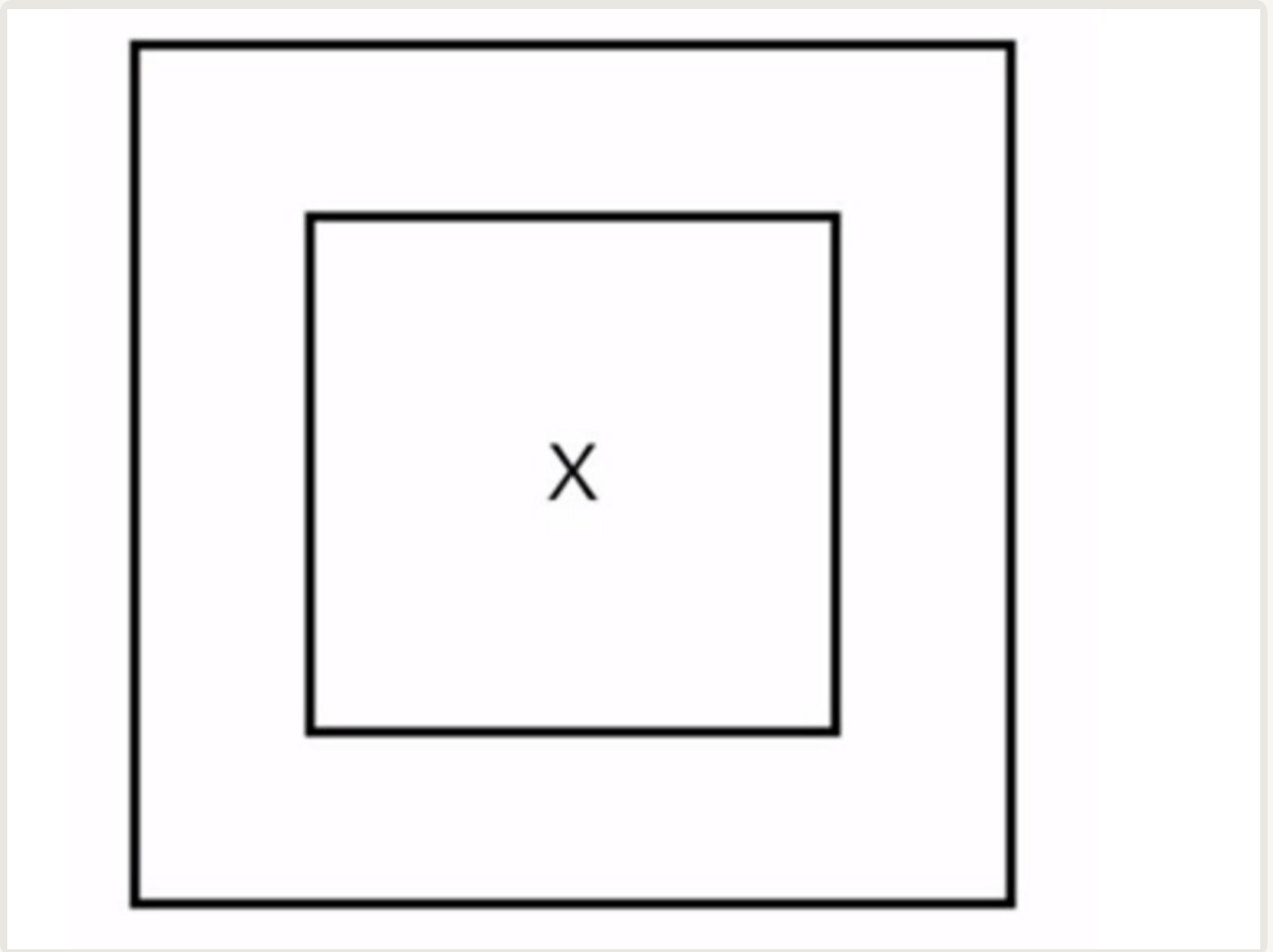
WHAT THIS SLIDE SHOWS

A yellow centre sits inside a blue field. Context can change the appearance of a colour even if the centre image stays the same.

EDITORIAL NOTE

Look at the X briefly, then turn the page and compare the perceptual effect.

Neutral surround



WHAT THIS SLIDE SHOWS

A light surround replaces the blue border. The exercise highlights colour contrast and visual adaptation.

EDITORIAL NOTE

Viewing conditions, display calibration and screen settings can change the effect.

Opponent signals

Though **color discrimination** arises from the different **spectral sensitivities** of the three cone photoreceptors.

(Signals from these cones do not directly produce color vision)

Cone signals form chromatic receptive fields which are circular center and concentric annular surround collections of photoreceptors circuited **to a ganglion cell**.

(The center/surround contributions are opposite, each being either excitatory or inhibitory)

The **receptive fields** involving cones **are circuited such that some center/surround pairs respond to (loosely stated) yellow and blue light**, other center/surround pairs to **red and green light**.

This is the basis for the two chromatic channels of visual information.

The third channel carries luminance information. Input from the three cone photoreceptors is apparently processed as to produce these three channels.

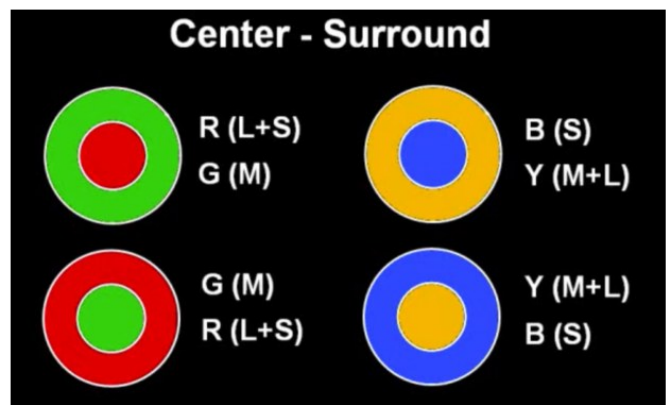
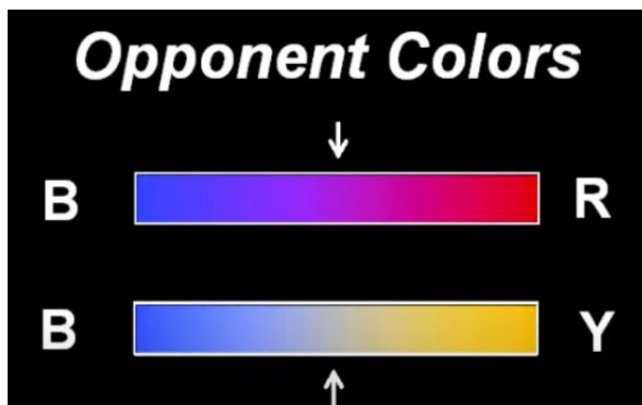
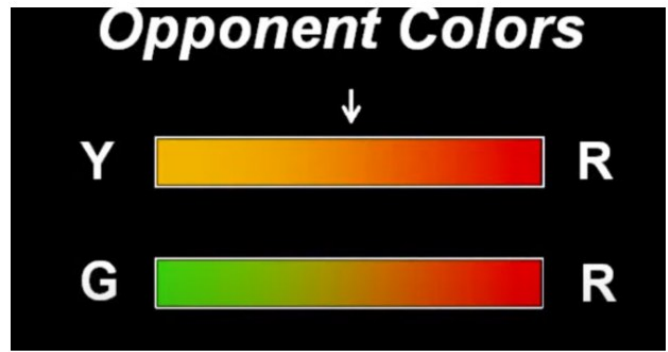
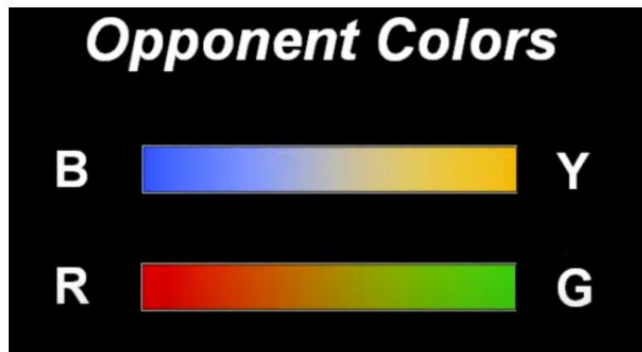
WHAT THIS SLIDE SHOWS

Cone outputs are recombined into opponent channels, commonly described in red-green and blue-yellow terms, plus a luminance pathway.

EDITORIAL NOTE

The diagram is a useful model, not a direct wiring diagram for every ganglion cell.

Centre and surround



CBLACWELL2013

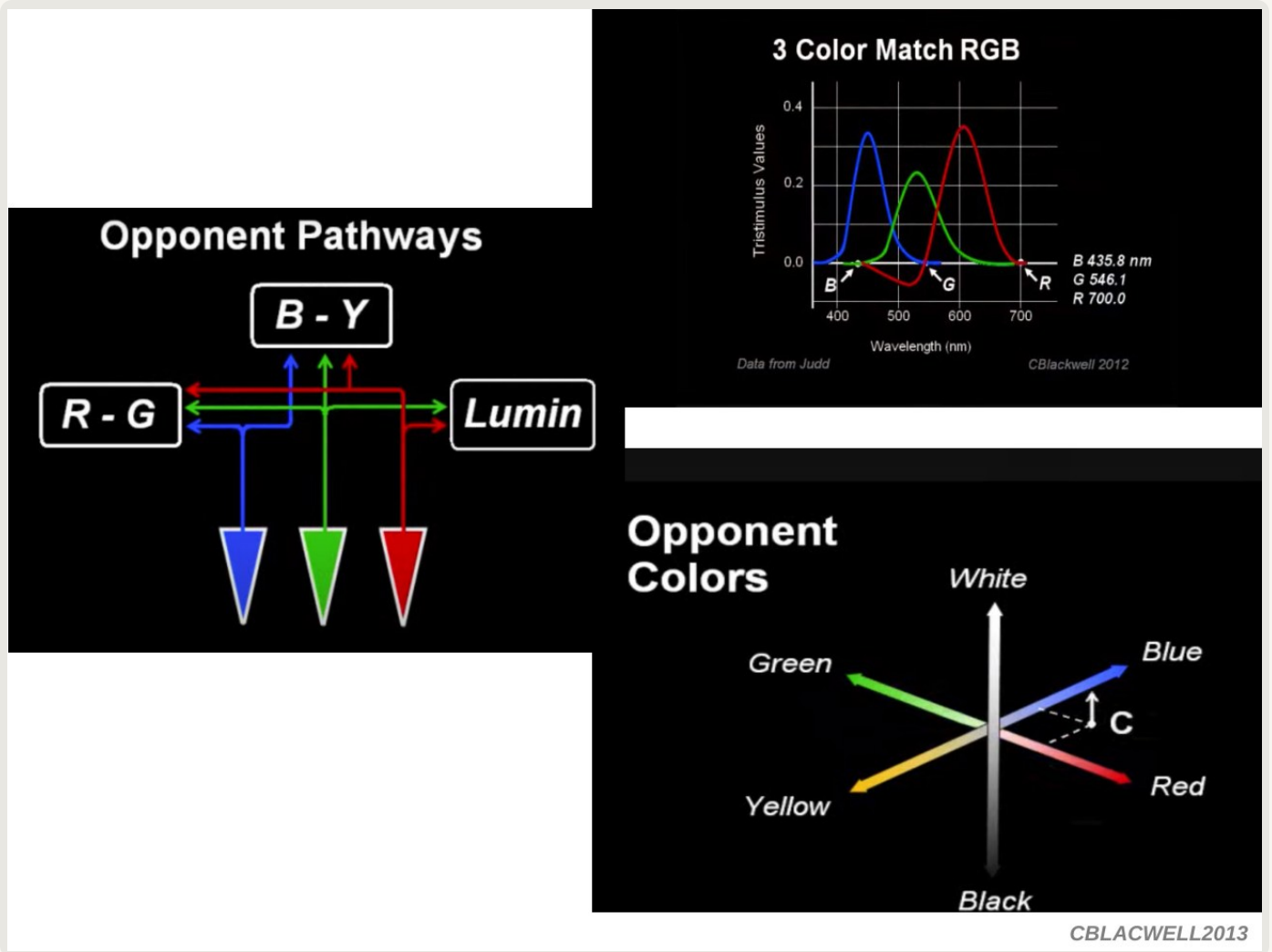
WHAT THIS SLIDE SHOWS

Neural receptive fields compare signals from a central region and its surround. This contributes to edge detection and colour contrast.

EDITORIAL NOTE

Surrounding finishes in a room can therefore change how a material appears.

Three matching functions



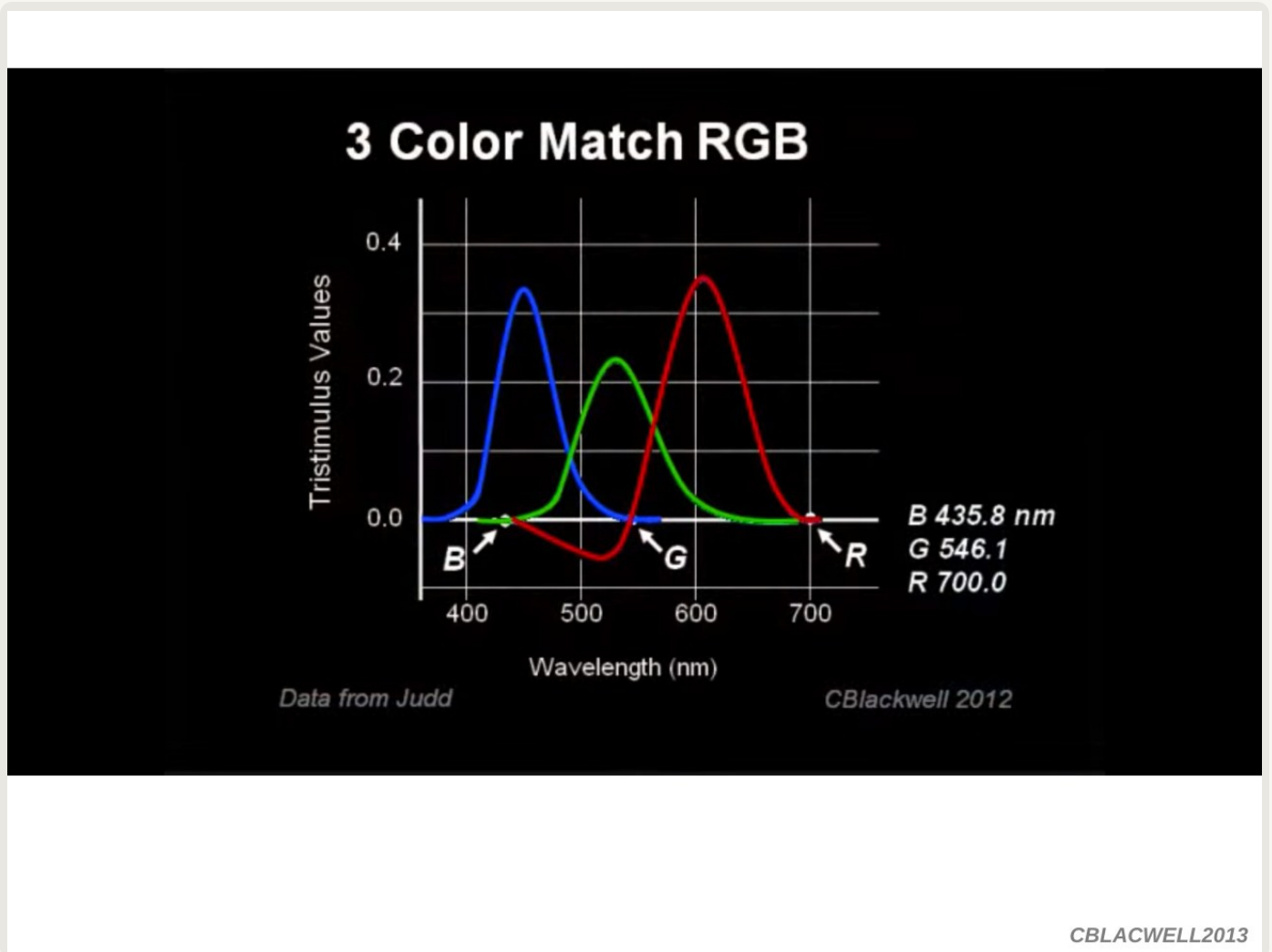
WHAT THIS SLIDE SHOWS

Three colour matching functions describe how combinations of primaries can match many colours for a standard observer.

EDITORIAL NOTE

The graphs explain measurement and matching; they do not directly predict every appearance in a finished room.

Opponent processing



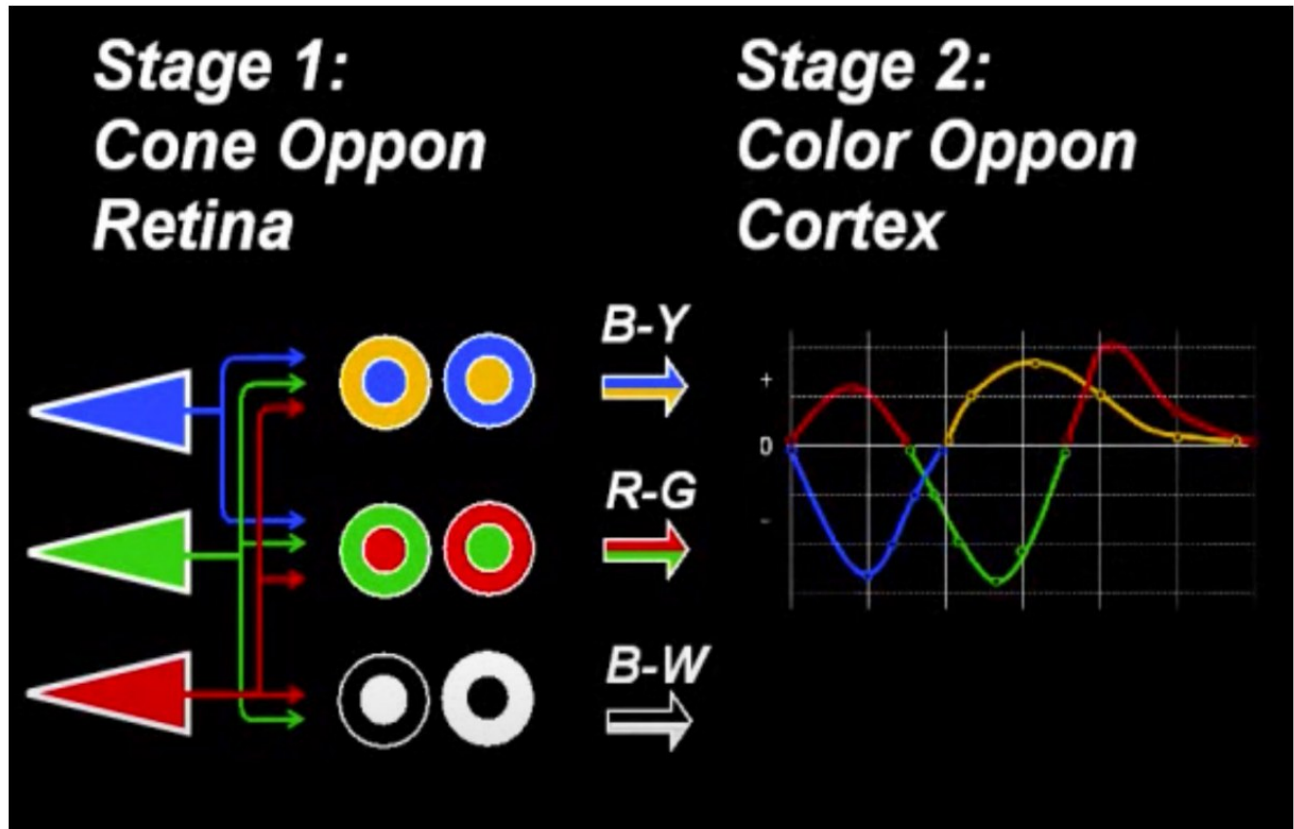
WHAT THIS SLIDE SHOWS

The slide brings colour matching and opponent pathways together. These are different stages in describing visual response.

EDITORIAL NOTE

Use the diagrams to ask how source spectrum and neighbouring surfaces interact.

From retina to cortex



CBLACWELL2013

WHAT THIS SLIDE SHOWS

The illustration sketches stages of colour-opponent processing along the visual pathway.

EDITORIAL NOTE

Colour experience depends on retinal signals and later processing, with adaptation and context affecting the result.

The LED analogy

LIGHT is to LED & LED is to Antibiotics

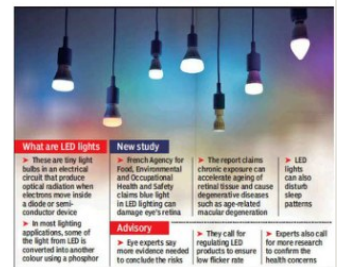
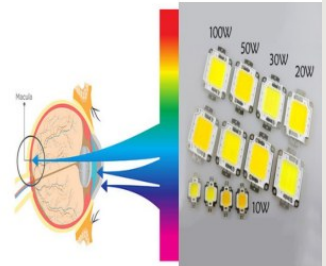
As Antibiotics are essential to treat bacterial infections. LEDs are efficient and provides us the flexibilities in the designs for many applications to be sufficed.

Too much of antibiotics weakens the immune system. the same goes for LEDs- inappropriate usage and farcical lighting designs can be detrimental to the brain, skin and the eyes.

Too much of increase in cortisol is too much of activity & which lowers the immune activities because of which they are unable to kill the cancer cells at an early stage & thus can lead to the cancer .

In the absence of UVB as a good character for VITAMIN-D, now-a-days almost many office goers have the deficiency of the same.

Too much of short wavelengths : Retinal damage, brain fatigue and so on



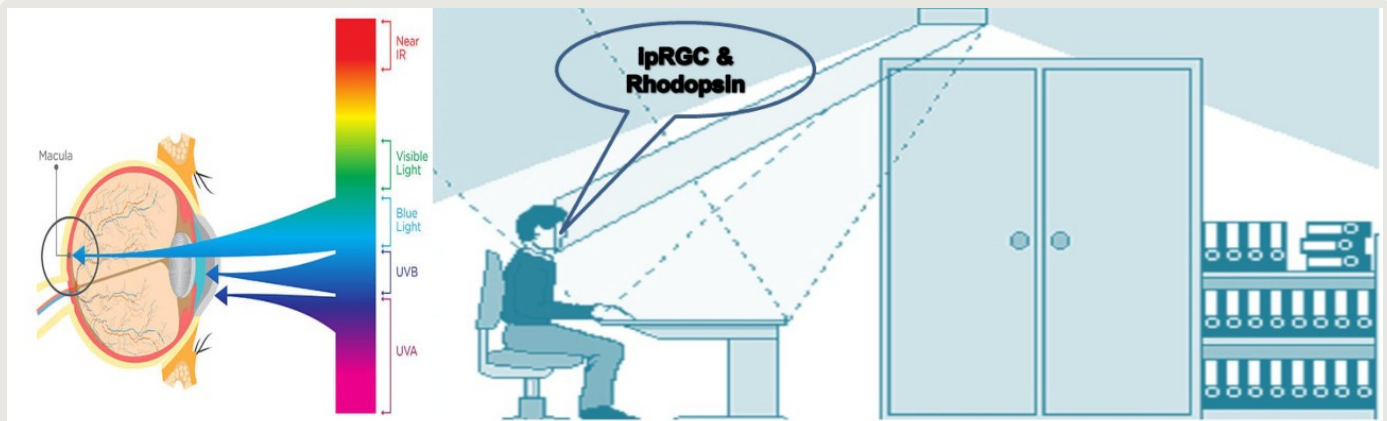
WHAT THIS SLIDE SHOWS

LEDs are flexible sources that can support good design. The analogy warns against using a technology without attention to dose and purpose.

EDITORIAL NOTE

The source slide's claims that LEDs weaken immunity or cause cancer are unsupported as general lighting statements. Avoid those claims.

Retinal safety and AMD



AMD :

This high energy blue light passes through the cornea and lens to the retina causing Age related macular degeneration (AMRD or AMD).

Macular degeneration causes loss in the centre of the field of vision. In dry macular degeneration, the centre of the retina deteriorates. With wet macular degeneration, leaky blood vessels grow under the retina. Blurred vision is a key symptom.

Reports have suggested that the **blue light severely damages retinal photoreceptor cells**. The short wavelength (blue) light usually recover Rhodopsin by photoreversal of bleaching in rod photoreceptor cells.

The exposure to blue LED lights affects 661 W cells and primary retinal cells. Furthermore, it is evaluated that the effects of an antioxidant, *N*-acetylcysteine (NAC), against the blue LED light-induced photoreceptor-derived cell damage.

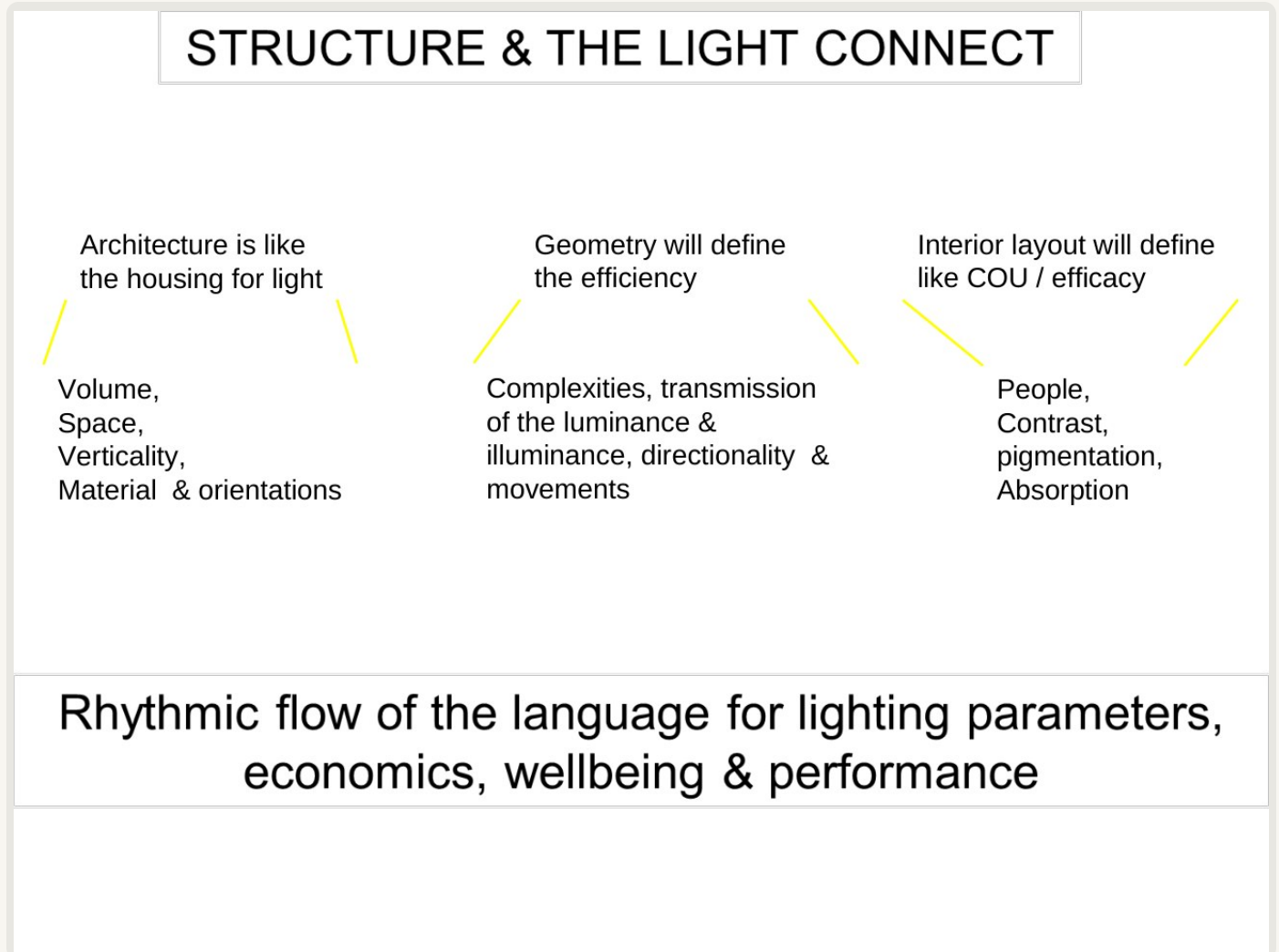
WHAT THIS SLIDE SHOWS

The slide raises a legitimate question about intense short-wavelength exposure, then overstates the evidence for everyday LED lighting and age-related macular degeneration.

EDITORIAL NOTE

Assess any hazardous source using recognized exposure limits. Do not state that normal white LED use causes AMD.

Building and light



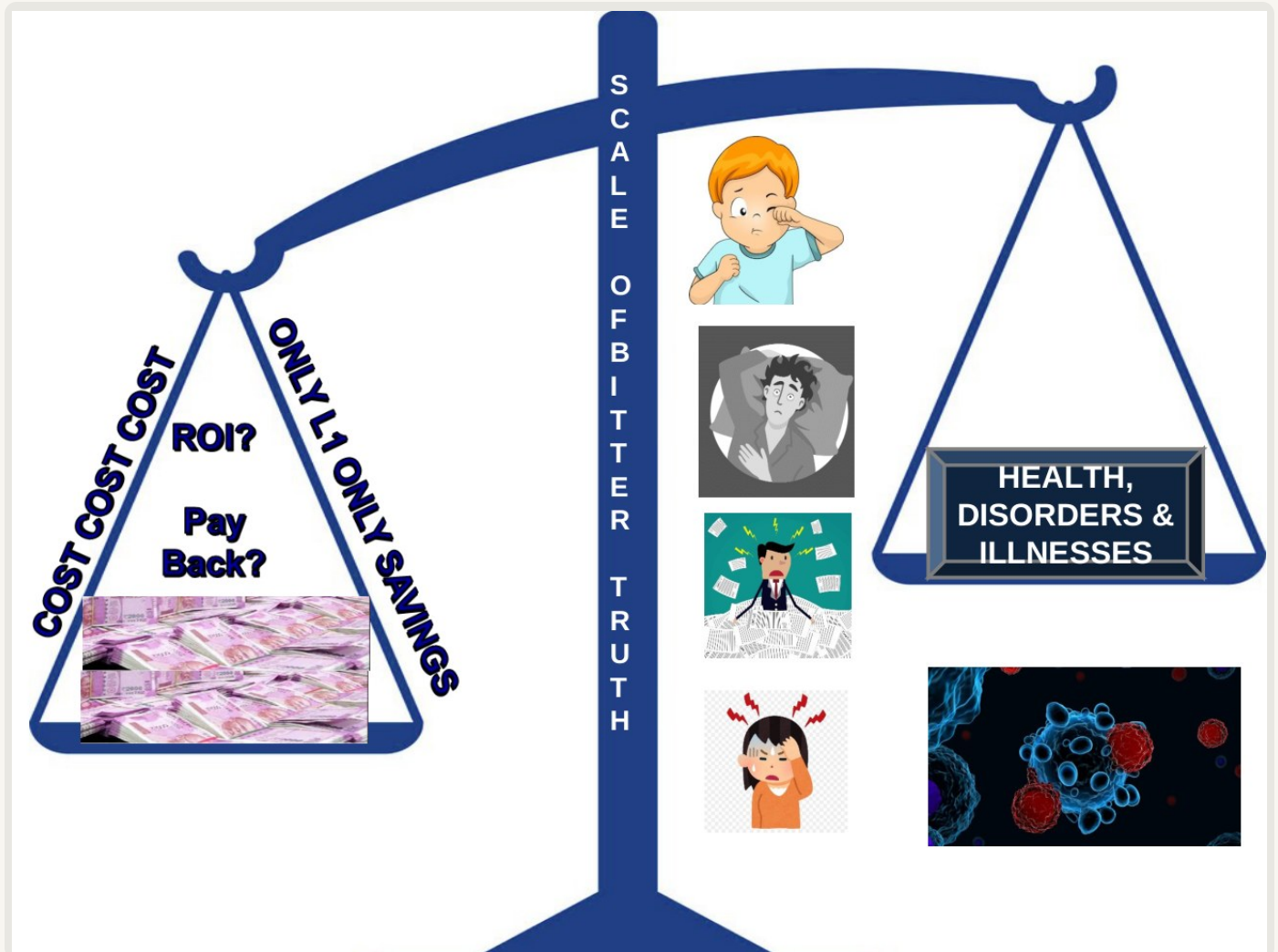
WHAT THIS SLIDE SHOWS

Building form, geometry and interior finishes influence light distribution, contrast and eye-level exposure.

EDITORIAL NOTE

Evaluate the complete room and installation rather than treating a lamp specification as the final answer.

Balancing outcomes



WHAT THIS SLIDE SHOWS

The closing image asks teams to balance costs and visual aims with wellbeing.

EDITORIAL NOTE

Define measurable visual and exposure goals. A balance scale cannot quantify health effects or replace clinical evidence.

Reading the evidence

The source

All 31 slide images are retained from “AN AWARENESS ON LIGHT & PHYSIOLOGY(1).ppt”, supplied by Girish Bhardwaj. Source slide labels and older claims remain visible as part of the original presentation.

Circadian pathways

Blume et al., “Effects of light on human circadian rhythms, sleep and mood,” *Somnologie* (2019), PMC6751071; Zisapel, “New perspectives on the role of melatonin in human sleep,” *Br J Pharmacol* (2018), PMC6057895.

Nonvisual measurement

CIE S 026/E:2018, System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light. Consult the CIE alpha-opic toolbox user guide for calculation conventions.

Retinal safety

CIE Position Statement on the Blue Light Hazard (2019), cie.co.at/publications/position-statement-blue-light-hazard-april-23-2019. Evaluate exposure and viewing geometry rather than using LED or CCT alone as a risk label.

For building teams

The editorial notes distinguish an illustration from evidence of a health outcome. Medical diagnoses and treatments require clinical expertise. A building brief can document timing, spectrum, eye-level exposure, glare and intended occupants.

A hand holding a glowing lightbulb against a sunset sky with clouds. The lightbulb is in the foreground, and the background is a vast sky with soft, golden light from the setting sun. The text "Light is the governor of the universe©" is overlaid on the image.

Light is the governor of
the universe©

LIGHT MOVES THROUGH US

The eye receives light. The brain reads its timing. The building shapes the exposure.

A visual guide for owners, architects, interior designers and lighting specifiers.

GIRISH BHARDWAJ