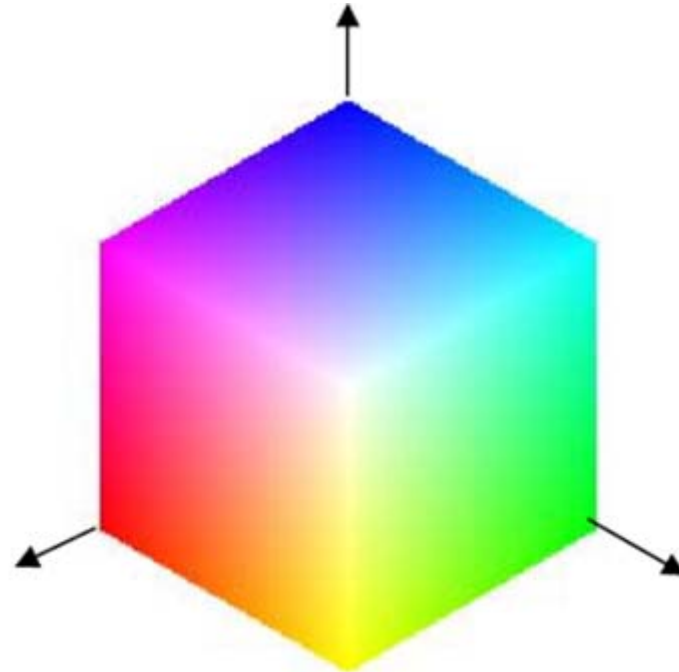




Image Processing II

Color images

Part 1 – Additive and subtractive color mixing





Color Fundamentals

Spectral sensitivity of the photoreceptors

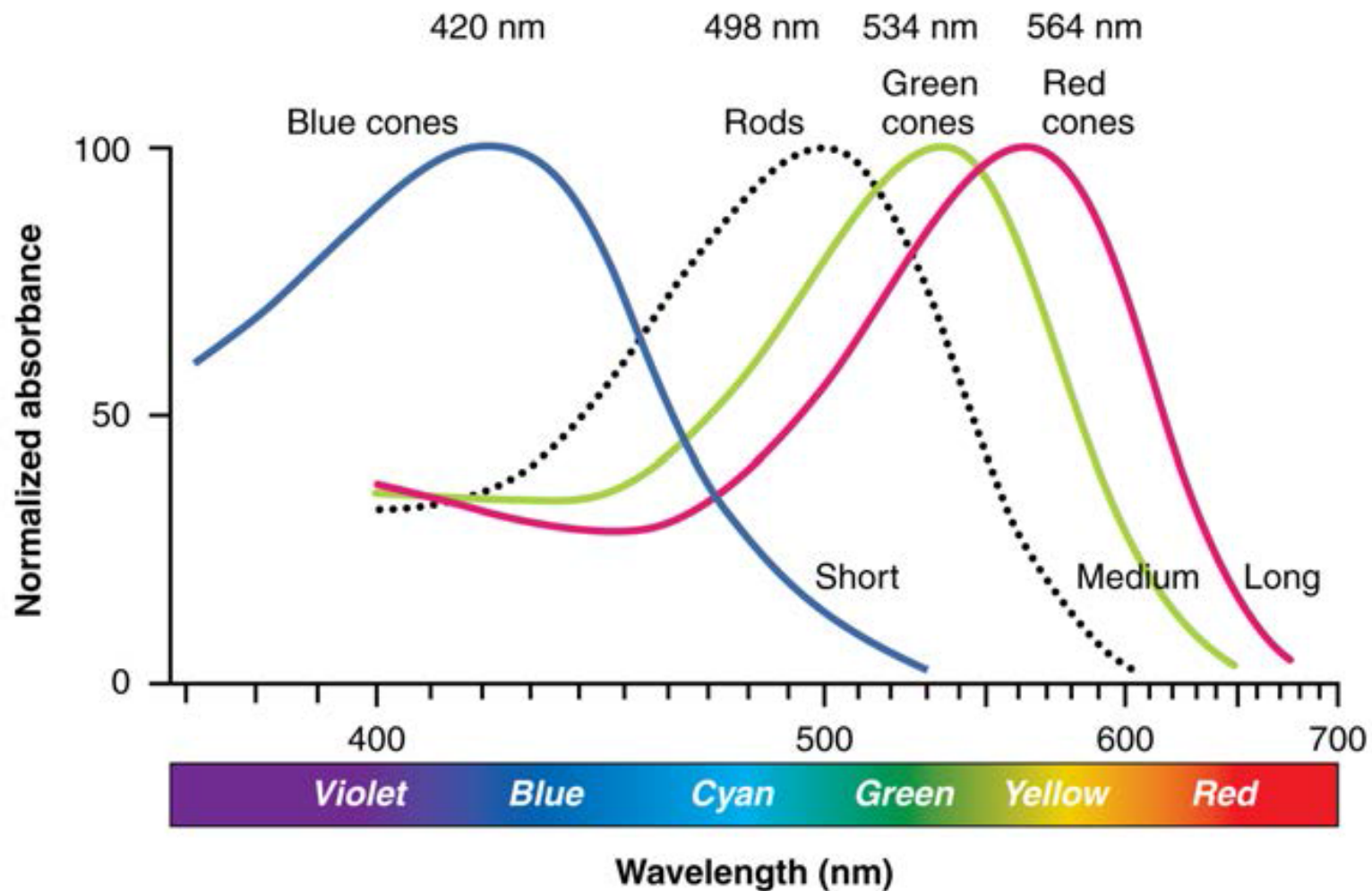


Fig. from: OpenStax College, Anatomy & Physiology. <https://openstax.org/details/books/anatomy-and-physiology>, p.620,





Color Fundamentals

Additive color mixing

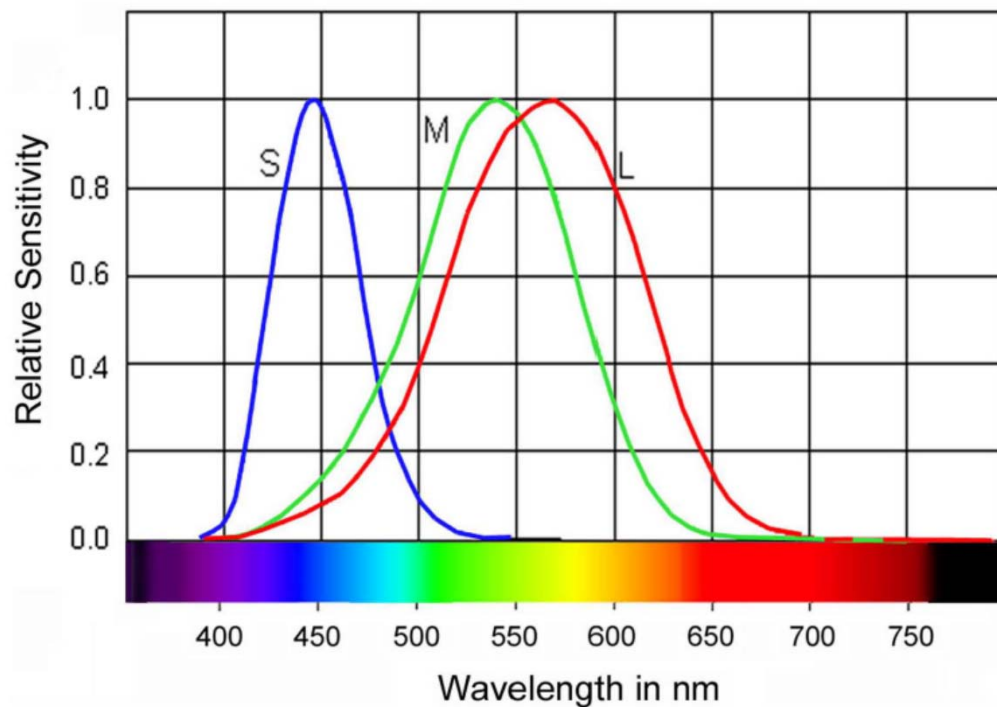


Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p. 53



Color Fundamentals

Additive color mixing

Standard primary colors defined in 1931 by the Commission Internationale de l'Eclairage (CIE)

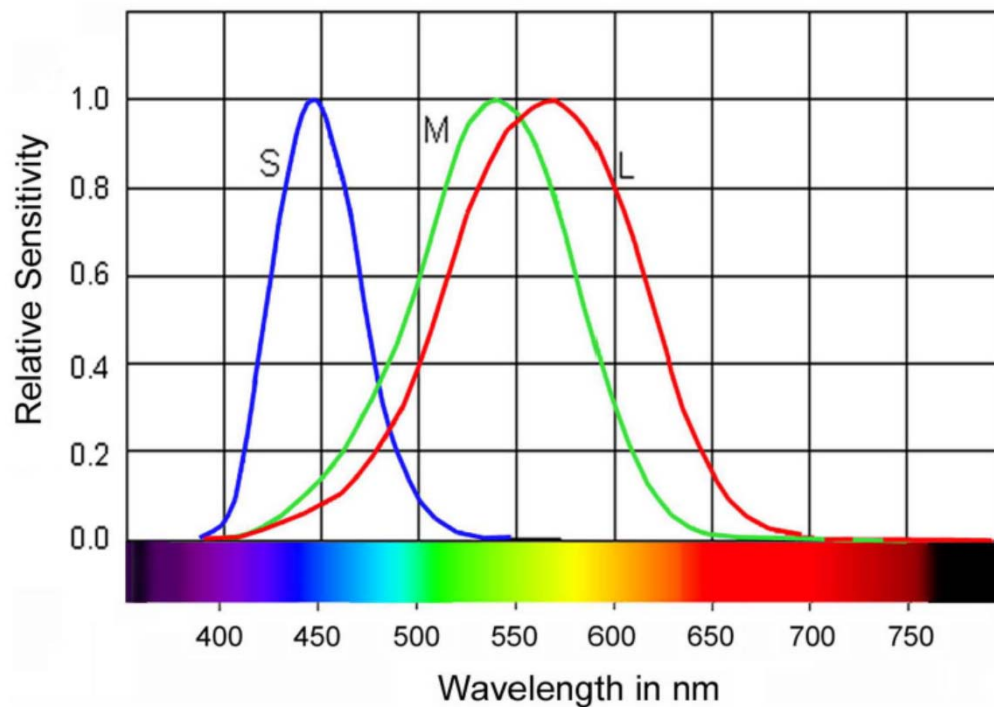


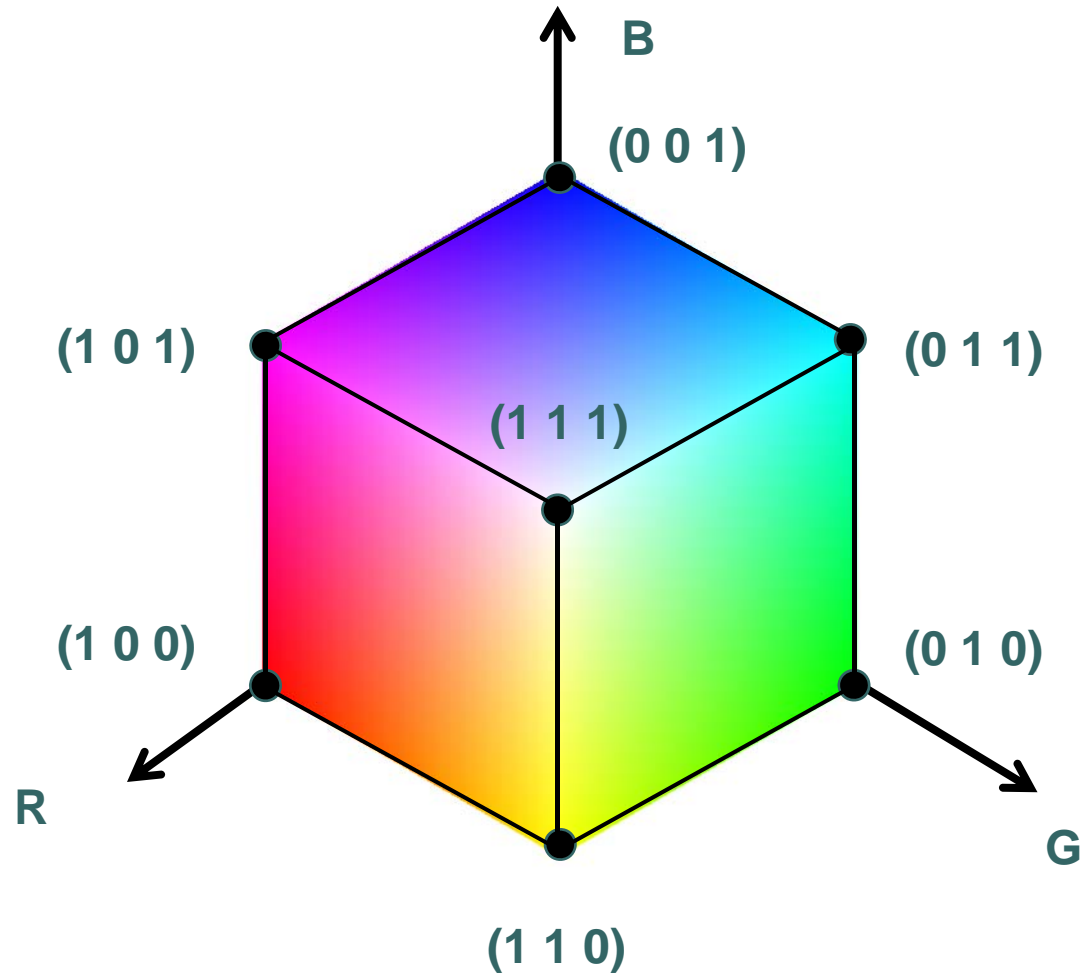
Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p. 53





Color Fundamentals

The RGB color space





Color Fundamentals

A prototype for an RGB output device:
The color cathode ray tube (CRT)

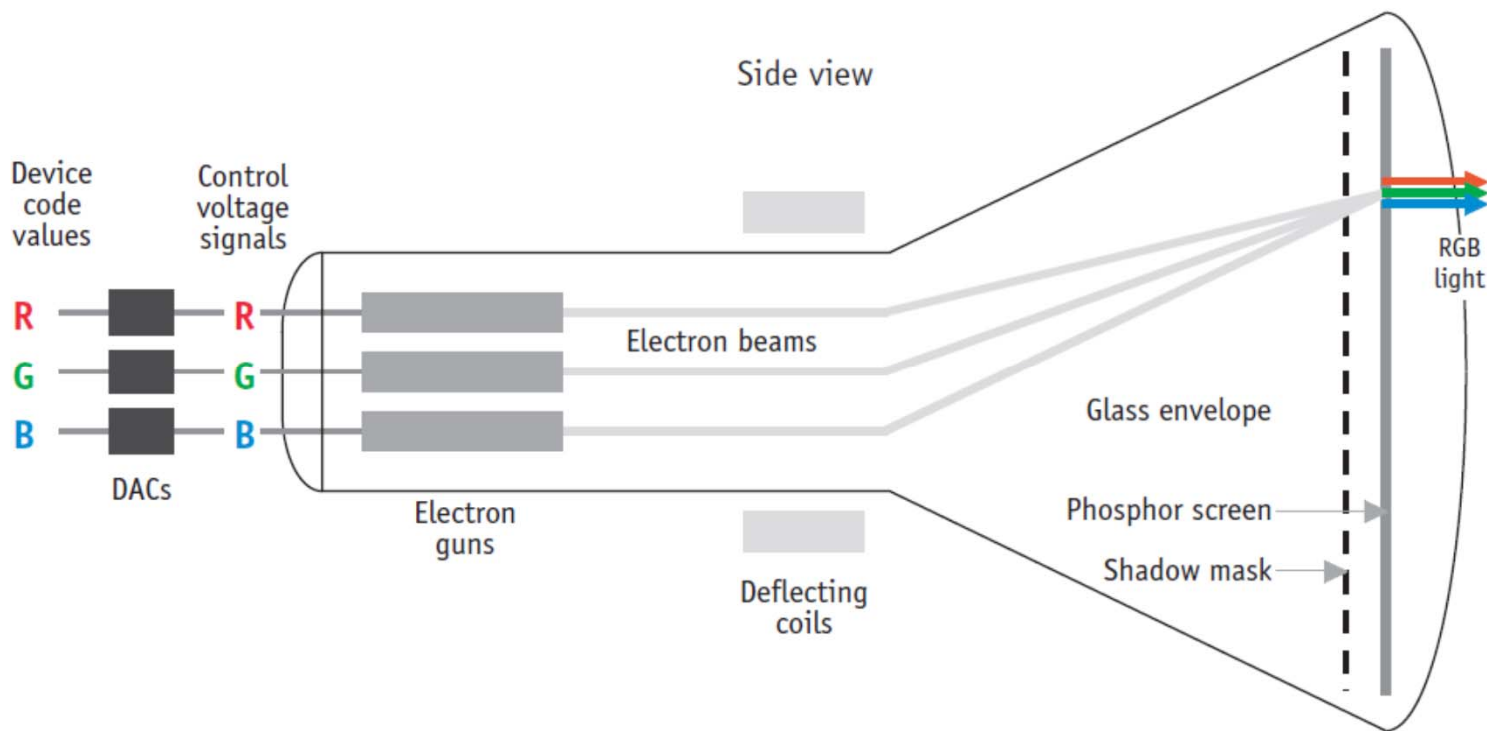


Fig. from: Giorgianni, Madden, Kriss, Digital Color Management-Encoding Solutions, Wiley (2009), p. 32





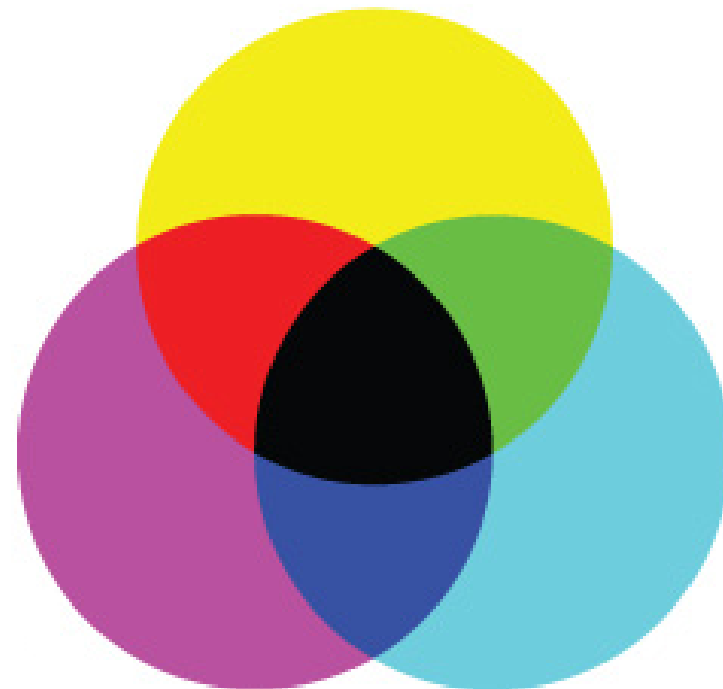
Color Fundamentals

Additive and subtractive color mixing

Additive color mixing



Subtractive color mixing



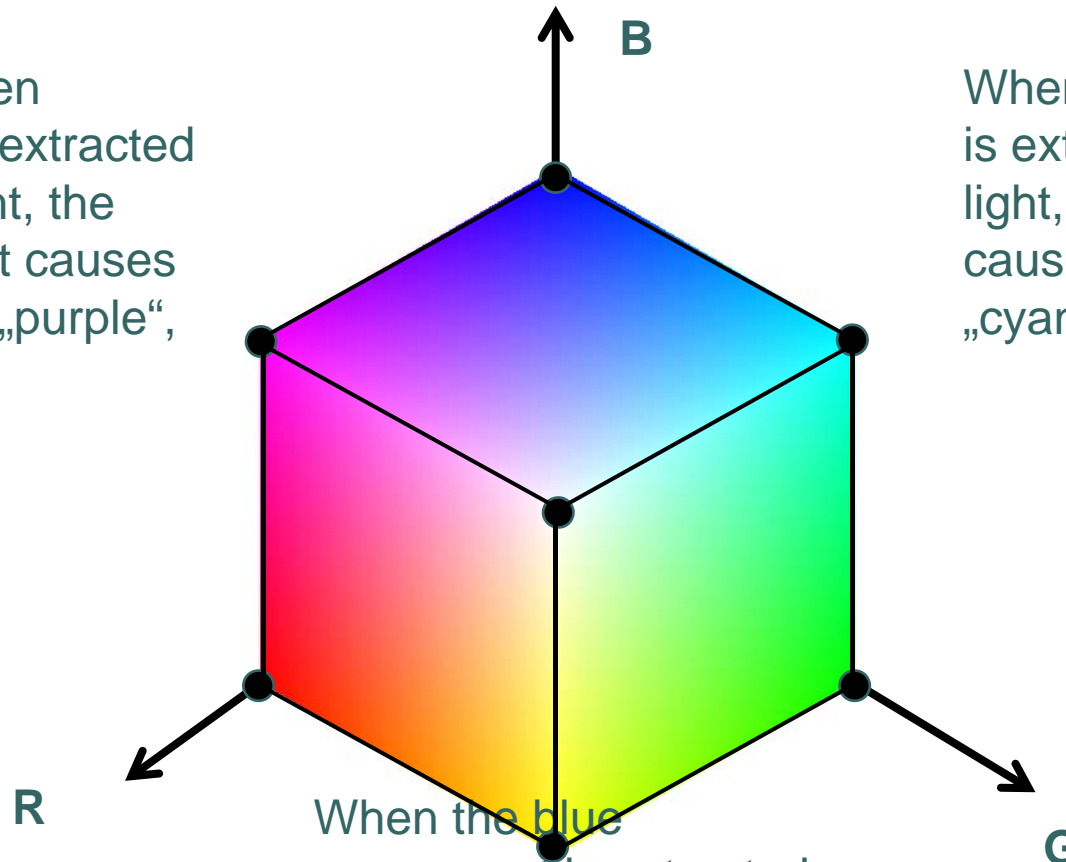


Color Fundamentals

Subtractive color mixing and the CMY color space

When the green component is extracted from white light, the remaining light causes the sensation „purple“,

When the red component is extracted from white light, the remaining light causes the sensation „cyan“.



When the blue component is extracted from white light, the remaining light causes the sensation „yellow“.





Color Fundamentals

Effect of Illumination

Exposure to daylight on a cloudy day



Exposure to room light (LEDs)



Illumination with a 85 W photo lamp (5500K)



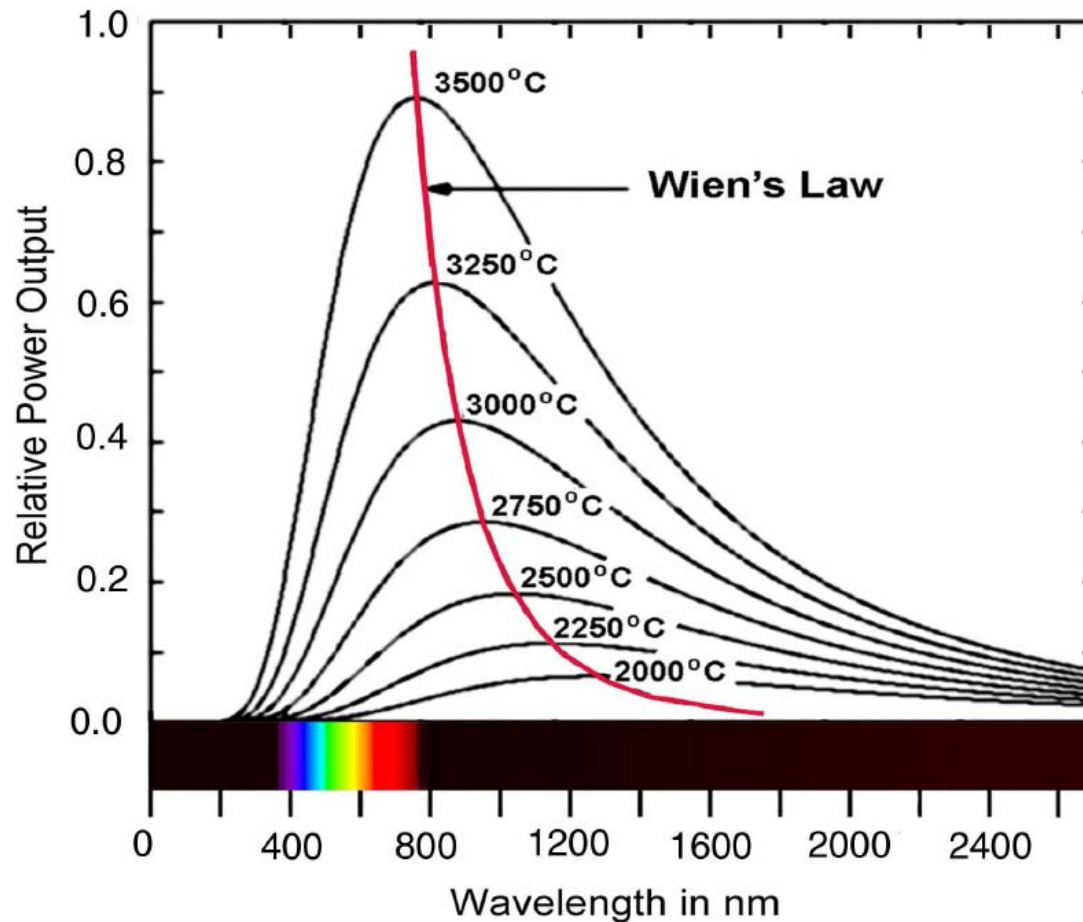
Illumination with a flash light





Color Fundamentals

Black-body radiation



Stefan-Boltzmann law:

$$M = \sigma T^4$$

$$\sigma = 5.67 \cdot 10^8 \frac{W}{m^2 K^4}$$

Wien's displacement law:

$$\lambda_{max} T = const$$

Planck distribution:

$$\rho(\lambda) = \frac{8\pi hc}{\lambda^5} \frac{e^{-hc/\lambda kT}}{1 - e^{-hc/\lambda kT}}$$

Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p.24.



Color Fundamentals

Radiation emitted by the sun

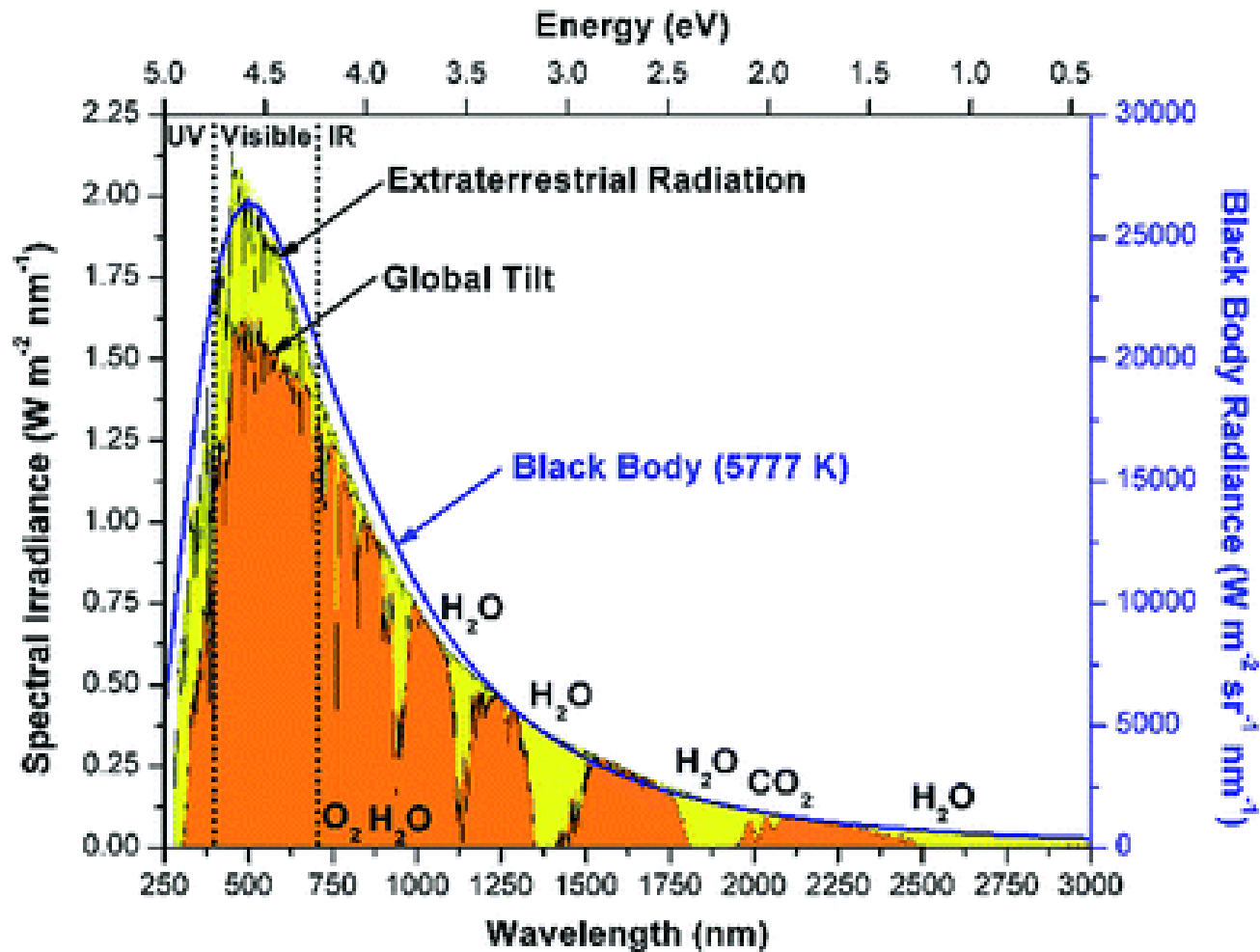
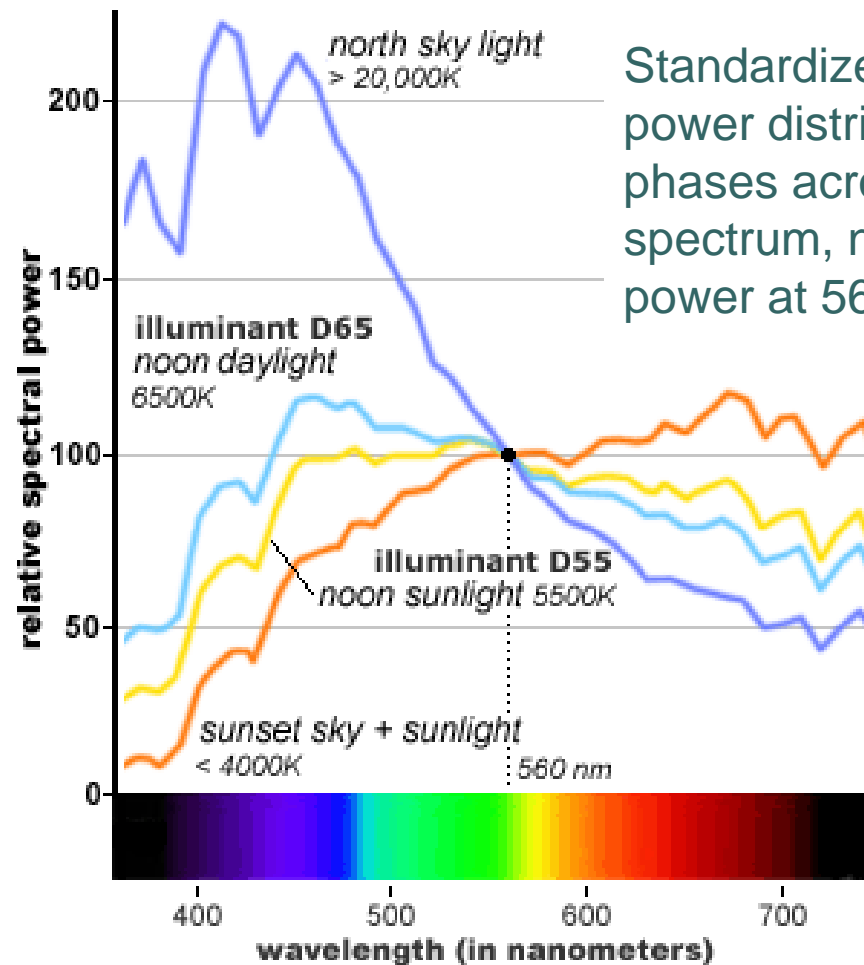


Fig. from: Herron, Energy Environ Sci 9, 126-157 (2015)



Color Vision

Spectral variations in natural light

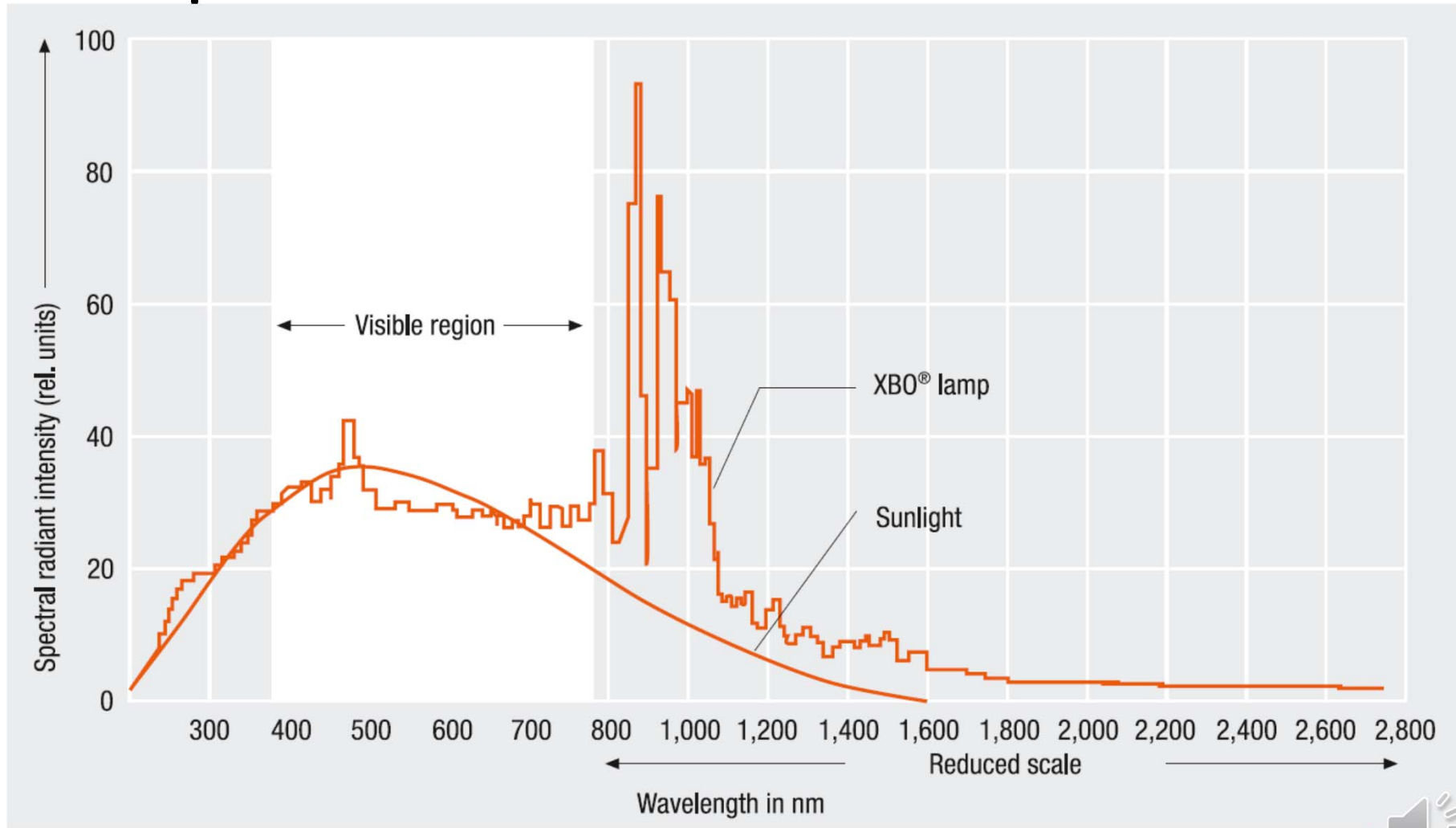


Standardized relative spectral power distributions for daylight phases across the visible spectrum, normalized to equal power at 560 nm.

Fig. from: Wyszecki & Stiles, Color science: Concepts and methods, quantitative data and formulae, Wiley (1982).

Color Vision

Artificial light sources: The xenon arc lamp



Source: Osram, XBO – Technology and Application (2008)





Color Vision

Artificial light sources: Gas discharge lamps

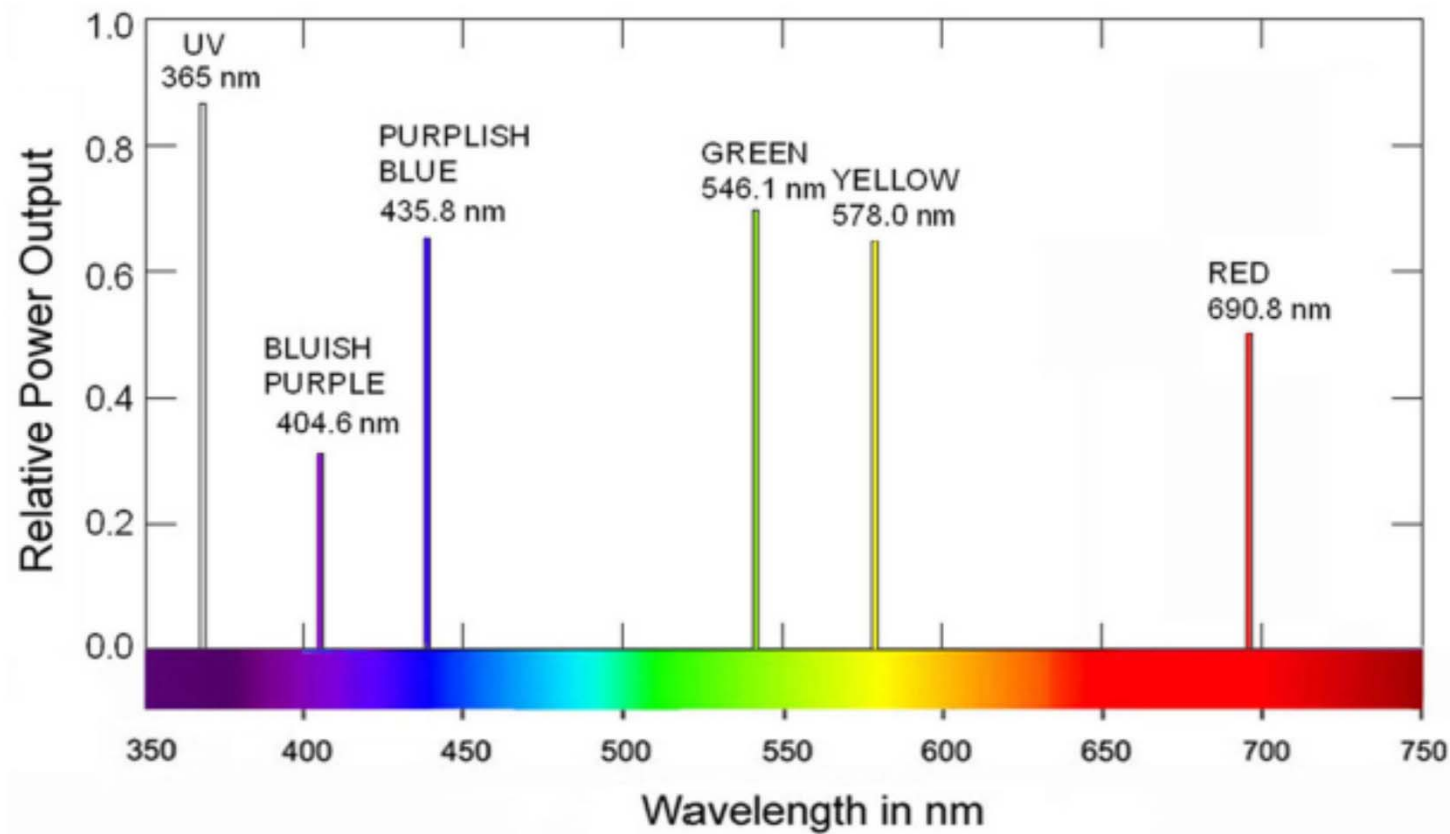


Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p. 27



Color Vision

Artificial light sources: Light emitting diodes (LEDs)

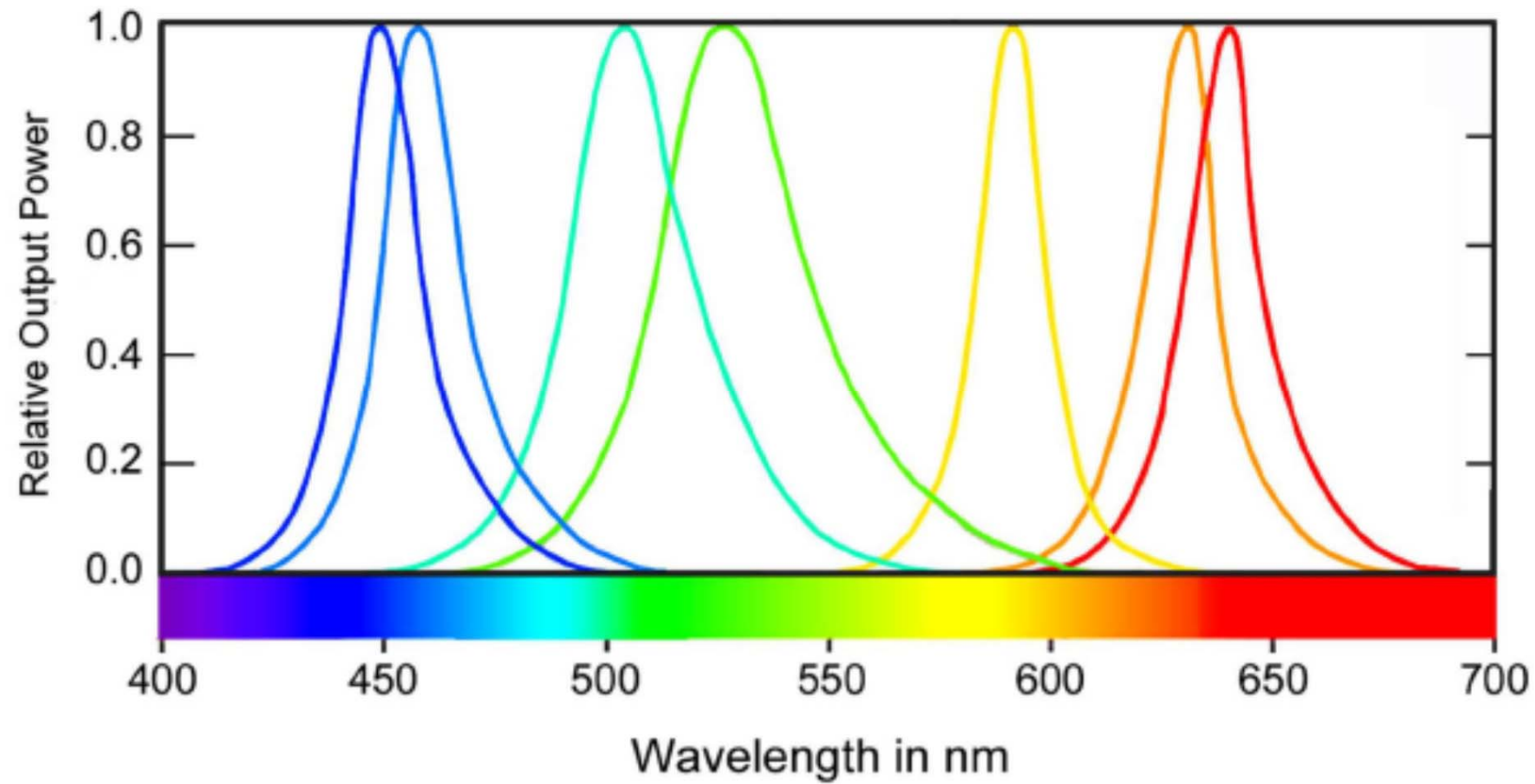


Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p. 30



Color Vision

Artificial light sources: White light LEDs

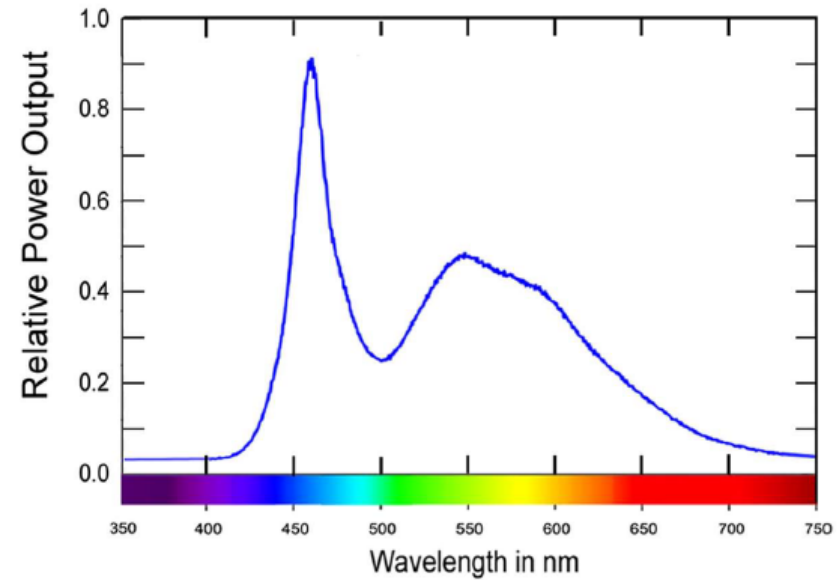
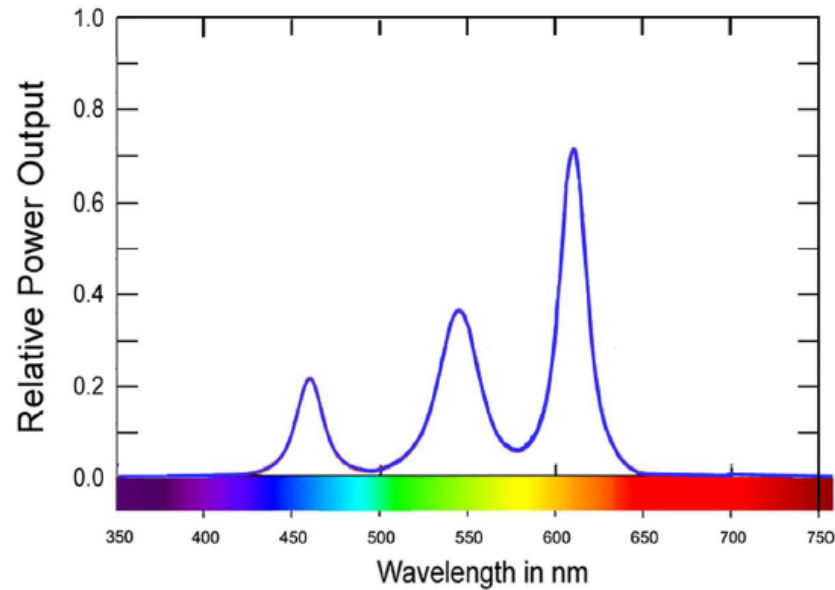


Fig. from: Malacara, Color Vision and Colorimetry, SPIE Press (2011), p. 31



Color Vision

Summary

The activation of each photoreceptor is the integral of the product of three spectra:

$$A = k \int E(\lambda) O(\lambda) S(\lambda)$$

$E(\lambda)$ = spectral power distribution of the illuminant

$O(\lambda)$ = object spectrum, i.e. reflectance or transmittance

$S(\lambda)$ = Sensitivity of the photoreceptor

k = scaling factor