Relative Brightness Depends on Melanopic Content

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2008 – U12 Soccer Fields lit by LED and HID

Our Initial Message:

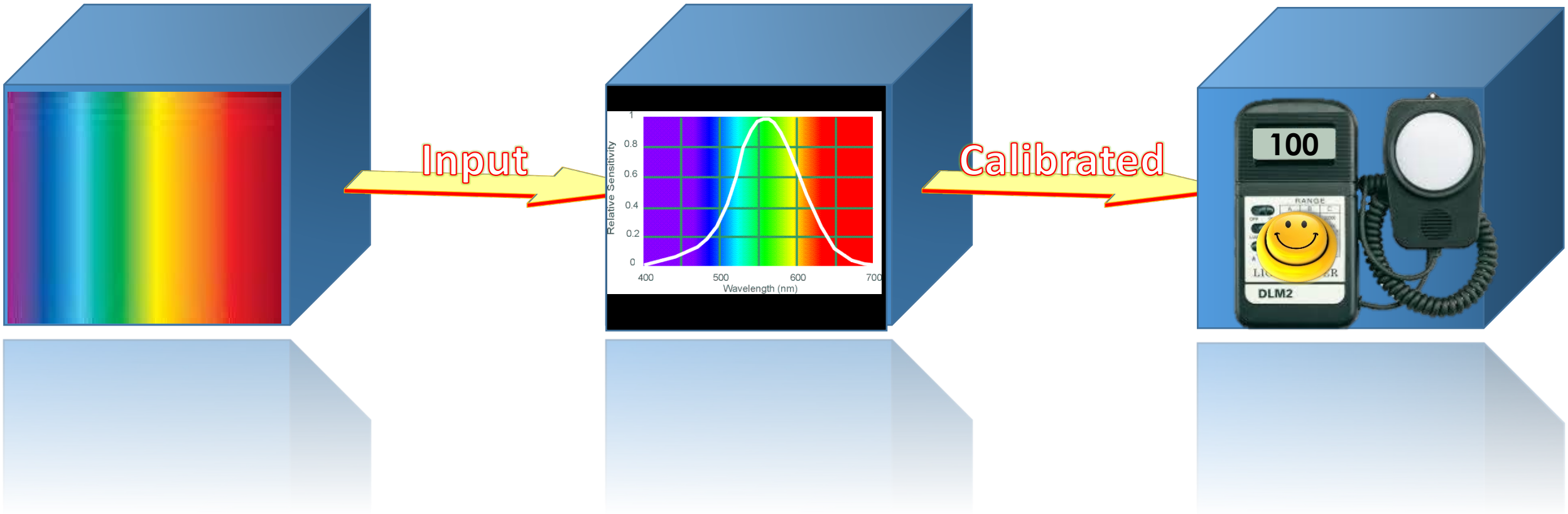
1. It could be done!
2. Cost 8 to 10 times that of MH.
3. No energy savings.

Visitor Feedback & Findings:

1. LED field looks crisper/cleaner.
2. MH field looks dingy/dirty.
3. **What would the cost be if they were lighted to the same levels?**

Who has experienced a parking lot that has been through a retrofit or is undergoing a retrofit from HID to LED?

Some Background on Light Meters and Brightness Perception

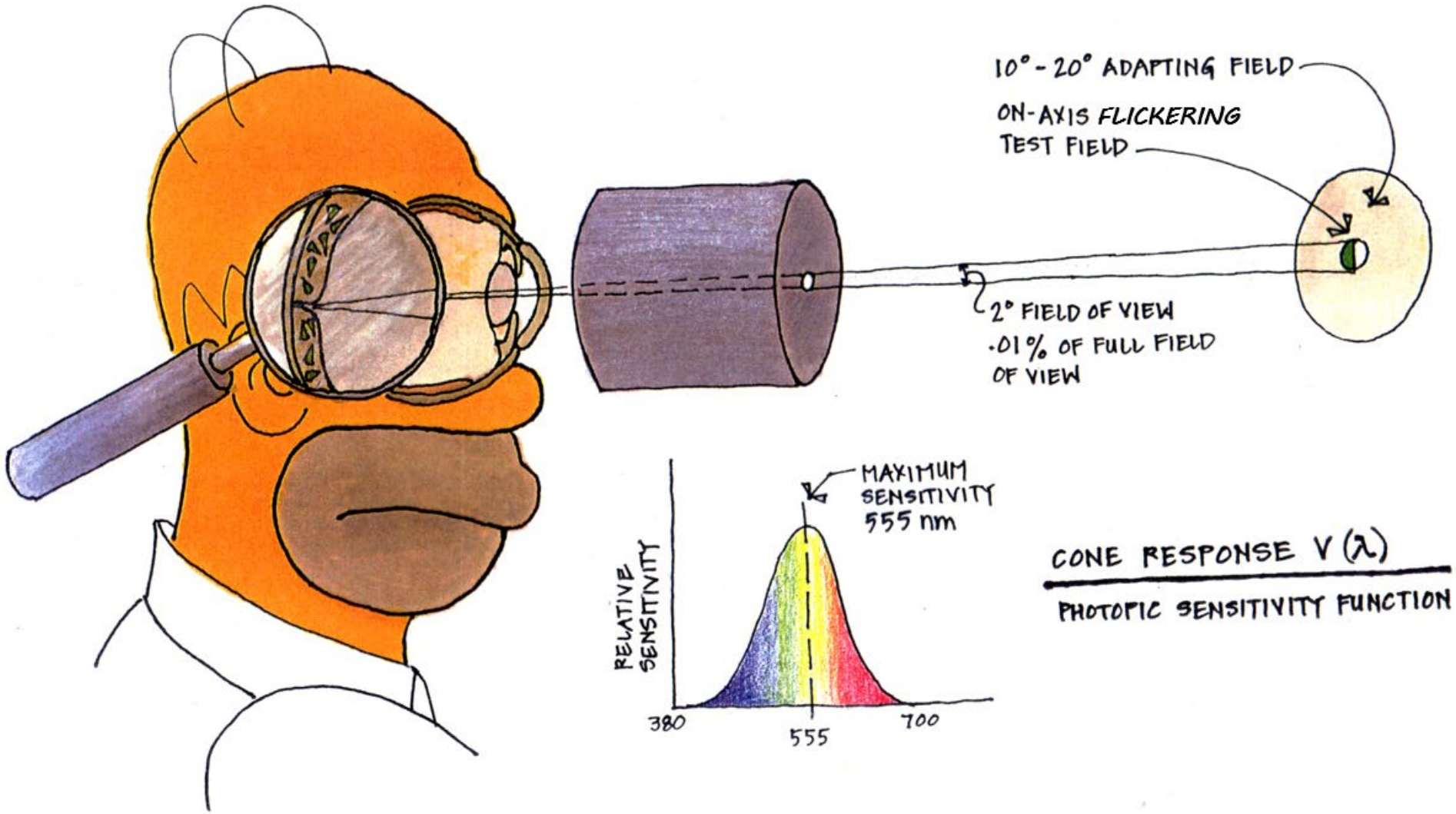

Input
Relative Sensitivity
1
0.8
0.6
0.4
0.2
0
400
500
600
700
Wavelength (nm)
Calibrated
100
DLM2

Conditions of CIE Photometry – 75 years ago

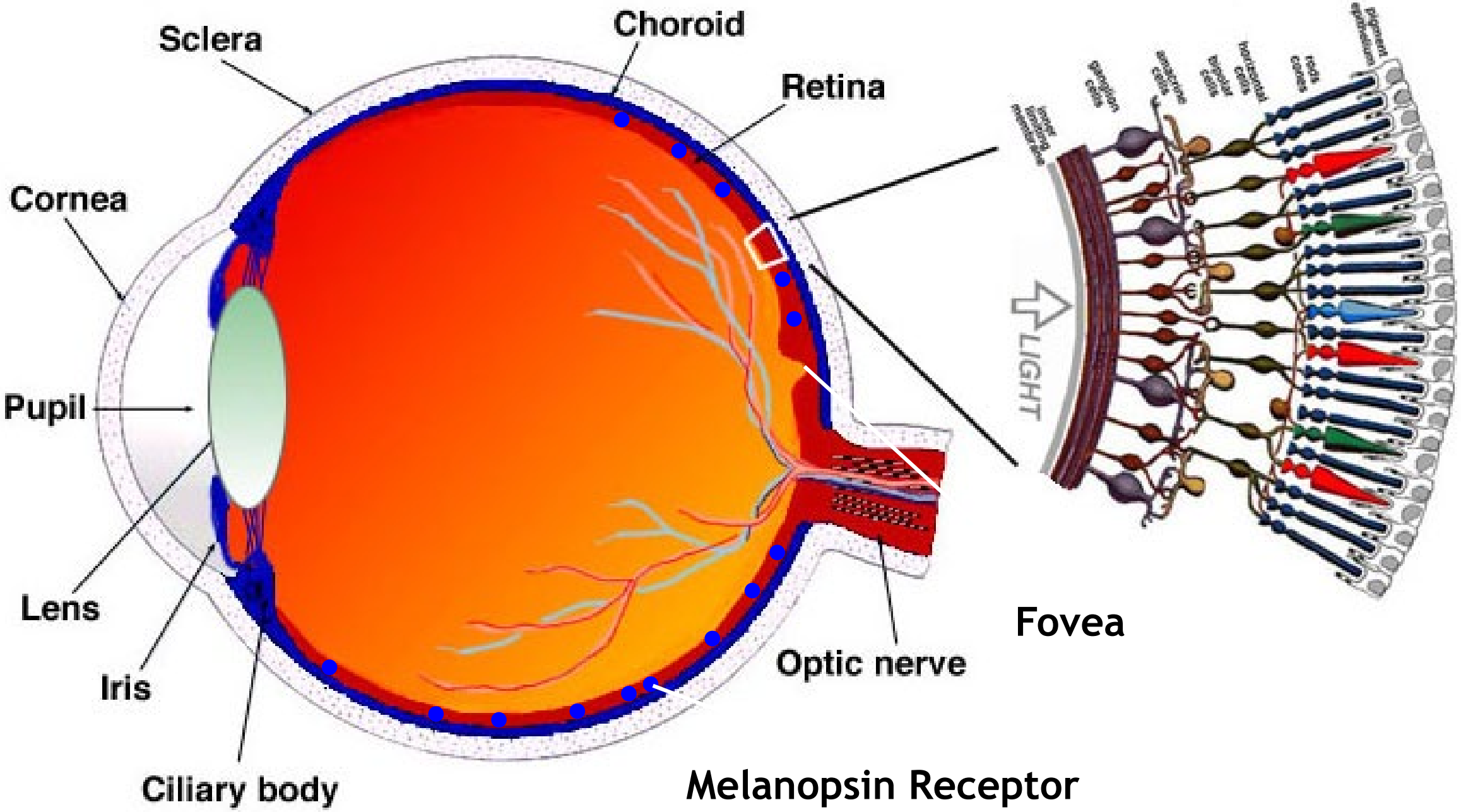
The Photopic (Cone) Sensitivity Function, V (λ), is basic to Vision Science.

Determined by restricting the visual conditions to isolate the Cones.

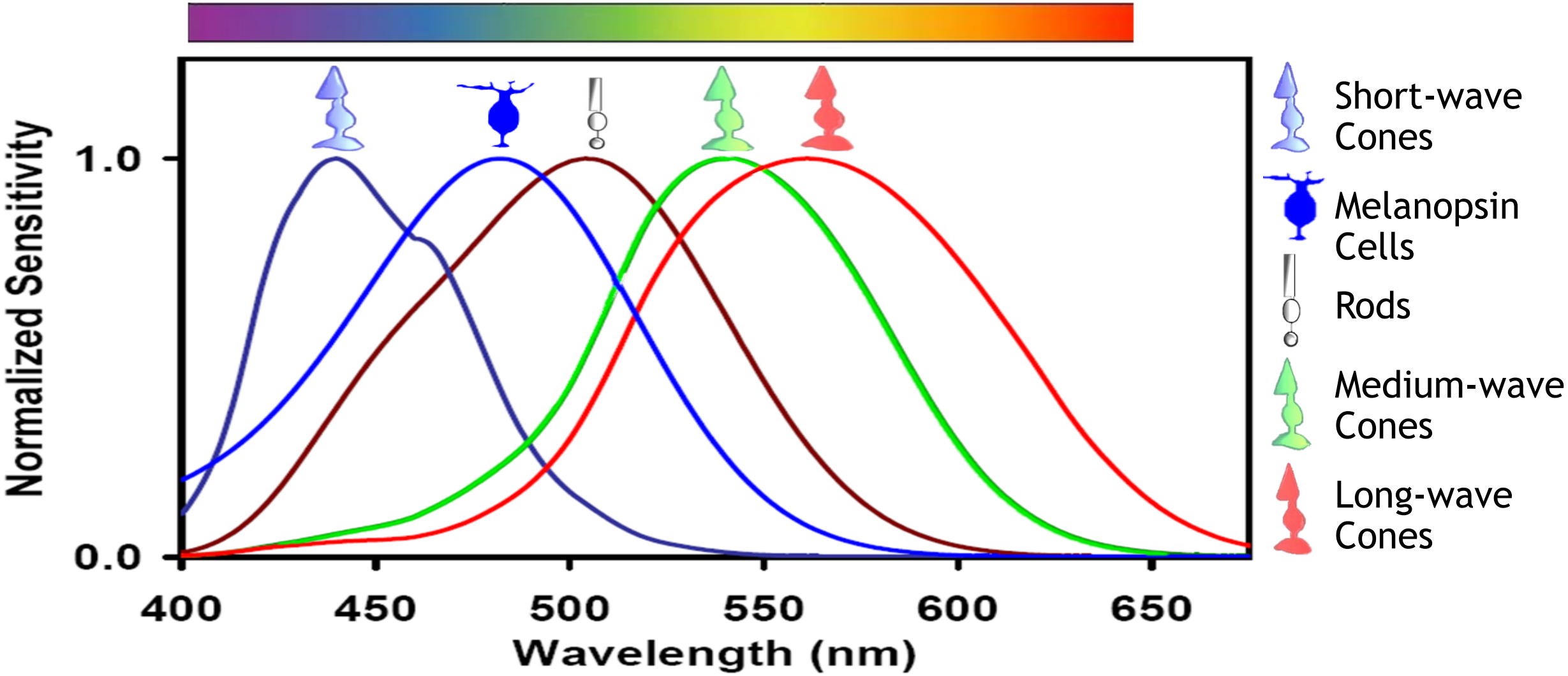
Foveal (Tunnel) Vision



Oh my! A new retinal receptor functioning primarily at photopic levels with a peak sensitivity around 490 nm – very close to the rod peak sensitivity of 508 nm!


Sclera
Choroid
Retina
Cornea
Pupil
Lens
Iris
Ciliary body
Optic nerve
LIGHT
Fovea
Melanopsin Receptor

Spectral Sensitivity of All Known Photoreceptive Cells After 2000



Quantifying the Melanopic Content

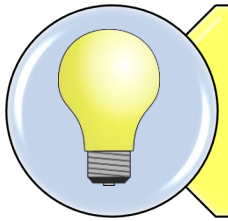
Use the ratio M/P (an intensity independent spectral descriptor)

$$\text{M/P for a given spectrum} = \frac{\text{Spectrum weighted by the melanopic sensitivity function normalized to unity at its peak}}{\text{lumens associated with the same spectrum}}$$

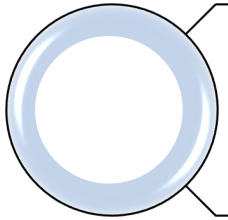
Definitions

- **P(Lumens) = ∫S(λ)V(λ)dλ**
- **M(eff mel mwatts) = ∫S(λ)M(λ)dλ**
- **S(λ) is SPD in milliwatts/ nm**
- **V(λ) is the photopic sensitivity function (normalized to 683 lumens at 555nm)**
- **M(λ) is the melanopic sensitivity function (normalized to 1 'effective melanopic' milliwatt/milliwatt at 490 nm)**
- **M/P (effective melanopic milliwatts/lumen)**

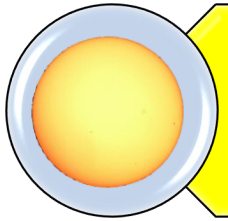
Some Typical Values for M/P



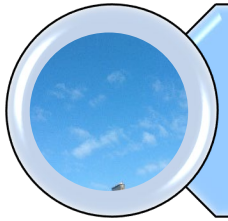
Incandescent lamp (100W): 0.65



Equal energy white: 1.2

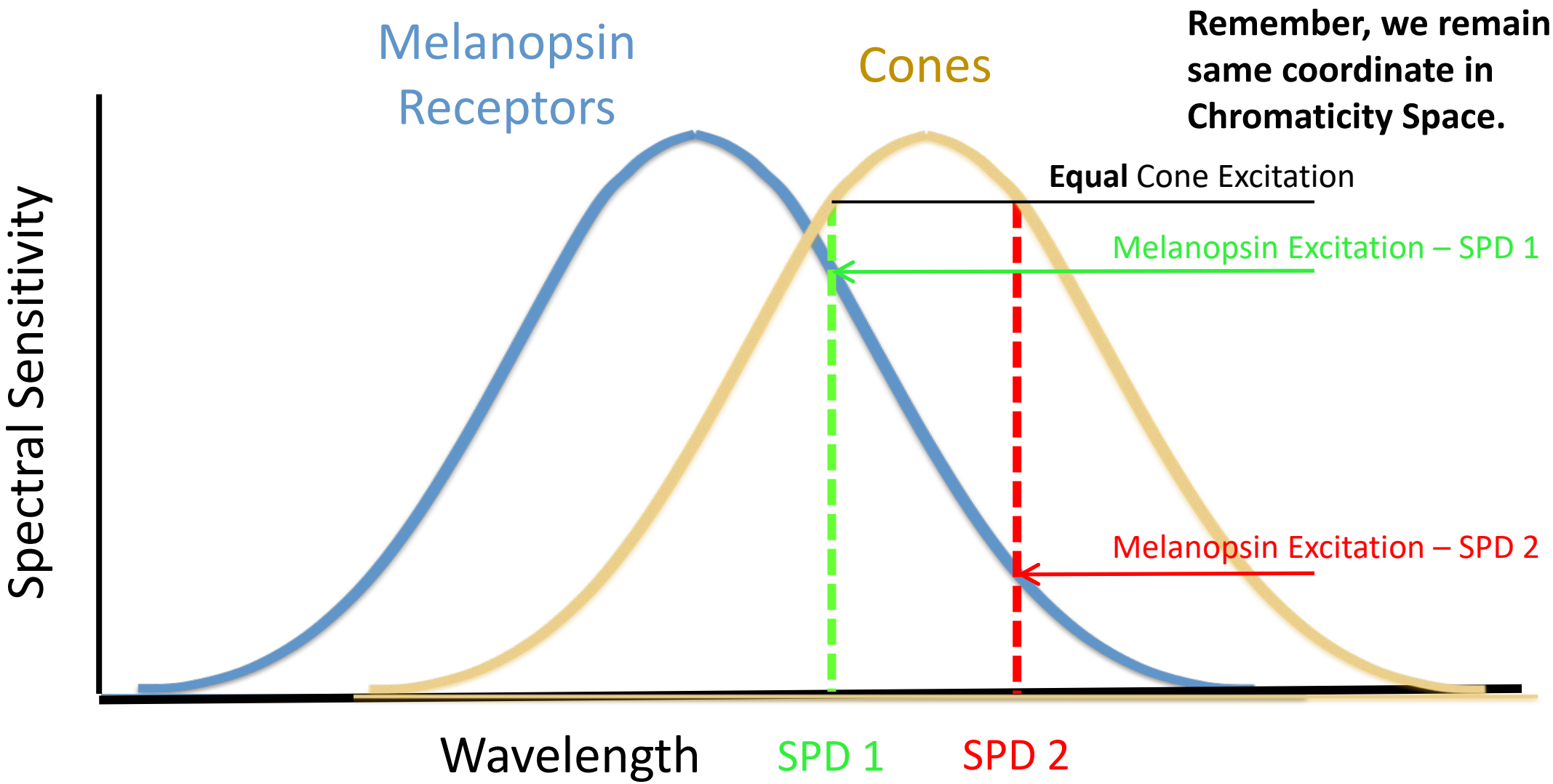


Sunlight (5000K): 1.07

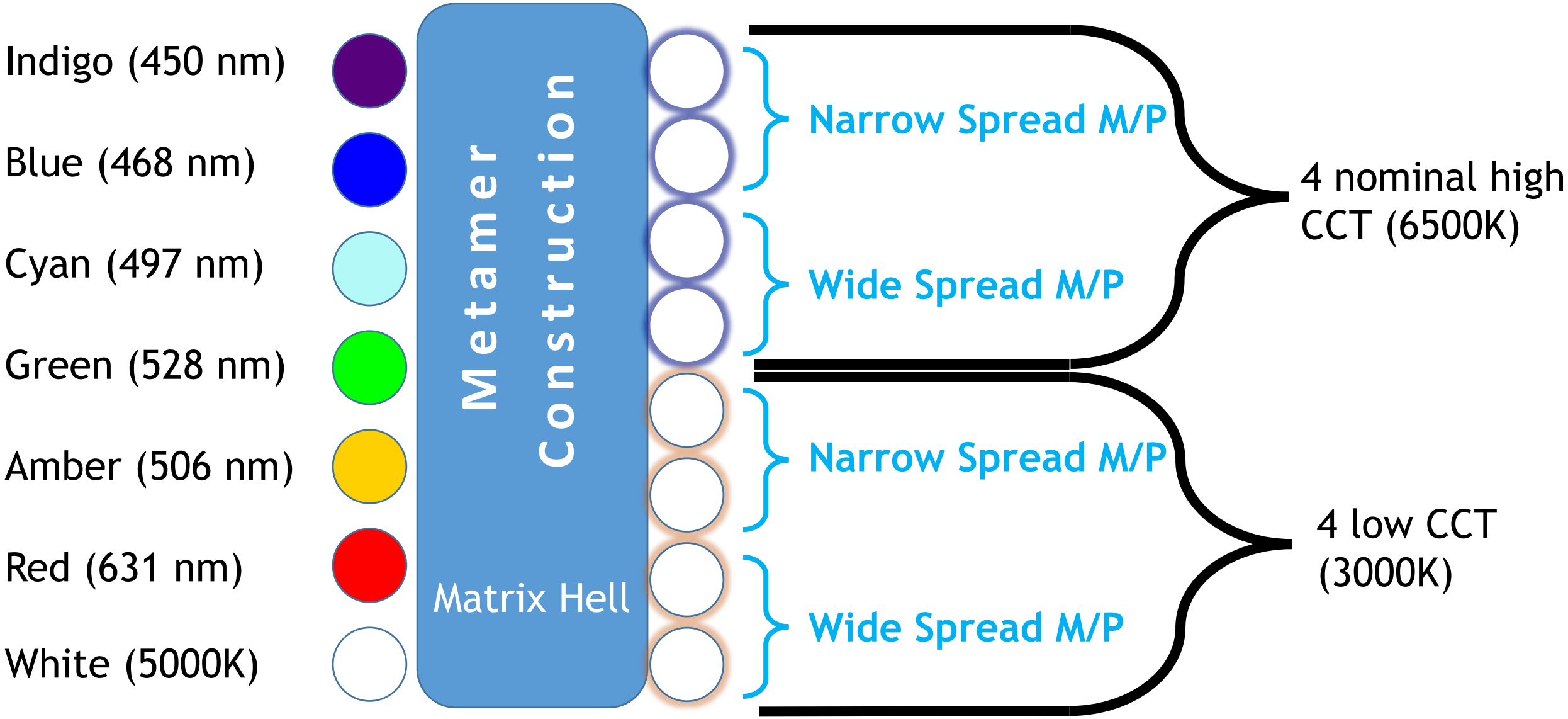


Blue sky: 1.45

Metamerism Simplified



The 7 LED Types

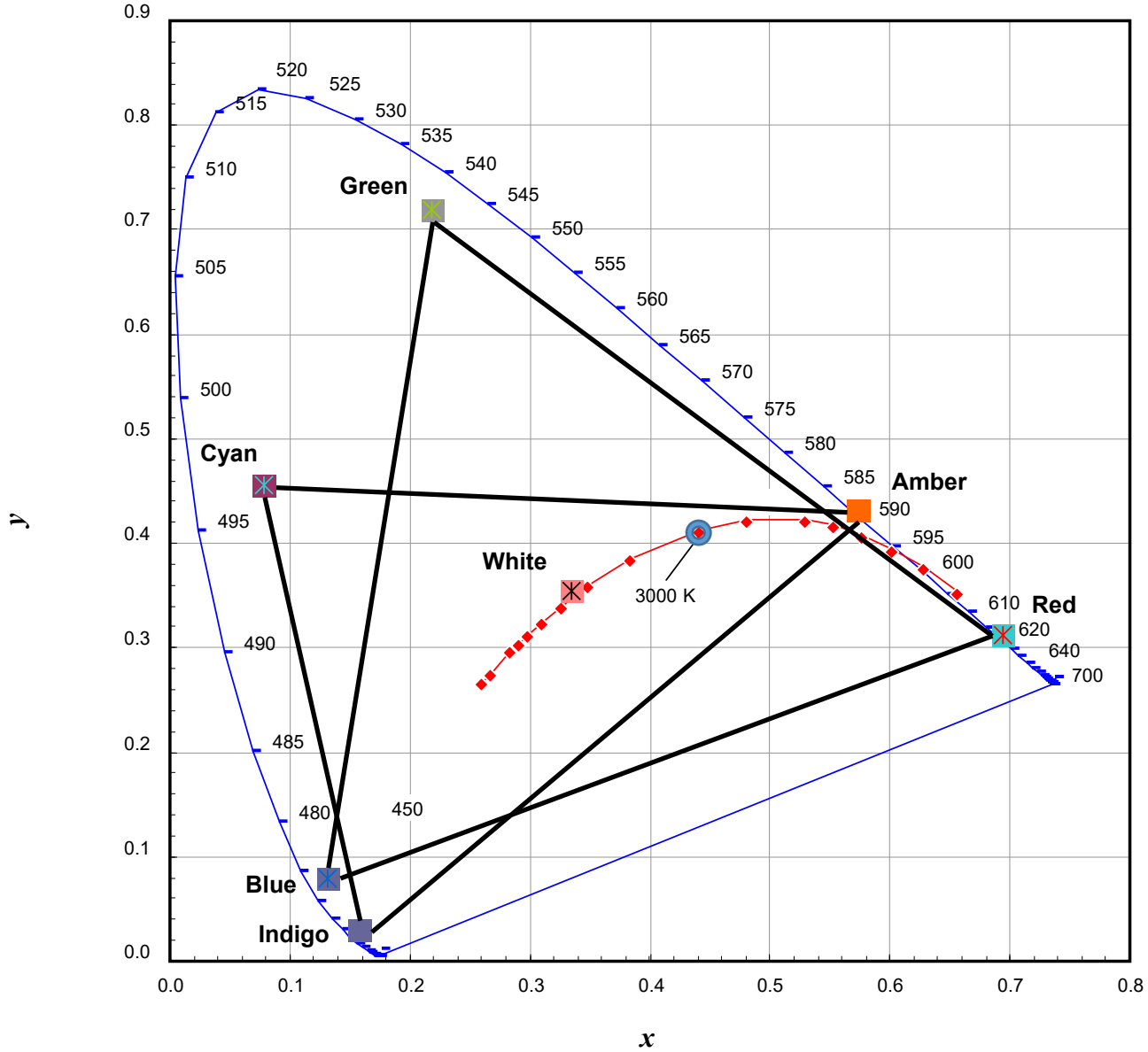


Principle Result

Two different sources have the same brightness when…

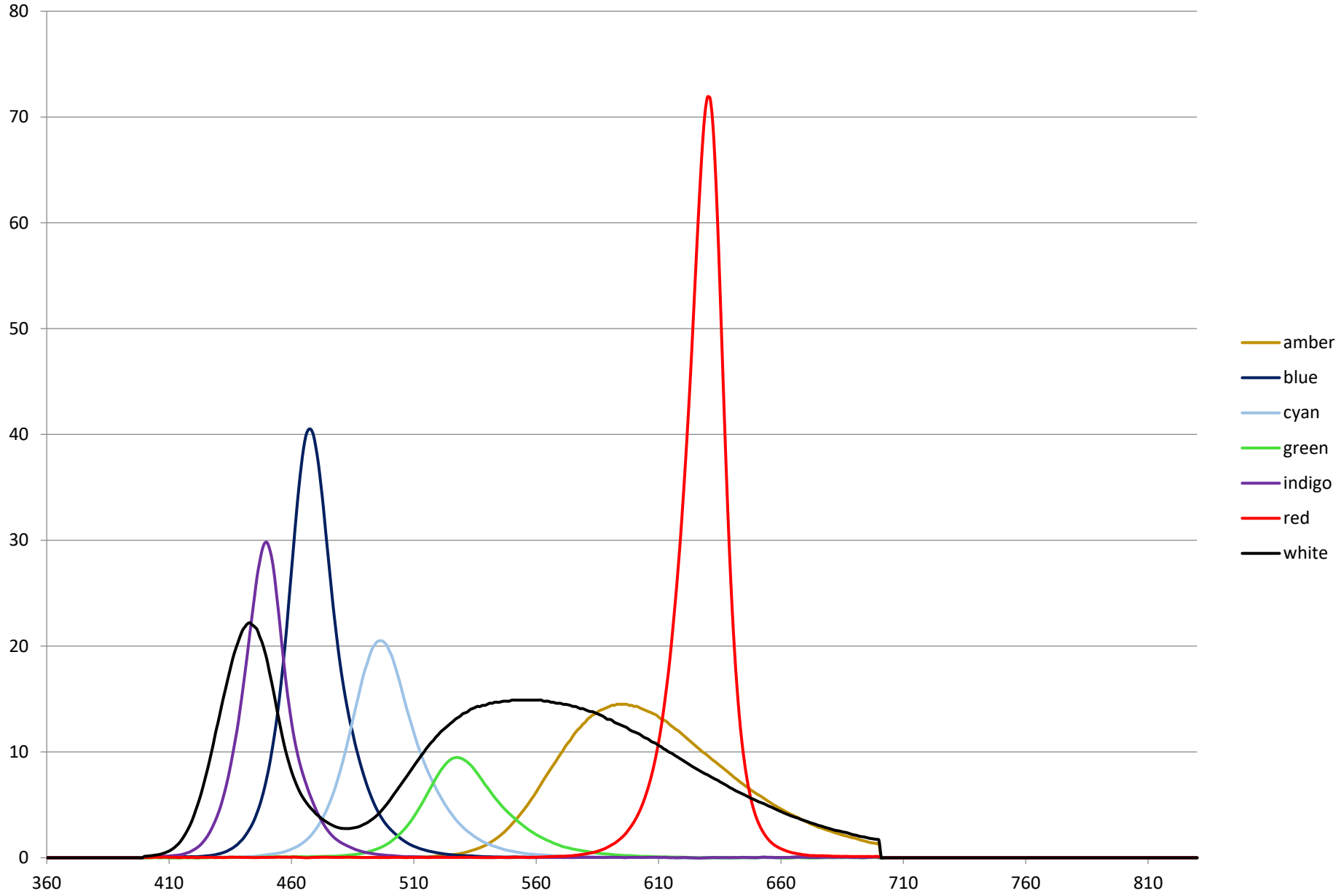
$$\frac{P_2}{P_1} = \left[\frac{(M/P)_1}{(M/P)_2}\right]^{0.33}$$

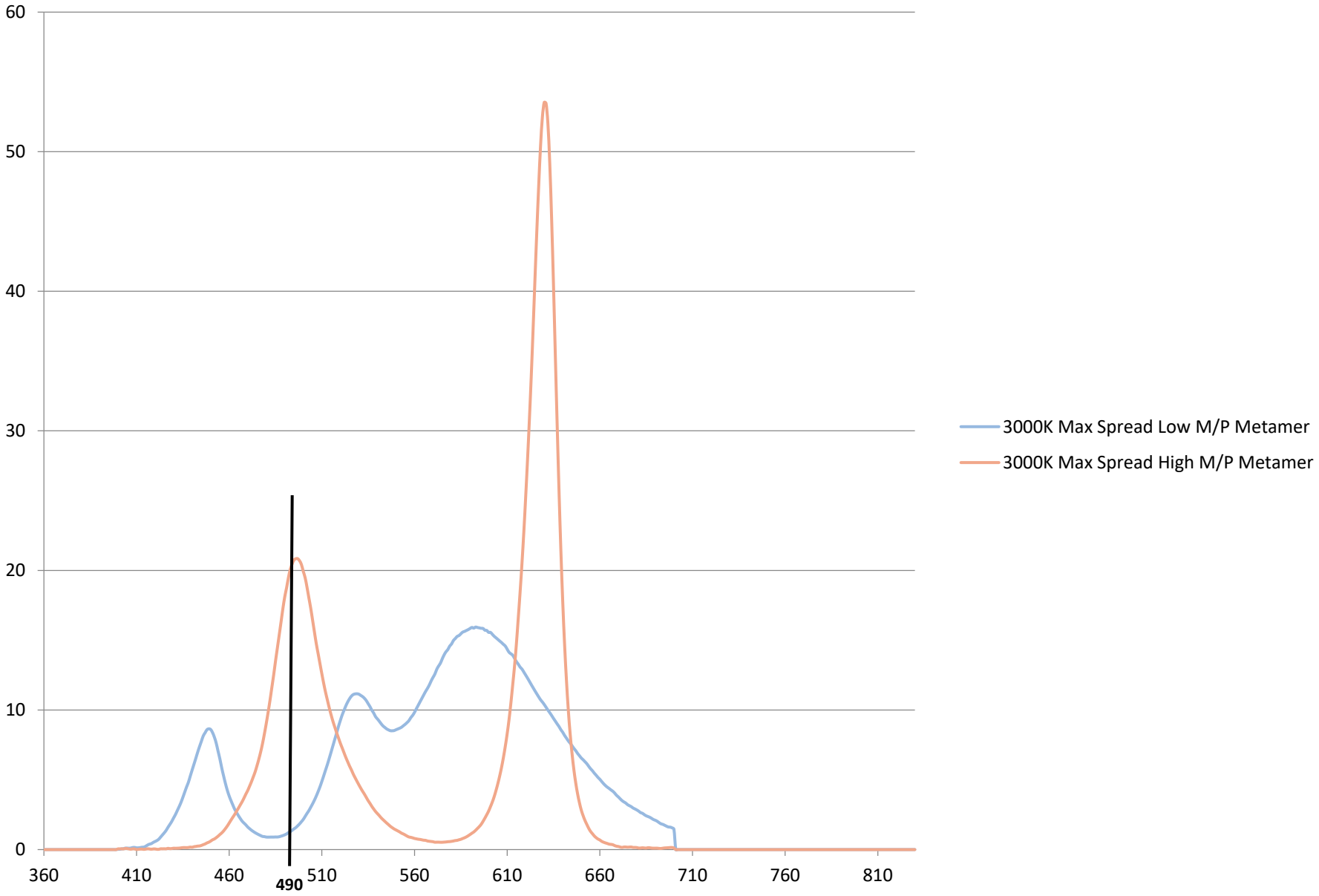
ETC Source Four – Luminaire Source Distribution



The ability of human eyes to see two colors as being the same even when the spectral power distribution of the two colors is different, is known as **Metamerism.**

ETC Source Four – Emitter Spectral Power Distribution (SPD)




60
50
40
30
20
10
0
360
410
460
490
510
560
610
660
710
760
810
3000K Max Spread Low M/P Metamer
3000K Max Spread High M/P Metamer

See it for yourself!! Experience the melanopsin brightness effect in our demo. There you can compare 2 identically appearing white lights at equal photopic illuminance. But they differ in melanopic content.