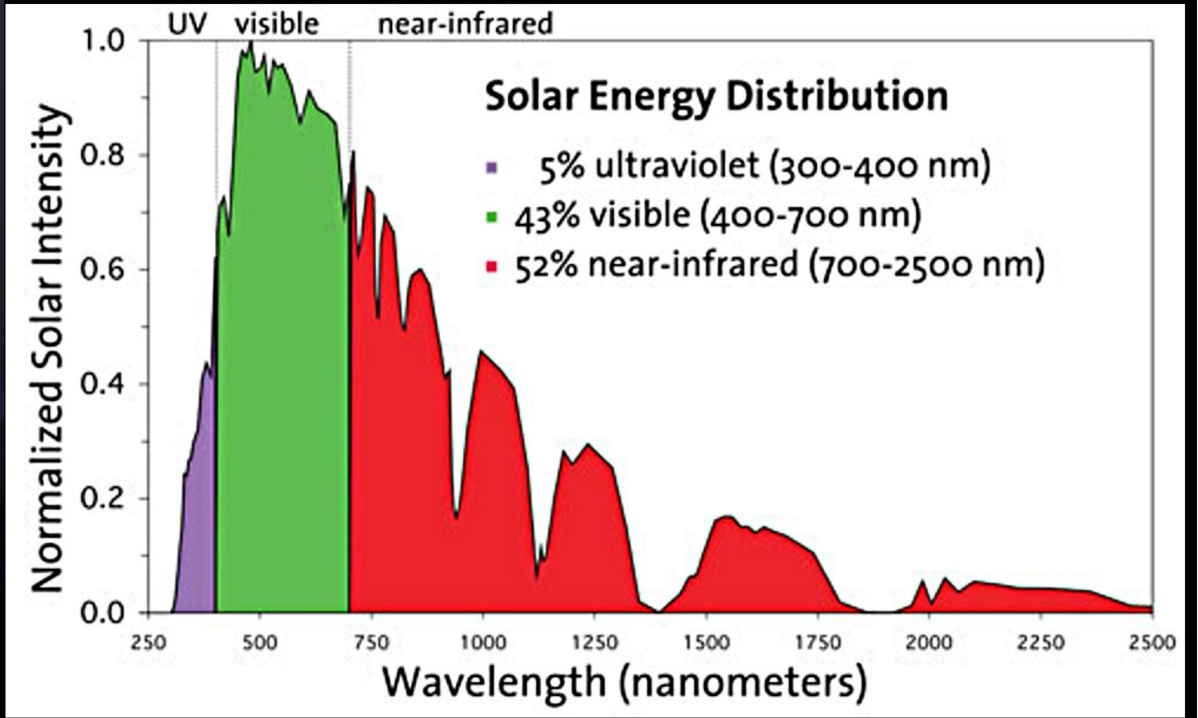
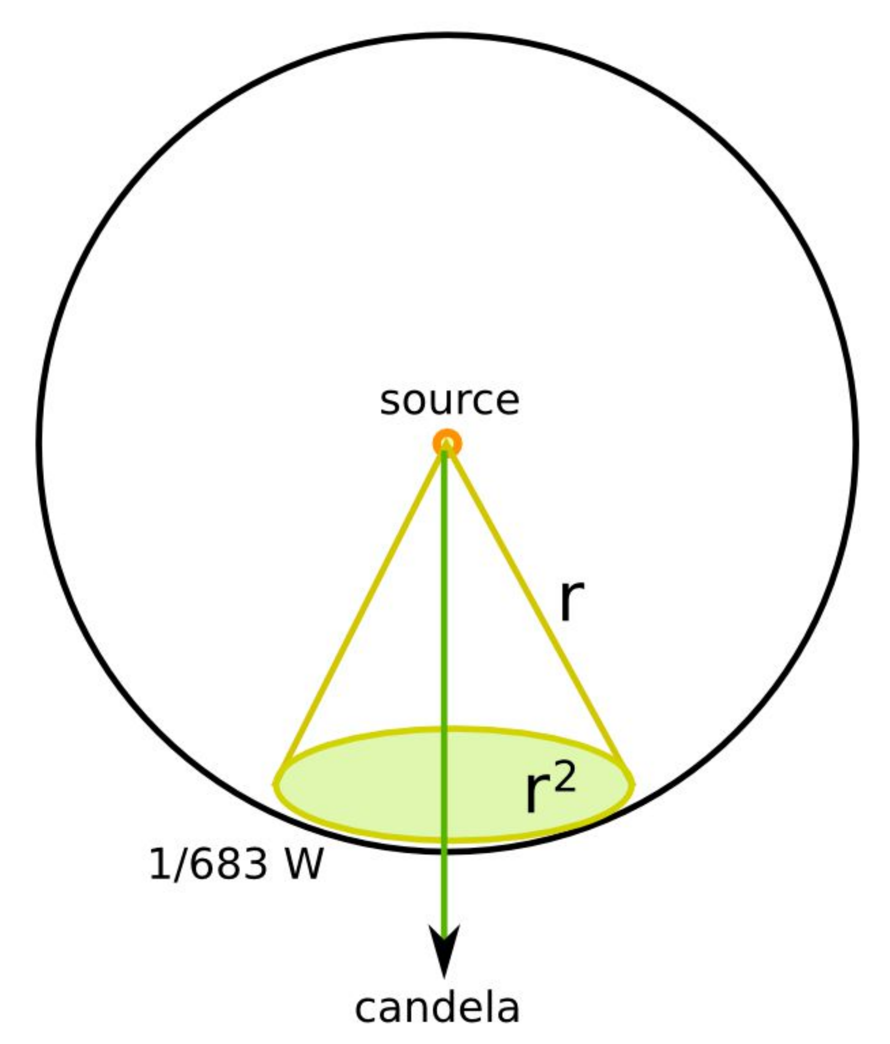
Preventive Conservation and Energy conservation

Units of light,
Perception of colour,
Energy used by lighting.

Aalborg Art Museum

Sunlight is free energy, but it turns to heat within the building and much of the solar energy is useless to us, being in the infrared. This energy has to be removed or rejected, which takes energy. Also, sunlight is variable.

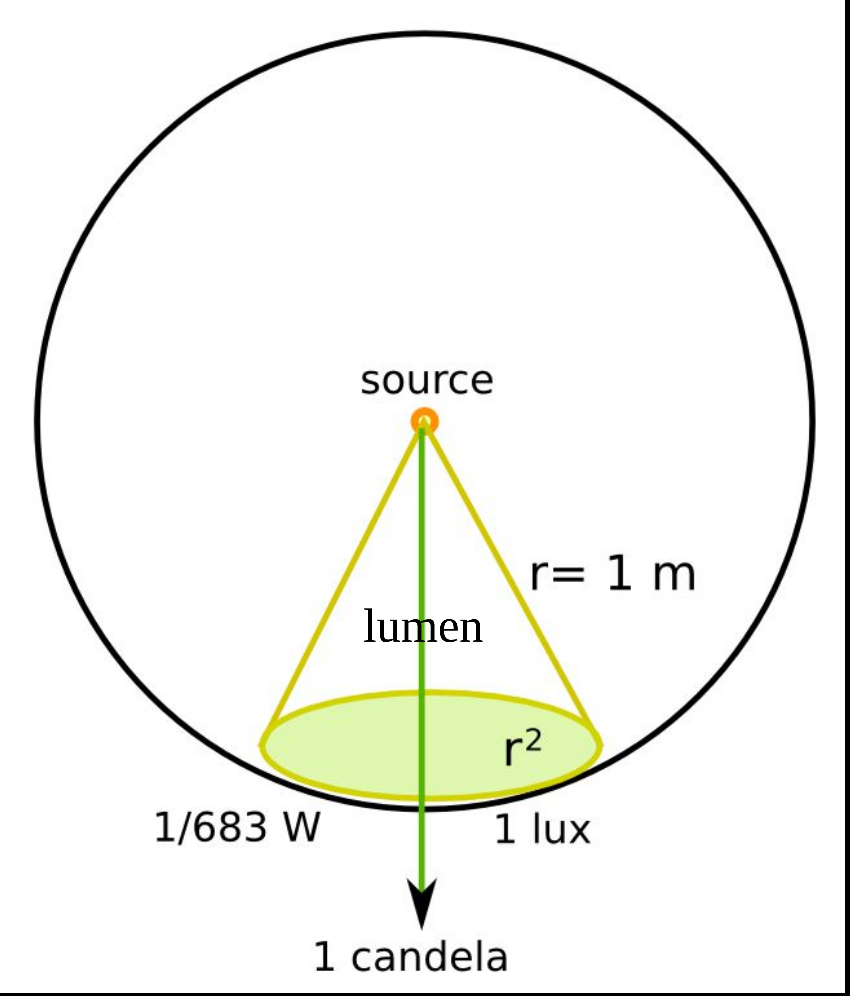




The Candela is the SI base unit from
Which all other light units are derived

The intensity from a source emitting
1/683 W of radiation at 555 nm
uniformly over one steradian

Start Point lighthouse
In Devon UK has a
Luminous intensity of
200,000 candela

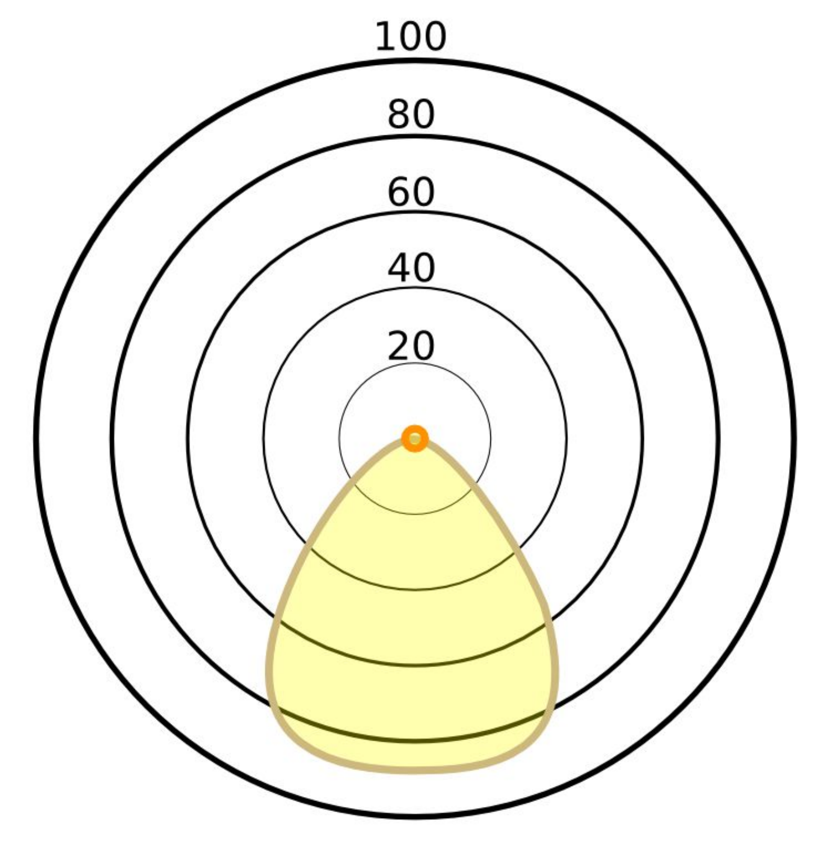


The lumen is the light energy moving out through the steradian (the yellow-green area)

The lux is the light energy falling on a surface at one metre distance from the 1 candela source

Sunlight through glass gives
About 80,000 lux on surfaces

Køge Church, Denmark



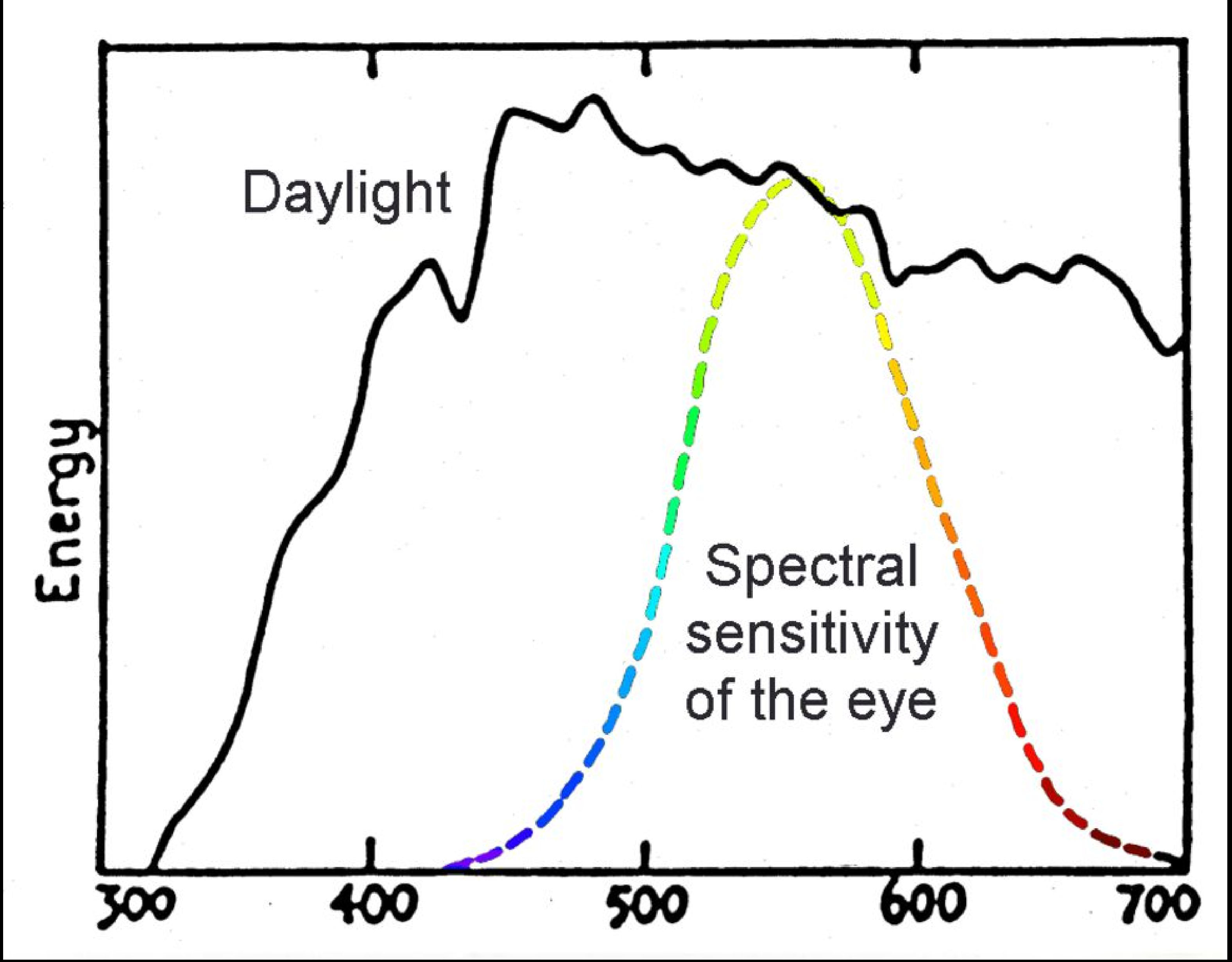
The linkage between candela, lumen and lux

A light fitting will have an uneven distribution of luminous intensity(candela) in different directions. The integral of candela intensities over the entire sphere is the lumen output of the lamp. The lux is calculated from the candela in the direction of the object and the distance from the source

In reality, designers don't do this because there are usually several light sources contributing to the illumination of one object (The National Museum of Denmark, Brede)

The candela is defined with monochromatic radiation at 555 nm.

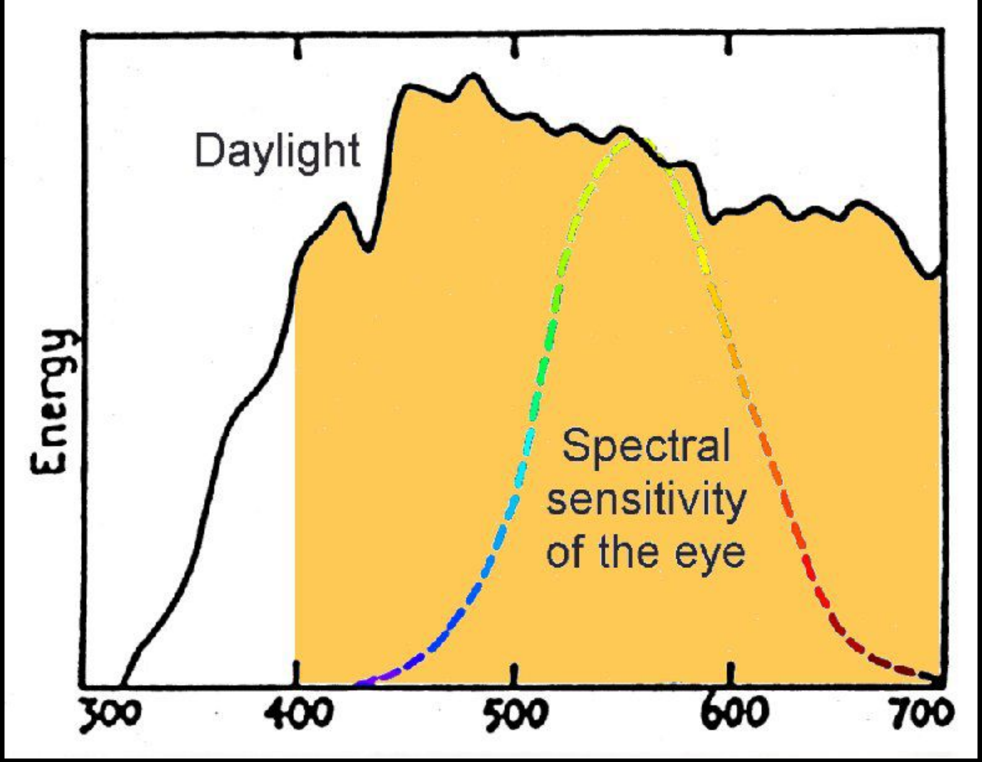
This is not too bad for the leaves at top right – but what colour is the building?

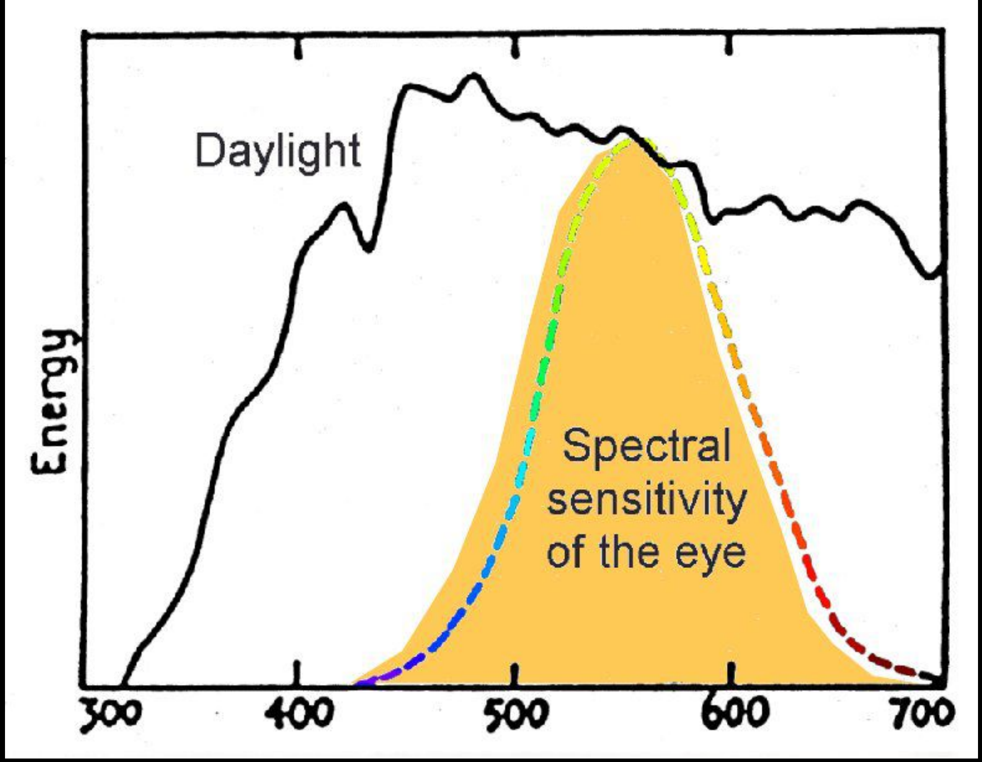


When the light source emits radiation over the range 400 – 700 nm
we can see colours. But the sensitivity of the eye falls off towards
The limits of the visible spectrum

This is Jean Nouvel's Serpentine Pavillion from 2010 (an annual event in London, open to architects who have not built in Britain)

The eye is not very sensitive to red light, even though it has a strong psychological effect



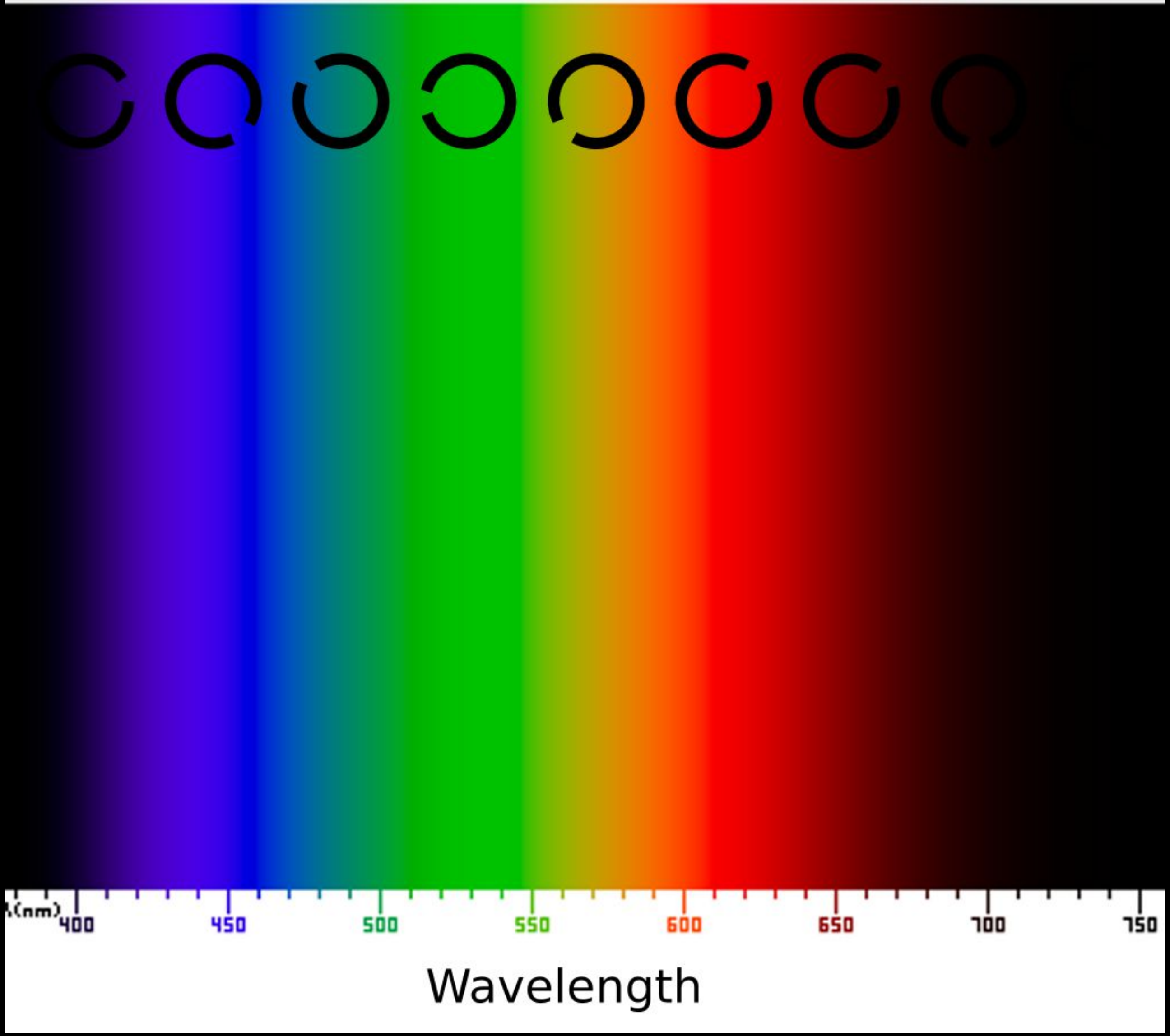


The distinction between the power of daylight and the power perceived by the eye

The power (rate of energy conversion) in watts of daylight is proportional to the yellow area under the spectral energy curve (assuming total elimination of UV and IR)

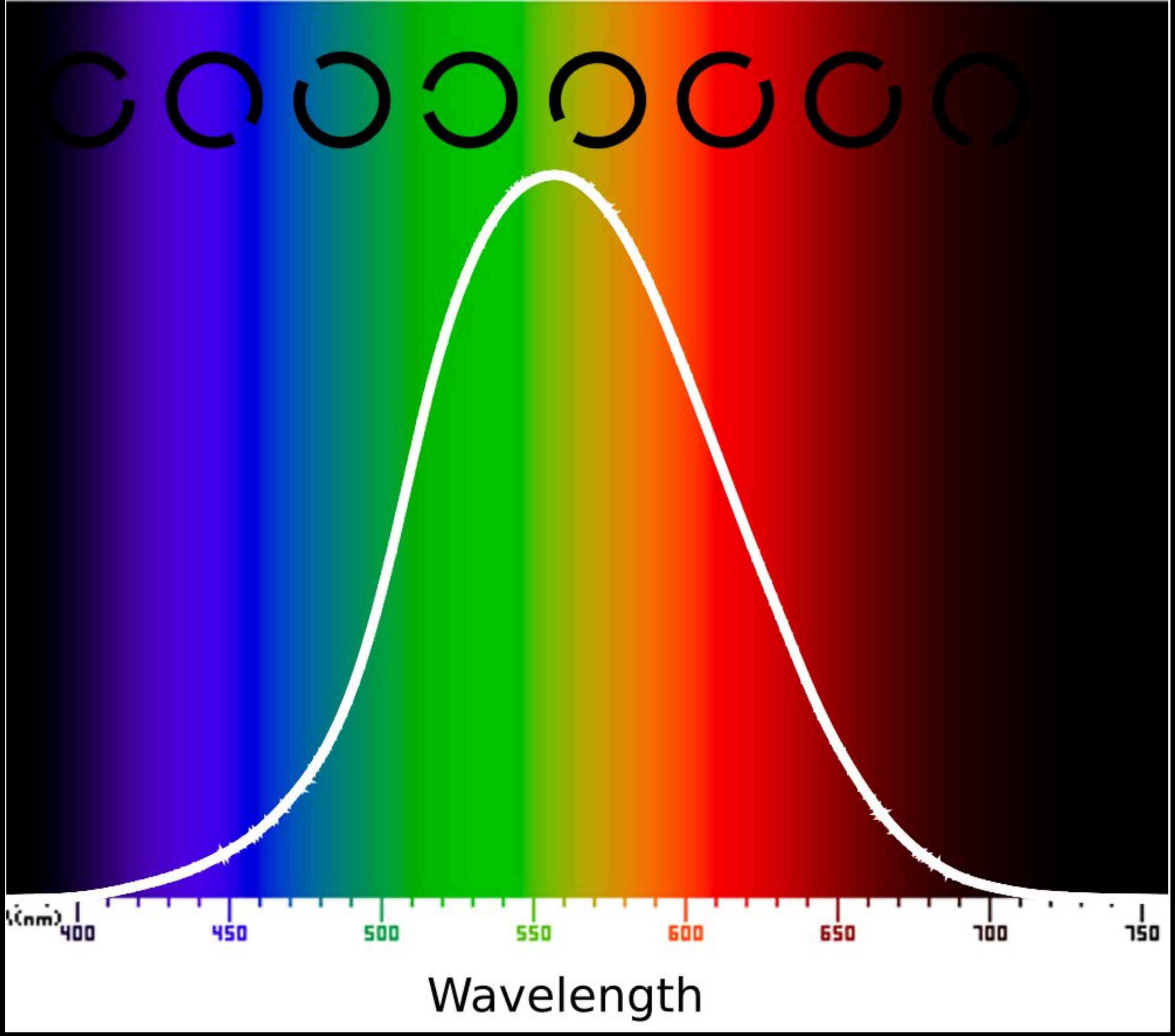
The power in lumens is the spectral watts multiplied by the sensitivity curve of the eye, the $V_M(\lambda)$ curve.

Daylight gives approximately 250 lumens per watt

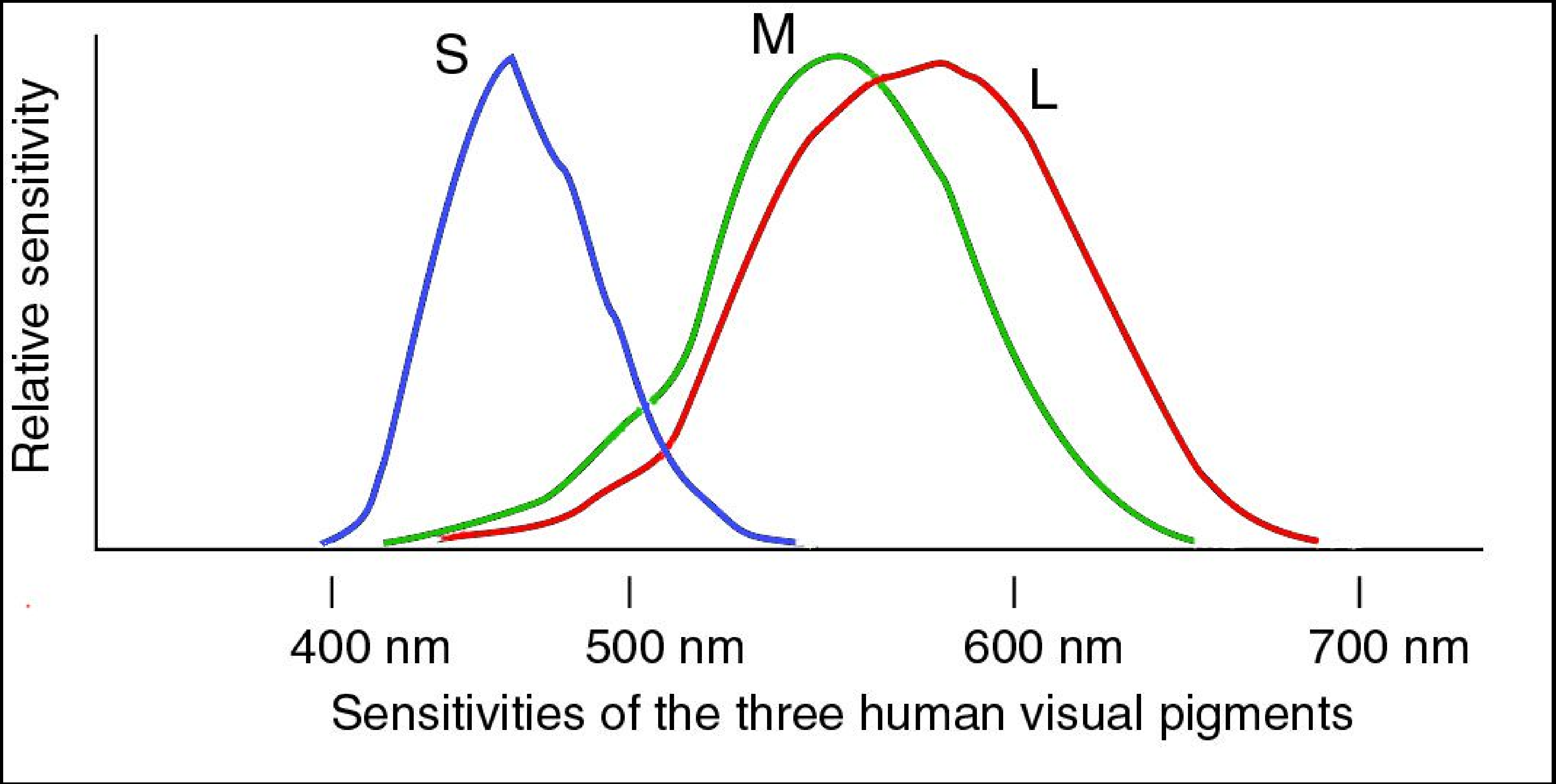


Origin of the v-lambda curve

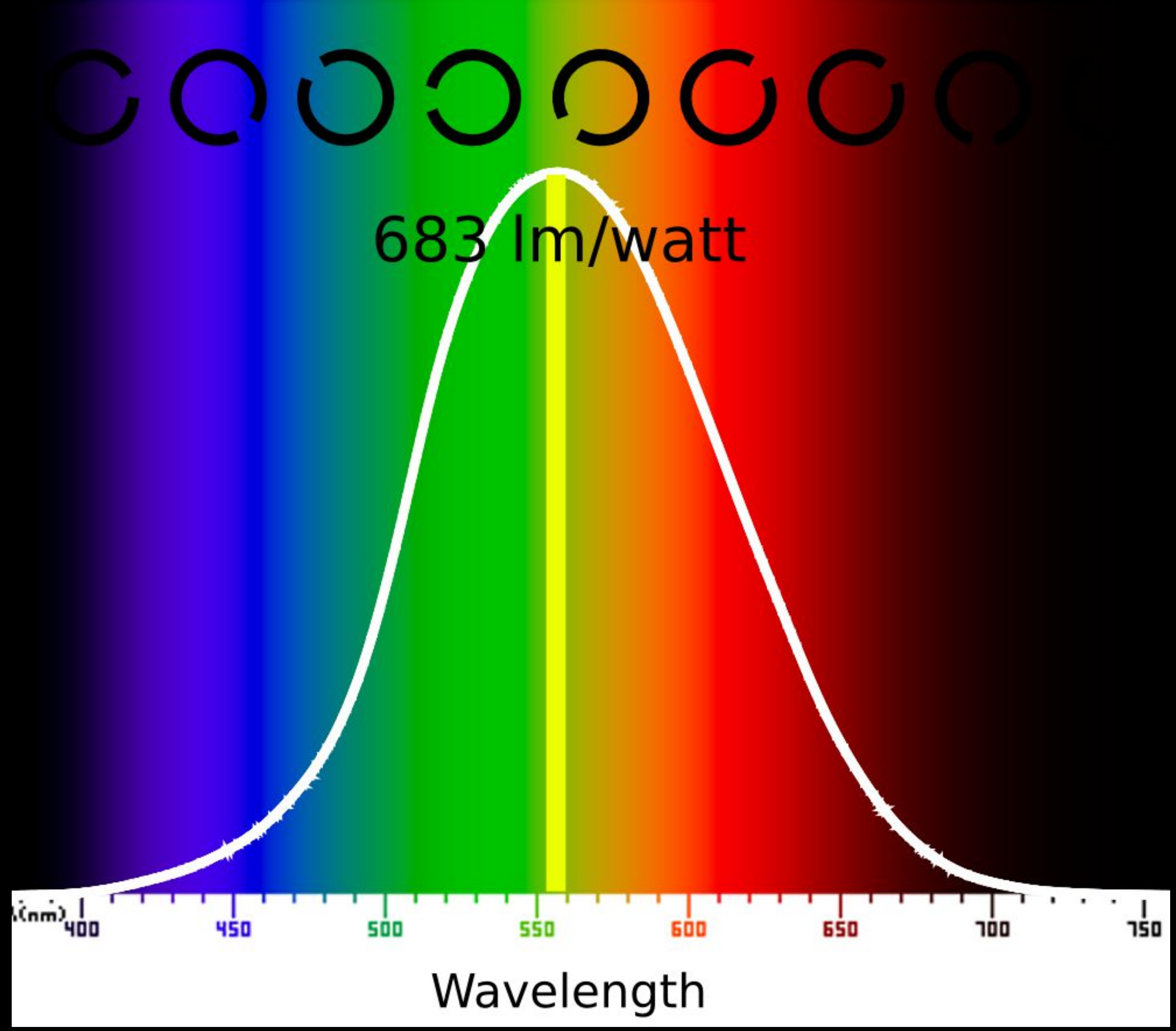
The sensitivity of the eye has been measured in several ways, such as the ability to distinguish flicker and the apparent brightness compared with yellow green light



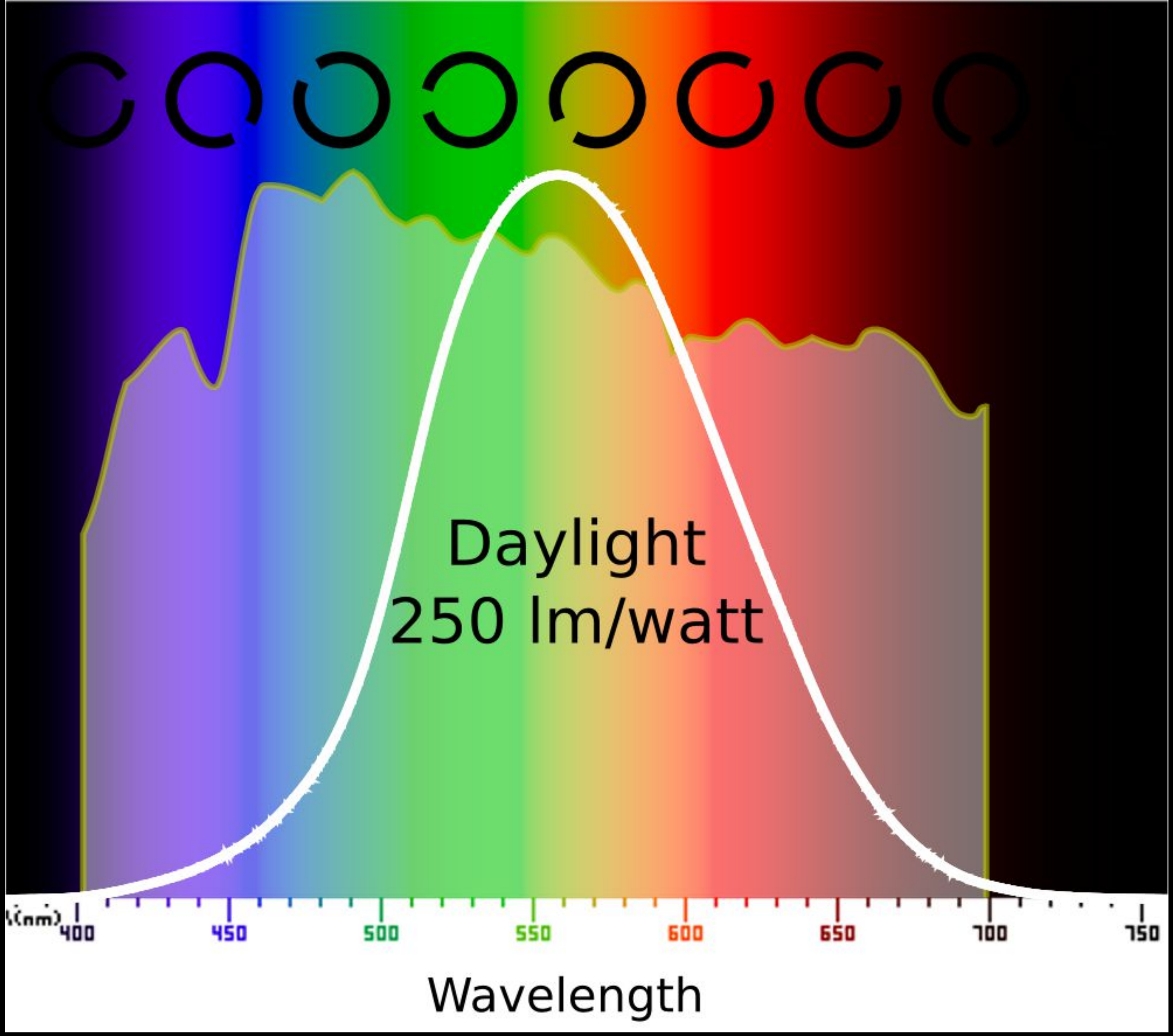
From these experiments we find this relationship between perceived brightness and wavelength of light



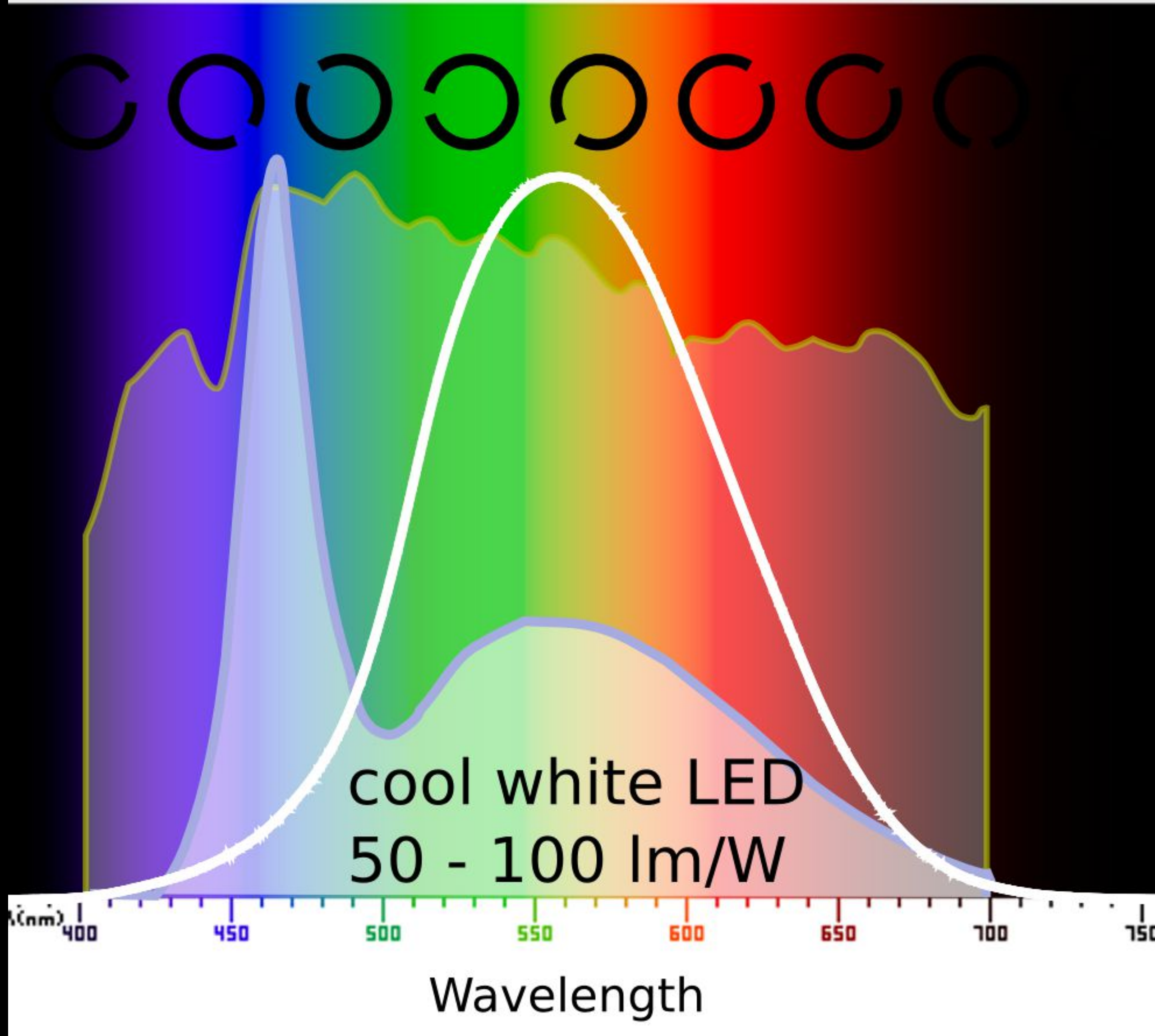
Colours are detected by the relative stimulation of three photon absorbing pigments in the retina. Notice that the middle and long wavelength sensors overlap considerably in sensitivity and that their sensitivity is low in the red end of the spectrum



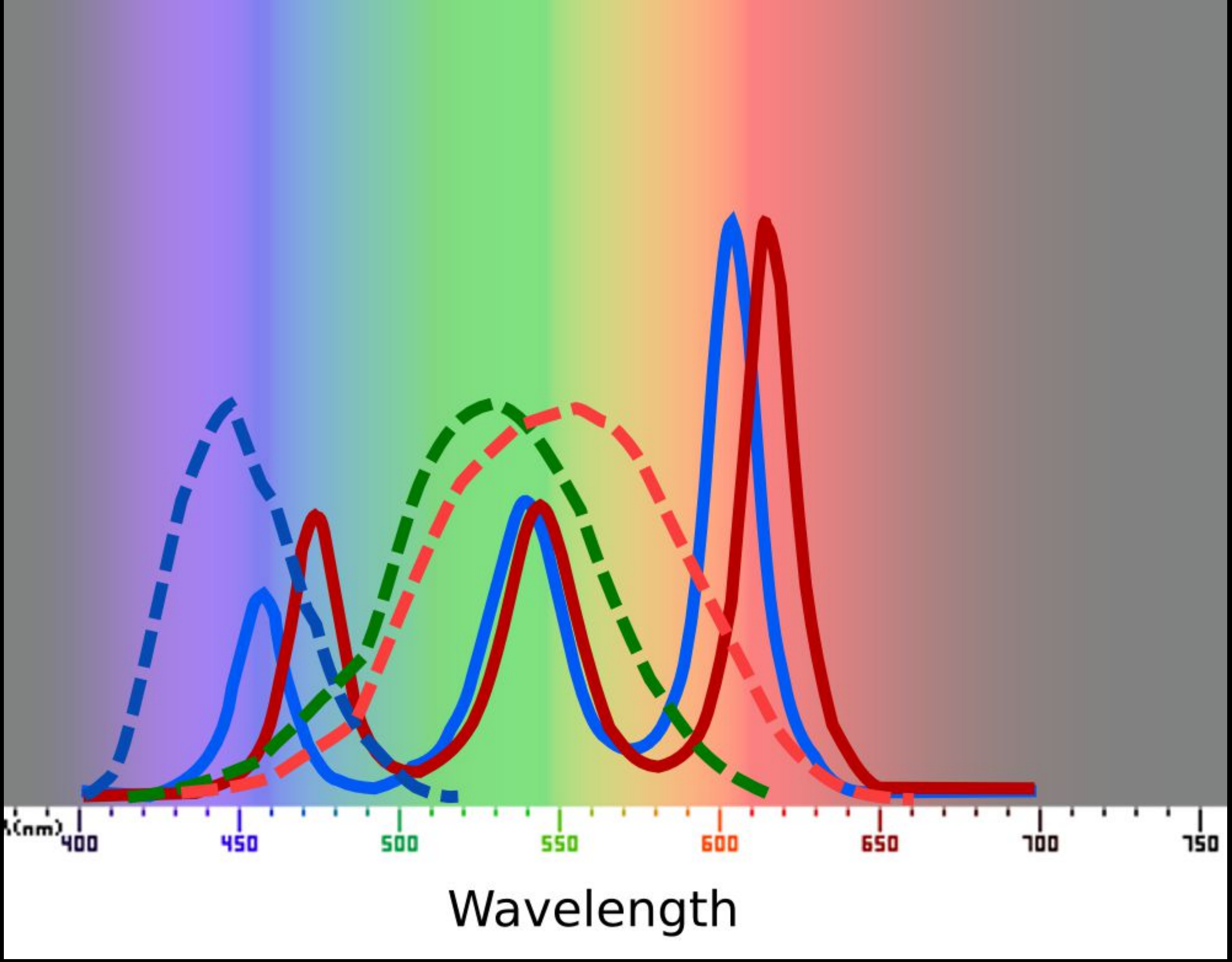
The candela is defined using the impractical monochromatic light source at 555 nm which is the peak of the eye's sensitivity. This has an efficiency of energy conversion of 683 lm/W



If we superimpose the spectrum of daylight we can see that much of its energy is in regions where the visual receptors are not very sensitive. The conversion efficiency is 250 lm/W



This is the spectrum of a white LED of the type with a single blue source with phosphors to spread the spectrum. It has a moderate colour rendering and a powerful photochemical potency from the blue source



The dashed lines are the visual pigment sensitivity curves. The solid lines are the spectral energy distribution of two three-component LED lamps. The 'blue' lamp has poor rendering of red - turning it brown because it stimulates the middle (green) sensor too much.

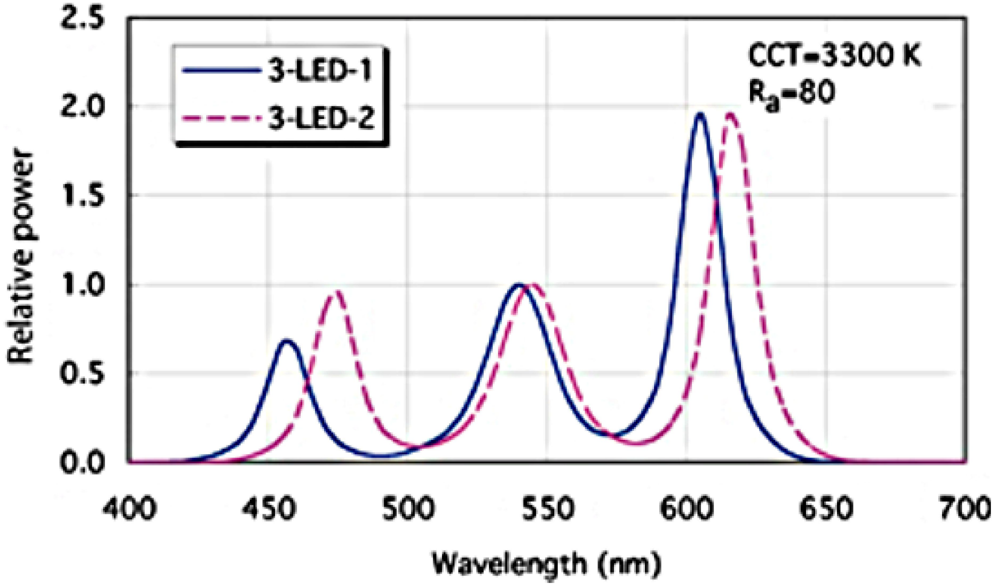


Figure 4: The SPDs of the two three-chip LED models, both having Ra=80 at 3300 K.

www.digikey.com/us/en/techzone/lighting/resources/articles/spectral-design-considerations-for-white-led.html

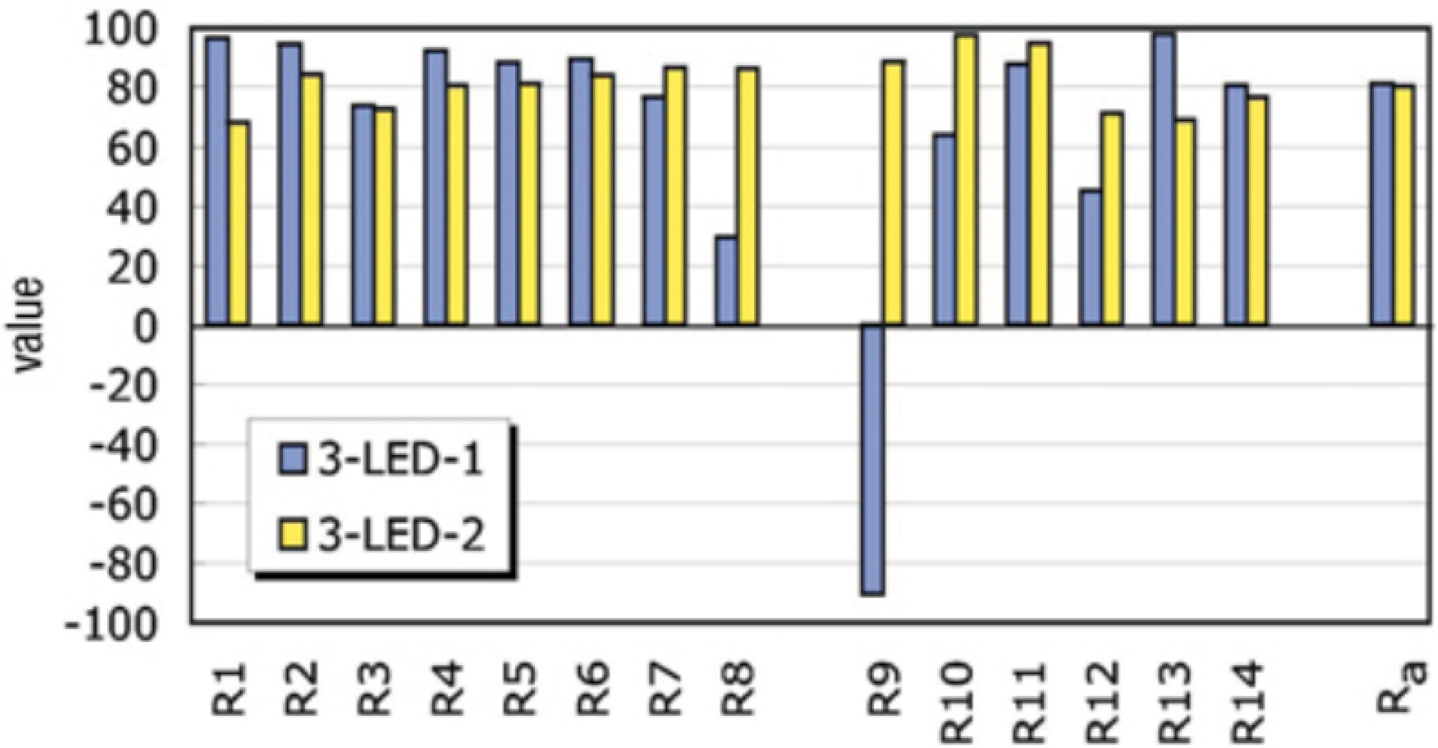
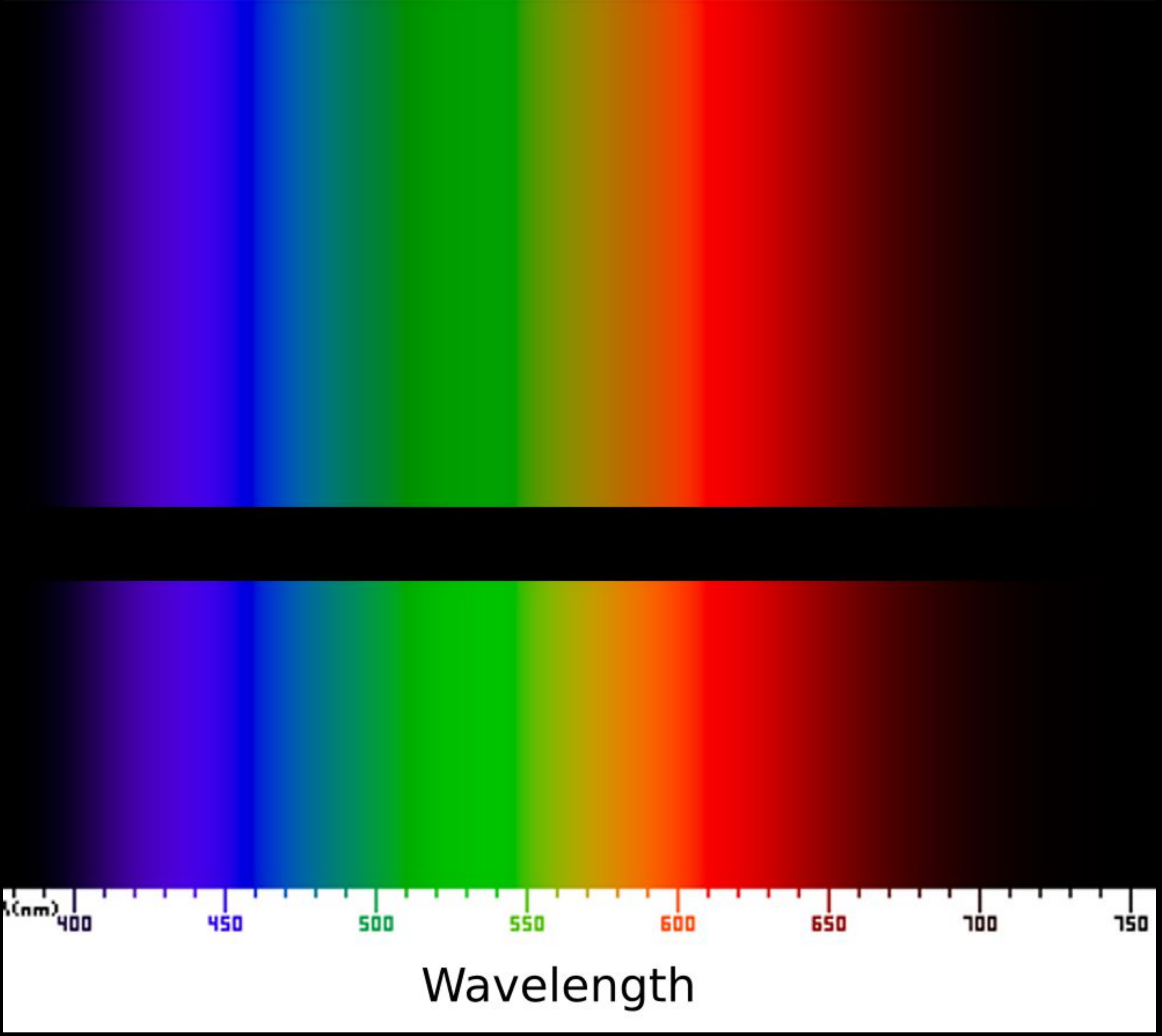


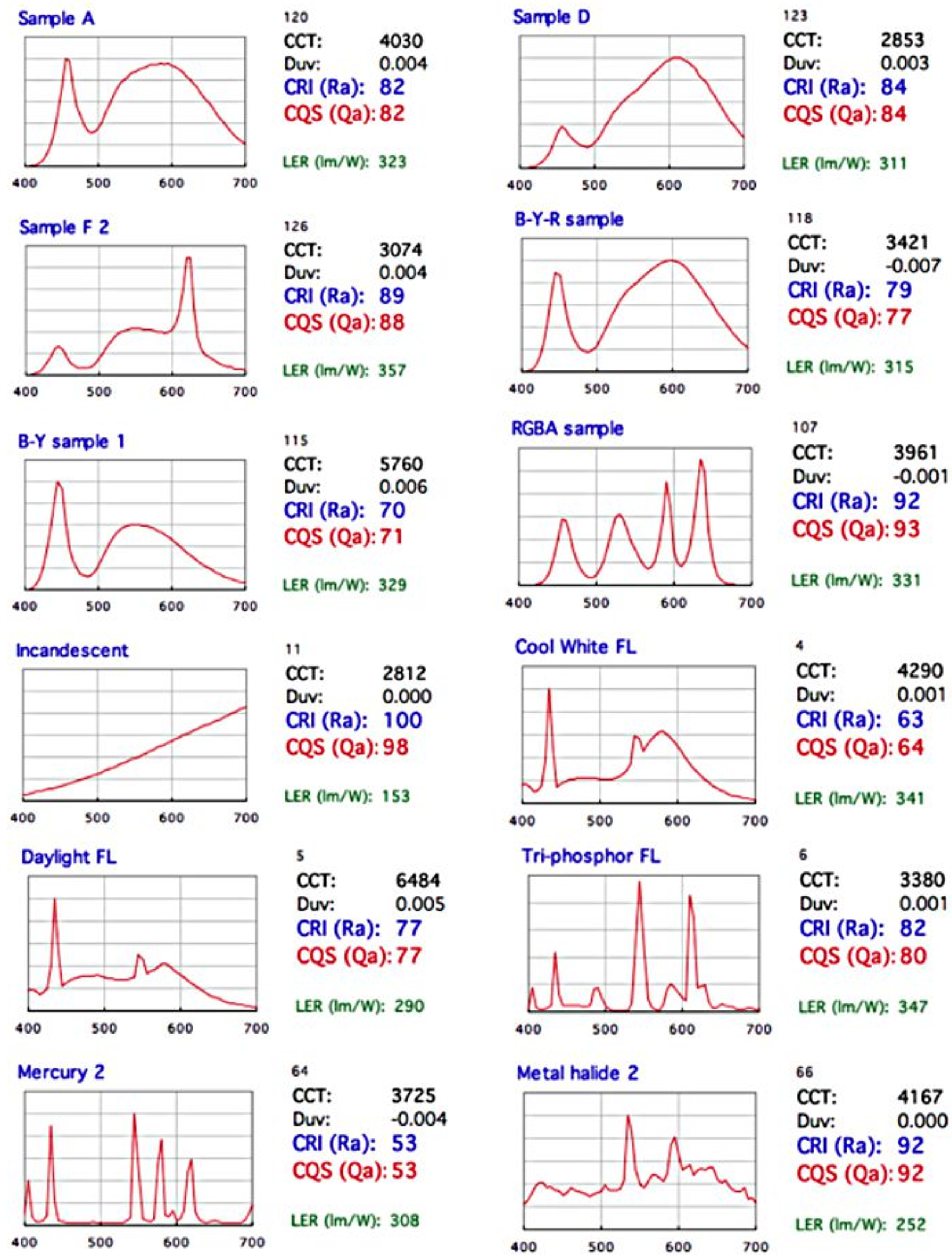
Figure 5: Special CRI of the two three-chip white LED models shown in Figure 4.

The alternative three or four colour LED array has an arbitrary choice of nearly mono-chromatic wave-lengths.

Colour rendering is variable, particularly for red and saturated colours



The colour rendering index is widely criticised by colour researchers. If the colour gamut is deliberately reduced by dimming the centre of the spectrum, people prefer the extra clarity and brilliance, but the luminous efficacy diminishes



The simplicity of earlier light sources, all based on glowing hot stuff, has now disappeared into a vast variety of sources. The human brain is good at correcting for deficiencies in the blue light from the smooth spectrum of hot sources. We are not so sure how good it is at compensating for the irregularities of modern light sources.

Magritte, The ignorant fairy, 1950

Much of the information in art
is less in the colour than in the
variation of luminosity of different
parts of the object.

Colour rendering will continue to
be debated, and its numerical
value used for marketing, as will
the lumens per watt efficiency.