

The effect of visible light on human health and implications for the work environment

Martin Jennings



United Nations
Educational, Scientific and
Cultural Organization



International
Year of Light
2015

Overview

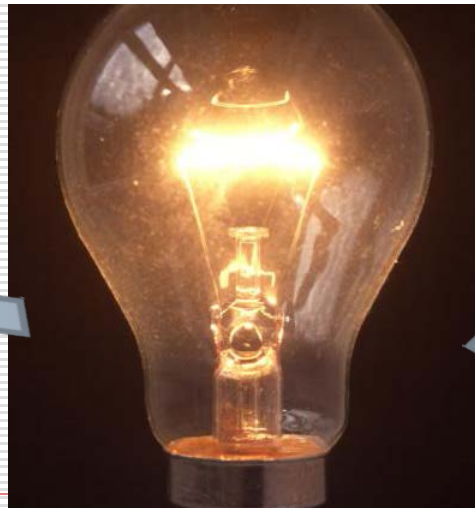
- Introduction
- The Eye and Light Receptors
- The non-Visual Response to Light
- Lighting and Health in Humans
- The ACGIH TLV for Visible Light
- Lighting and Ergonomics
- A New Exposure Standard
- Conclusion & Recommendations

Lighting and Human Evolution

- ❑ The role of the light/dark cycle
- ❑ Artificial light - a recent phenomenon
- ❑ Now exposed to high levels of light at night (LAN)
- ❑ Widespread working in hours of darkness



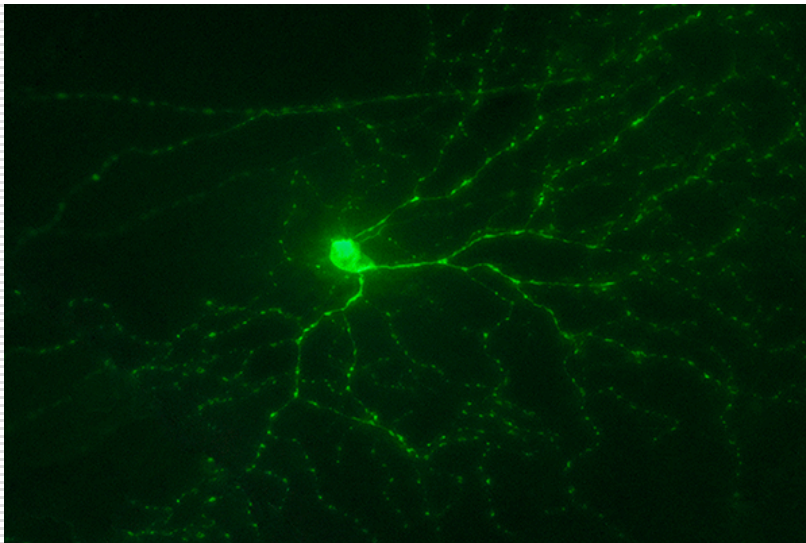
Advances in lighting technology



27 April 2015

10th IOHA Conference, London

Intrinsically photosensitive Retinal Ganglion Cells (ipRGCs)



- ❑ Contain melanopsin
- ❑ Action spectrum approximates to melatonin
- ❑ Peak at 460 – 480 nm
- ❑ Slow kinetics
- ❑ Play a vital role in entrainment of circadian rhythms

Image credit: GFP positive ganglion cell provided by [Ning Tian, M.D., Ph.D.](#), photographed by [Bryan William Jones, Ph.D.](#)

<http://webvision.med.utah.edu/2012/11/interesting-review-intrinsically-photosensitive-retinal-ganglion-cells/>

Non visual response to light

- Melatonin secretion by pineal gland
- Circadian disruption
- Linked to diseases such as
 - Breast cancer
 - Cardiovascular disease
 - Diabetes
 - Obesity, and
 - Sleep disorders

Five principles of healthy lighting

1. The daily light dose received by people in Western [i.e., industrialized] countries might be too low.
2. Healthy light is inextricably linked to healthy darkness.
3. Light for biological action should be rich in the regions of the spectrum to which the non-visual system is most sensitive.
4. The important consideration in determining light dose is the light received at the eye, both directly from the light source and reflected off surrounding surfaces.
5. The timing of light exposure influences the effects of the dose.

ACGIH TLV: Easy to apply??

700

$$\sum_{305} E_{\lambda} \cdot t \cdot B(\lambda) \cdot \Delta\lambda \leq 10\text{mJ/cm}^2 \quad (t \leq 104\text{s})$$

305

700

$$\sum_{305} E_{\lambda} \cdot B(\lambda) \cdot \Delta\lambda \leq 1.0 \mu\text{W/cm}^2 \quad (t > 104\text{s})$$

305

Blue-light hazard

- ❑ Under normal conditions when light hits a photoreceptor, the cell bleaches and becomes useless until it has recovered through a metabolic process called the visual cycle
- ❑ The mechanisms for photochemical induced retinal injury are caused by the absorption of light by photoreceptors in the eye
- ❑ Potential for a photochemical induced retinal injury from EMR at wavelengths between 400 - 500 nm
- ❑ Not shown to occur in humans, only inconclusively in some rodent and primate studies

Lighting surveys

- ❑ Quantitative, not qualitative
- ❑ Measure illuminance as being adequate for the task
- ❑ Ergonomic issue, not health



WHS Legislation

- A PCBU must ensure lighting enables each person to carry out work without risk to health and safety



Parameters for an exposure standard

- Wavelength (nm)
- Timing (00.00 – 24.00 hrs)
- Intensity (lux)
- Duration (h/m/s)
- Pattern of light exposure (continuous, intermittent, etc.)

Measuring exposure

- Daysimeter – a personal circadian light exposure and activity meter
 - Photopic illuminance
 - Circadian response to light
 - Activity (with 2 accelerometers)



An emission standard

- ❑ Sensitivity to daylight, photopic luminous efficiency function $V(\lambda)$, where λ is the wavelength, peaks at 555nm
- ❑ Circadian function, $c(\lambda)$ peaks at 460 nm
- ❑ Lamp spectra are weighted ‘biologically’ against $c(\lambda)$ and then compared to spectra weighted with respect to the $V(\lambda)$
- ❑ The ratio of both scores is defined as the circadian factor
- ❑ The Lighting Technology Standards Committee FNL 27 (Effects of light in Humans) has incorporated $c(\lambda)$ into the German pre-standard DIN V 5031-100
- ❑ This enables a qualitative comparison of the biological effectiveness of light sources

Conclusions

- ❑ Neuroendocrine effects of light on health are too significant to ignore
- ❑ More needs to be known of the relationship between light and non-visual receptors of the eye
- ❑ A standard may be a function of 5 parameters, and may include daylight component
- ❑ Emission standard is more practical

Questions?

Lighting and Human Evolution

- ❑ The role of the light/dark cycle
- ❑ Artificial light is a recent phenomenon
- ❑ High levels of light at night (LAN)
- ❑ Widespread working in hours of darkness



The Caveman's Guide to
Quality Sleep

www.sleepwarrior.com



▲ Estimated Breast Cancer Incidence Worldwide in 2008

