

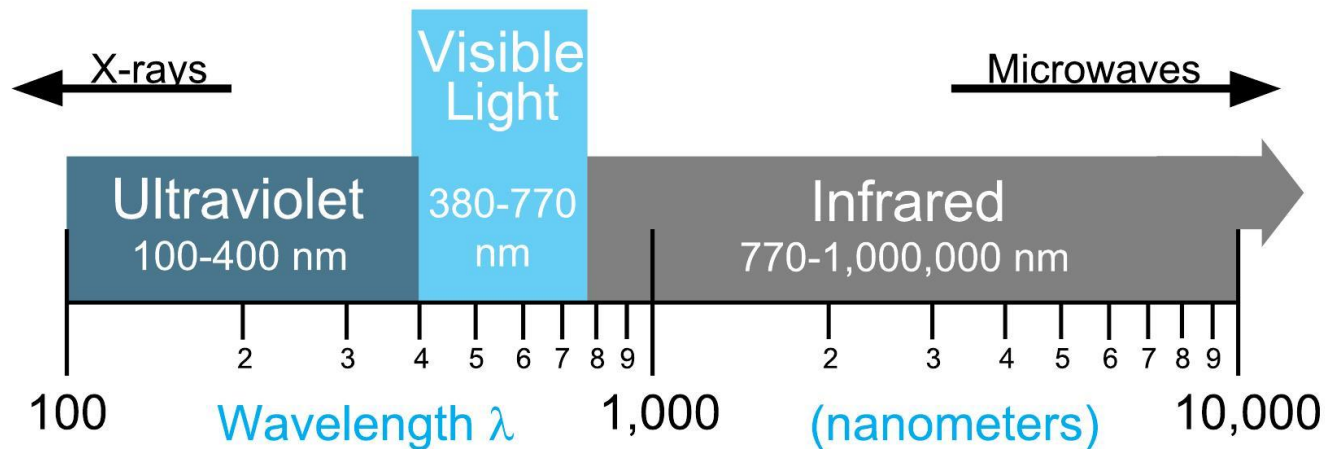
# Lighting: Hygienic Approaches

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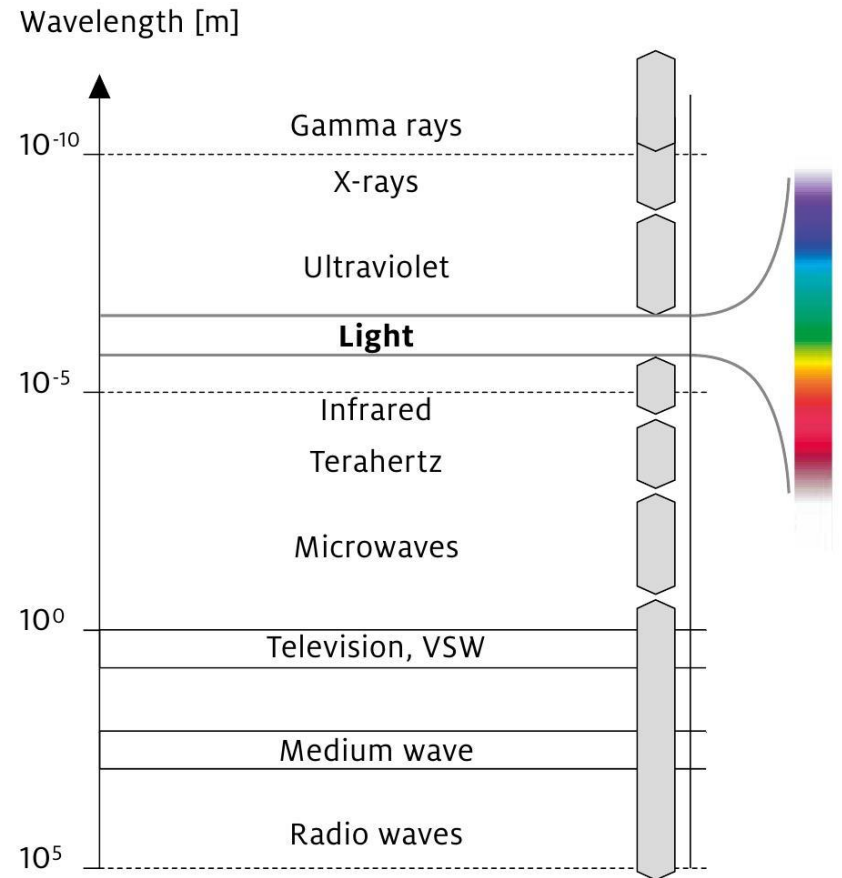
# What is light?

- Light is just one portion of the various electromagnetic waves flying through space.
- The electromagnetic spectrum covers an extremely broad range, from radio waves with wavelengths of a meter or more, down to x-rays with wavelengths of less than a billionth of a meter. Optical radiation lies between radio waves and x-rays on the spectrum, exhibiting a unique mix of ray, wave, and quantum properties.



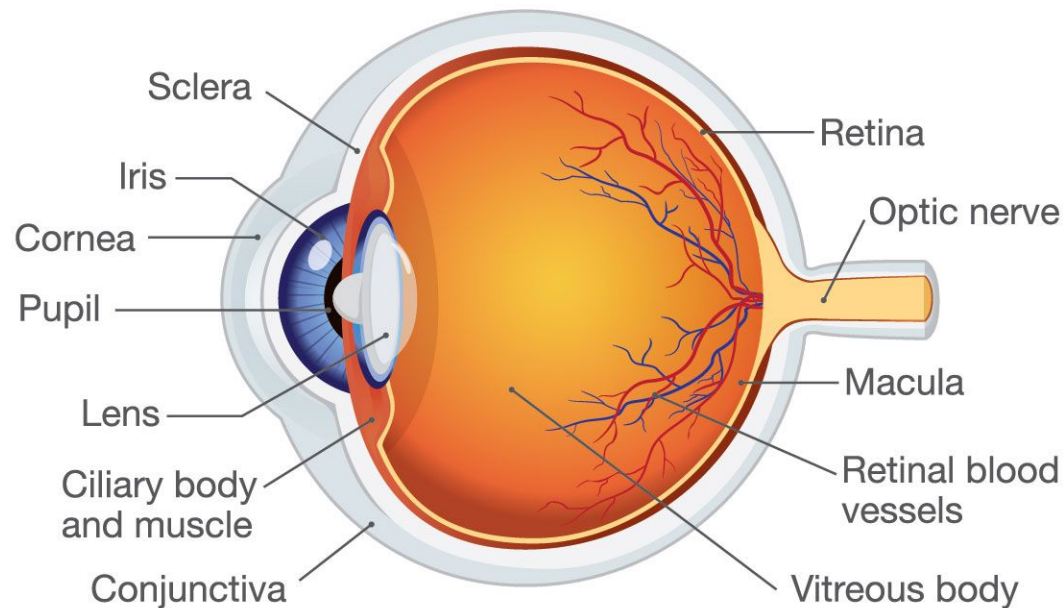
# What is light?

- Light is that part of the electromagnetic spectrum that is perceived by our eyes.
- The wavelength range is between 380 and 780 nm
- 1 nm (nanometer) =  $10^{-9}$  meters



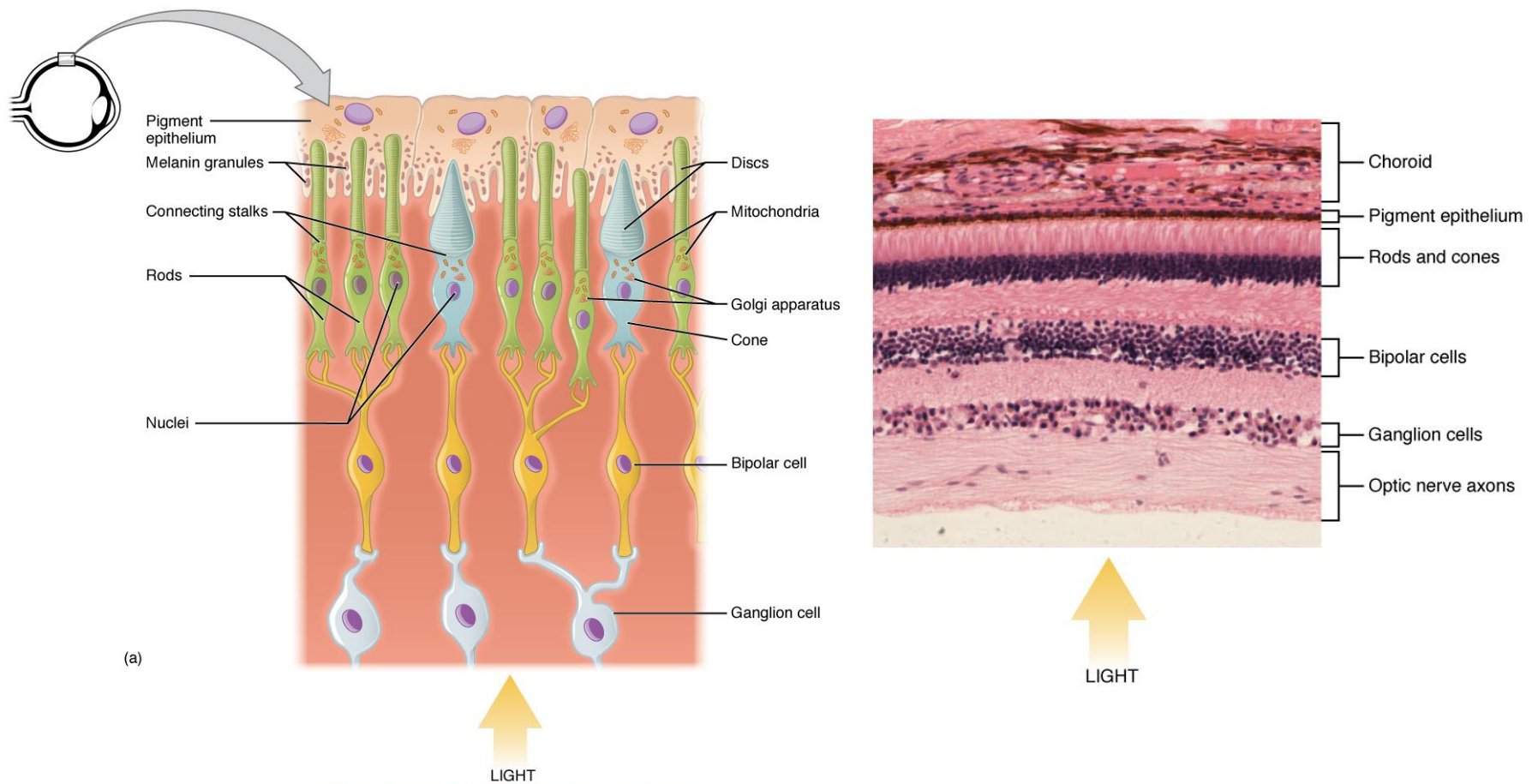
# Perception of light by eyes: anatomy

- Light perceived by special cells: **cones** and **rods**
- Cones and rods located at **retina**



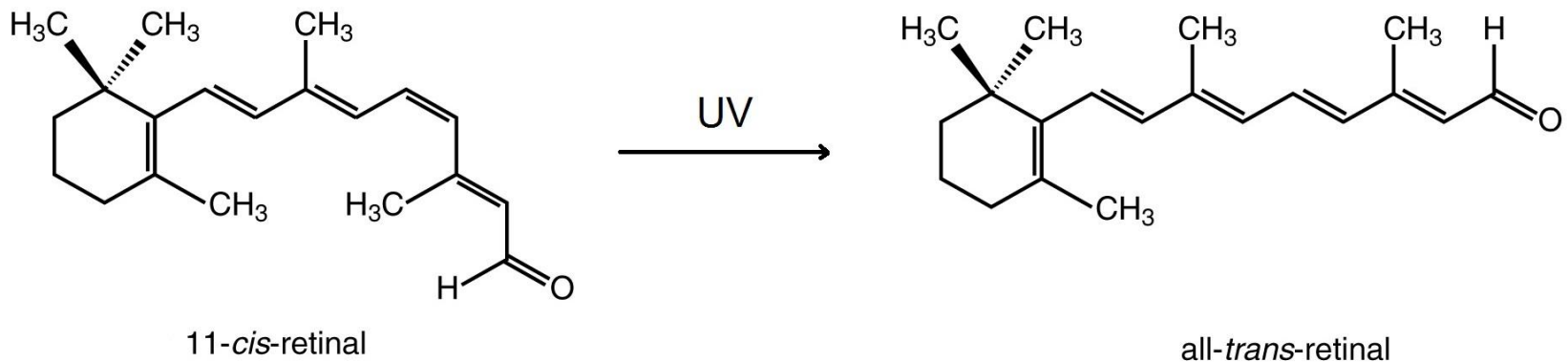
# Perception of light by eyes: histology

- Cones and rods are photoreceptor neuroepithelial cells



# Perception of light by eyes: biochemistry

- Photoreceptor cells contain a chromophore (**11-cis retinal**, the aldehyde of Vitamin A1 and light-absorbing portion) bound to cell membrane protein, **opsin**.
- Light perception starts from light photon interaction with the retinal in a photoreceptor cell. The retinal undergoes **isomerisation**, changing from the **11-cis** to **all-trans** configuration. That causes conformational change of **opsin** and undergoing change of membrane potential.



# Light has a triple effect

- Light for visual functions
  - Illumination of task area in conformity with relevant standards
  - Glare-free and convenient
- Light for emotional perception
  - Lighting enhancing architecture
  - Creating scenes and effects
- Light creating biological effects
  - Supporting people's circadian rhythm
  - Stimulating or relaxing

# Basic parameters used in lighting

- Luminous flux (Lumen, lm) (Сила света)
- Luminous intensity (Candela, cd) (Интенсивность света)
- Illuminance (Lux, lx) (Освещенность)
- Luminance ( $\text{cd}/\text{m}^2$ ) (Яркость)

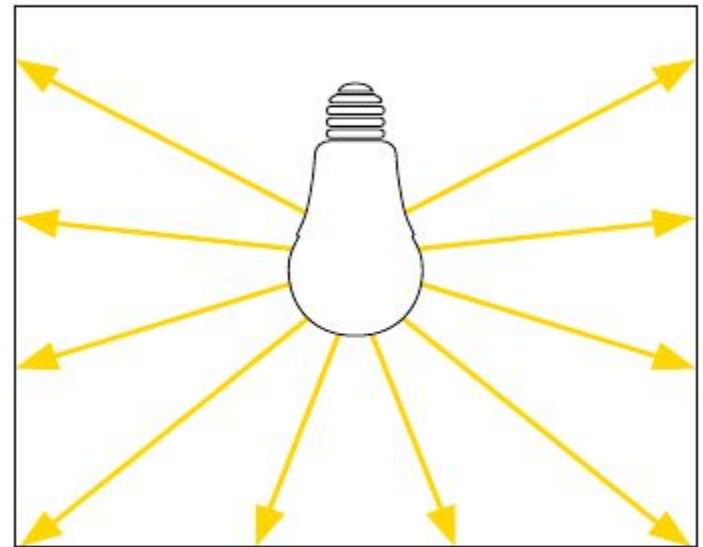




# Luminous flux

- The luminous flux describes the quantity of light emitted by a light source.
- The luminous efficiency is the ratio of the luminous flux to the electrical power consumed (lm/W). It is a measure of a light source's economic efficiency.
- Units: Lumen

## Luminous flux $\Phi$

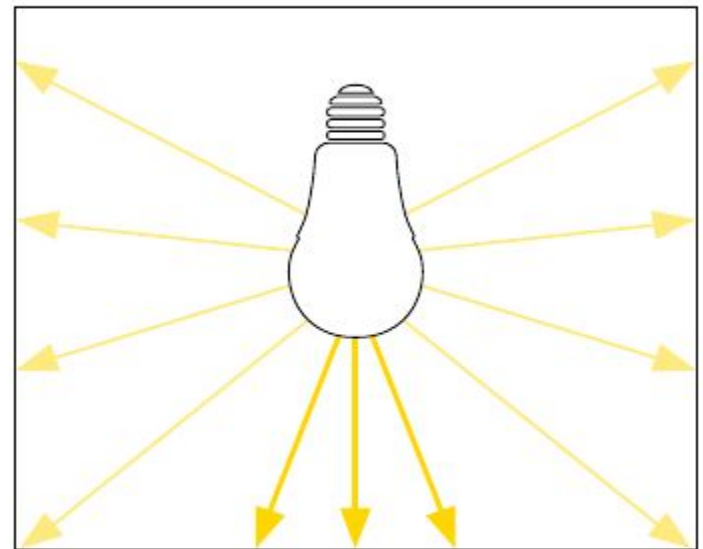


Lumen [lm]

# Luminous intensity

- The luminous intensity describes the quantity of light that is radiated in a particular direction. This is a useful measurement for directive lighting elements such as reflectors.
- Units: Candela

## Luminous intensity I



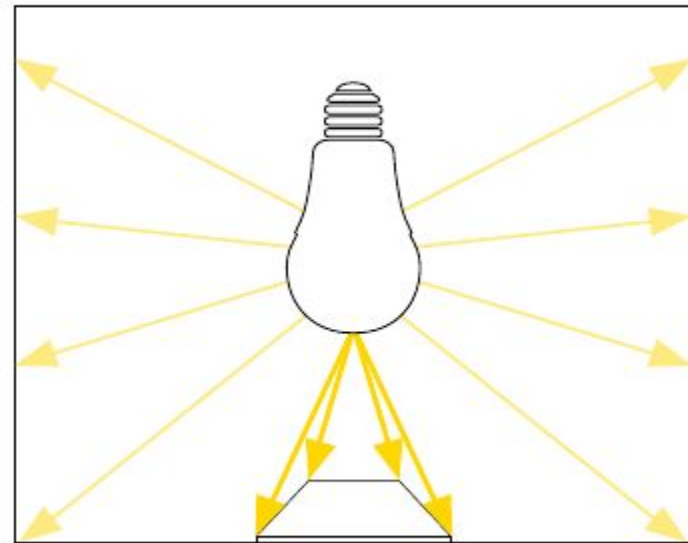
Candela [ $\text{lm}/\text{sr}$ ]=[cd]

# Illuminance

- Illuminance describes the quantity of luminous flux falling on a surface. Relevant standards specify the required illuminance.
- Units: Lux

$$\text{Illuminance: } E(\text{lx}) = \frac{\text{luminous flux (lm)}}{\text{area (m}^2\text{)}}$$

## Illuminance E

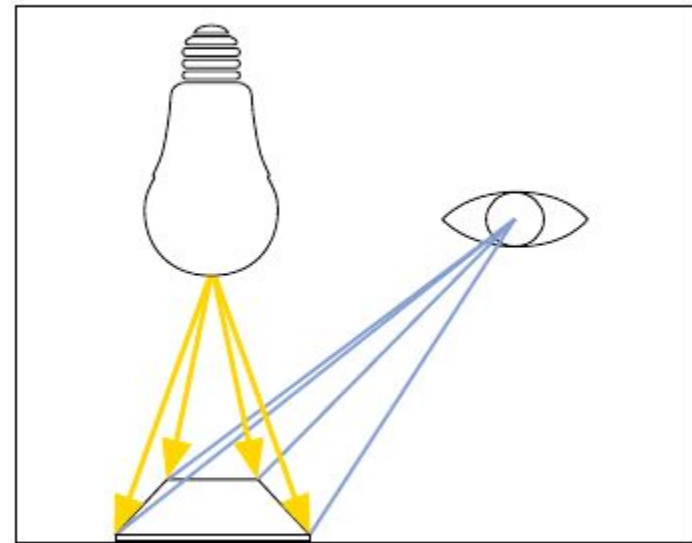


$$\text{Lux [lm/m}^2\text{]=[lx]}$$

# Luminance

- Luminance is the only basic lighting parameter that is perceived by the eye.
- It describes on the one hand a light source's impression of brightness, and on the other, a surface and therefore depends to a large extent on the degree of reflection (colour and surface).
- Units:  $\text{cd}/\text{m}^2$

## Luminance L

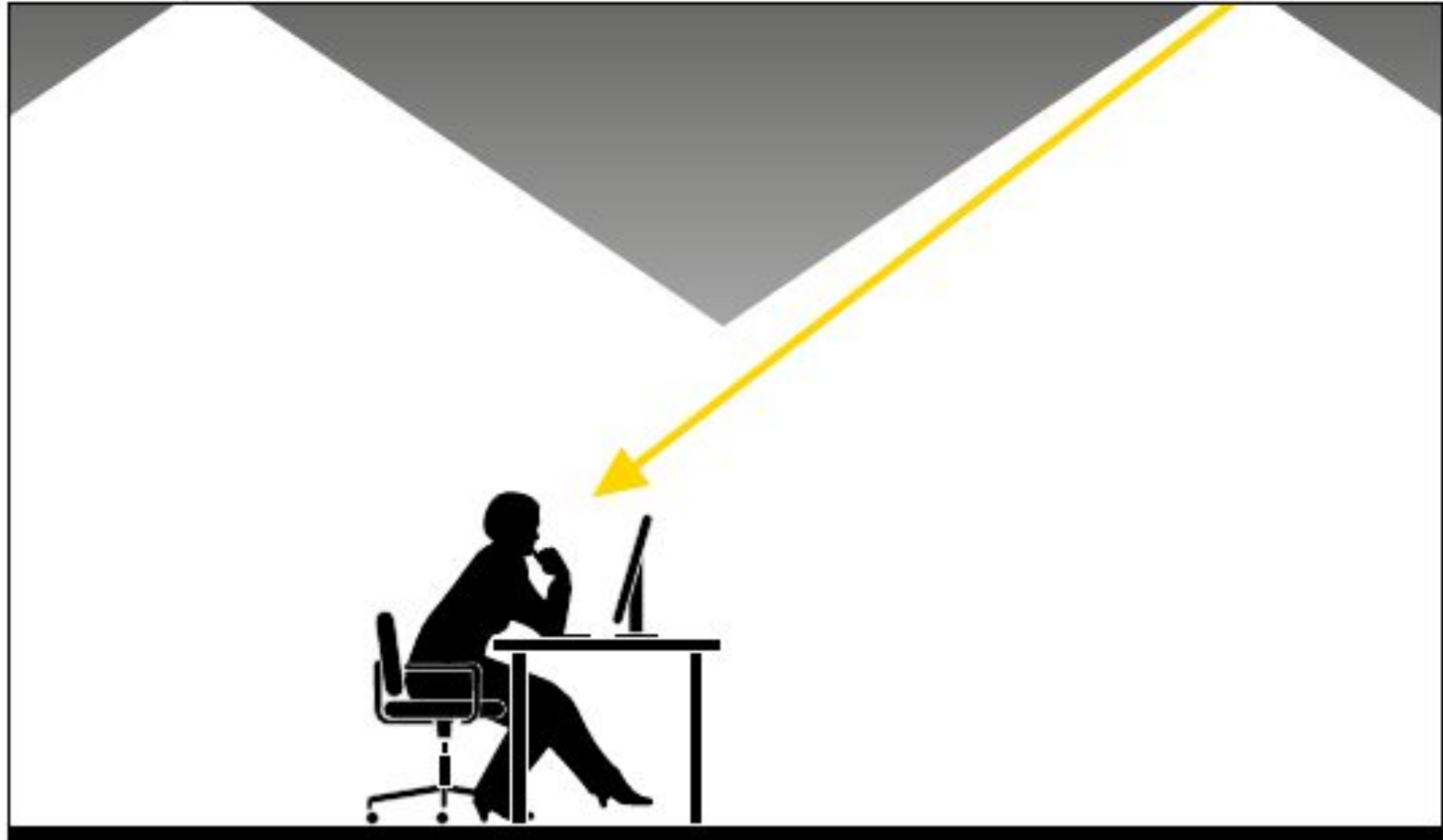


$$[\text{lm}/\text{sr} \cdot \text{m}^2] = [\text{cd}/\text{m}^2]$$

# Quality criteria of lightning

- Sufficient illumination level
- Harmonious brightness distribution
- Glare limitation
- Avoidance of reflections
- Good modelling
- Correct light colour
- Appropriate colour rendering
- Changing lighting situations
- Personal control
- Energy efficiency
- Daylight integration
- Light as an interior design element

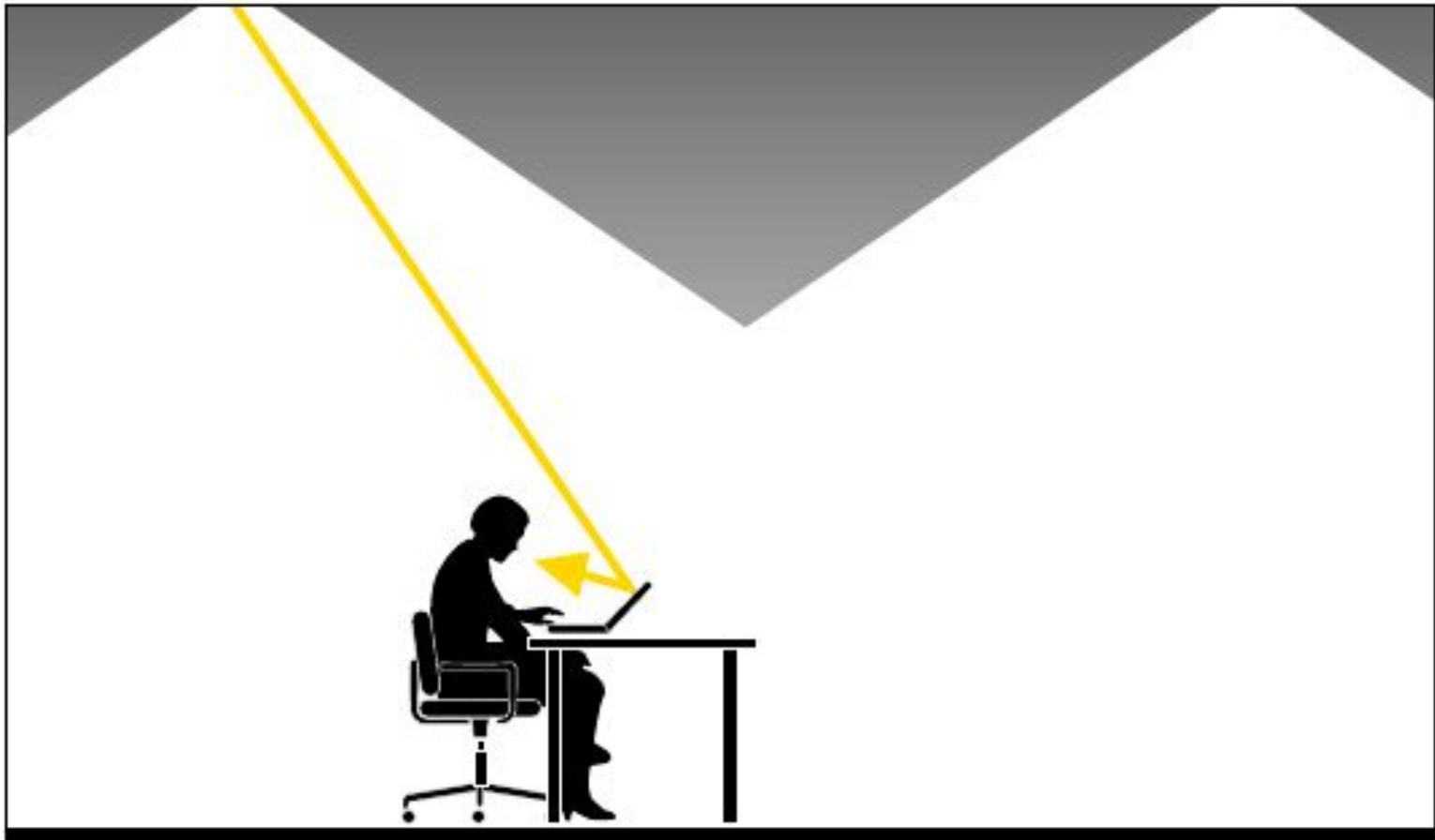
# Direct glare



# Glare limitation for direct glare

- Cause
  - Luminaires without glare control
  - Very bright surfaces
- Effect
  - Loss of concentration
  - More frequent mistakes
  - Fatigue
- Remedy
  - Luminaires with limited luminance levels
  - Blinds on windows

# Reflected glare





# Glare limitation for reflected glare

- Cause
  - Reflective surfaces
  - Incorrect luminaire arrangement
  - Incorrect workstation position
- Effect
  - Loss of concentration
  - More frequent mistakes
  - Fatigue
- Remedy
  - Matching luminaire to workstation (layout)
  - Indirect lighting
  - Matt surfaces

# Light colour

- Light colour measured in Kelvins (K)
- The light colour describes the colour appearance of the light.

	<b>Colour temperature</b>	<b>Appearance</b>	<b>Association</b>
<b>Warm white</b>	up to 3300 K	reddish	warm
<b>Intermediate white</b>	3300–5300 K	white	neutral
<b>Cool white</b>	from 5300 K	bluish	cool

# Measuring illuminance

- Measurement tool called **Luxmeter**



# Types of lighting

- Direct lighting
- Indirect lighting
- Indirect/direct lighting



# Direct lighting

- Light falls from the luminaires on the ceiling directly onto the workplace, in part highly directional
- Glare suppression is important under flat angles
- The ceiling can appear dark (cave effect)
- The workplace layout should not allow any shadows
- High energy efficiency is achieved for the work area

# Indirect lighting

- Light is directed to the ceiling and walls so that it illuminates the workplaces indirectly
- The lighting effect may appear diffuse through the absence of shadows
- The room increases in height
- The light is glare-free
- Workplaces can be arranged at random
- Lower energy efficiency

# Indirect/direct lighting

- Light is directed to the workplace directly and indirectly via the ceiling from suspended luminaires or free-standing luminaires
- Pleasant room visuals
- High user acceptance
- Good contrast ratios
- Flexible workplace layout with an indirect share of > 60 %
- Good combination of energy efficiency and lighting quality

# Standard values for lighting of workplaces

- **Illuminance levels** must not fall below the **maintenance values** in the visual task area.
- If the precise location is not known, the limit should be applied to the whole room or a specific working area.
- Maintenance levels:
  - School and university classes: 300 lx
  - Pediatrics medical room: 500 lx
  - Operating room: 500 lx
  - X-rays diagnostic rooms: 400 lx



# Application areas of lighting

Light for Offices and Communication



# Application areas of lighting

## Light for Offices and Communication

- Working and feeling at ease
  - Making work easier: Complying with standards (adjusting illuminance levels to tasks). Avoiding glare by light
  - Creating an identity: Lighting design in the overall architectural context
  - Promoting health: Adjusting biologically effective light to the circadian day/night rhythm. Daylight as preferred source of light
  - Employees as a cost factor: Staff cost analysis in comparison with investment and operating costs. Result: lighting solutions must be subject to people's demands. Light enhances people's performance and creativity.

# Application areas of lighting

## Light for Offices and Communication

- Technology and flexibility
  - Creating different zones: Structuring and orientation in space through lighting design for vertical surfaces, transit areas, pools of light etc. Arranging groups using lighting management
  - Bolstering activity: Adjustment through lighting management. Taking into account changing work media (such as tablets): no high luminance levels at steep angles
  - Preserving individuality: Keeping demographic trends in mind. Lighting management for individual control options
  - Being flexible: Glare limitation at all angles for flexible utilisation of space

# Application areas of lighting

Light for Education and Science



# Application areas of lighting

## Light for Education and Science

- Environmental aspects
  - Use of daylight: Energy efficiency through lighting management
  - Efficient luminaires and intelligent control: LED solutions are highly efficient. Frequent dimming and switching does not affect the LEDs' service life
- Ergonomic compatibility
  - Performance and concentration: Standards cover basic visual requirements such as glare or illuminance. Emotional components enhance concentration. Open room ambience thanks to brightening up of ceiling and walls

# Application areas of lighting

## Light for Education and Science

- Ergonomic compatibility
  - Feeling at ease and health: Feeling at ease enhances people's performance. Light stabilises the inner biological clock, measurably stimulates hormonal processes. Medical evidence shows that light enhances cognitive performance
  - Adjusting light to activities and visual tasks: Blackboard lighting: high visual demands because of accommodation required from the eye for close and distant vision when reading and copying from the blackboard



# Application areas of lighting

Light for Health and Care



# Application areas of lighting

## Light for Health and Care

- Health and activity
  - Quality for patients and persons in need of care: Taking into account dementia patients. Avoiding mirror effects and reflections (delusions)
  - Feeling at ease and supporting the inner clock: In many healthcare facilities, no daylight – an important means of stabilising the inner clock – is available. Little time is spent outdoors. Compensation by artificial lighting: well-adjusted changes in light colours and illuminance levels. High intensity in pools of light



# Application areas of lighting

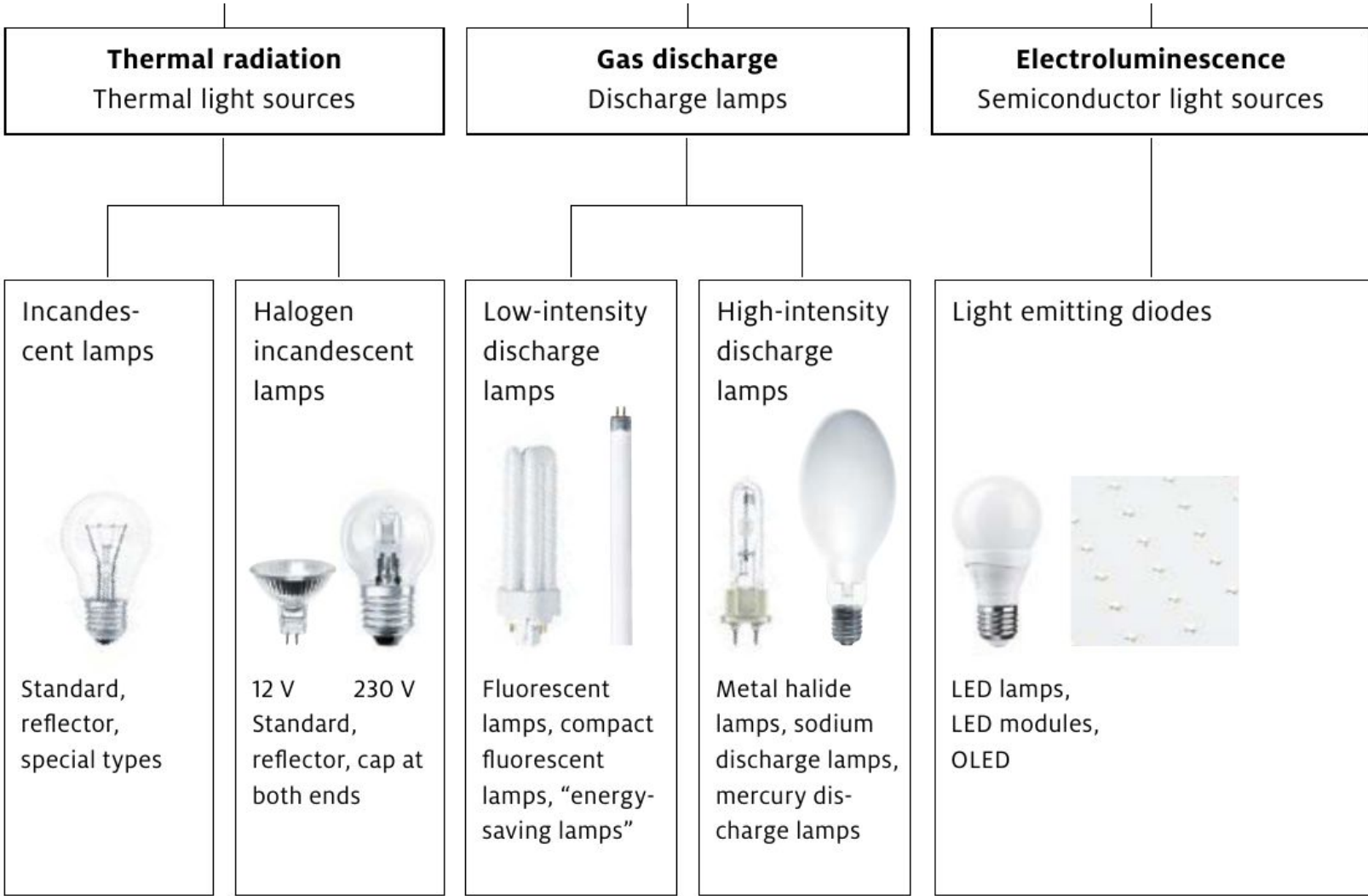
## Light for Health and Care

- Reliability and functionality
  - Visual comfort and security for patients and residents: Emergency lighting. Providing orientation. Avoiding heavy shadows and dark zones. Pleasant corridor design using indirect light components on ceiling and walls
  - Supporting diagnosis and treatment: Increase in illuminance levels: at the press of a button at the patient's bedside or via additional light components. High colour rendering index
  - Optimising doctors' and nurses' working conditions: Individual settings, intuitive operation. Where people work at night: support the circadian rhythm with biologically effective lighting

# Light production

- Light can be produced in a large number of different ways – naturally or artificially.
- Light is produced cost-effectively by using four main groups of light sources:
  - Thermal light sources
  - Low-intensity discharge lamps
  - High-intensity discharge lamps
  - Semiconductor light sources

# Light production



Thanks for attention!

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