

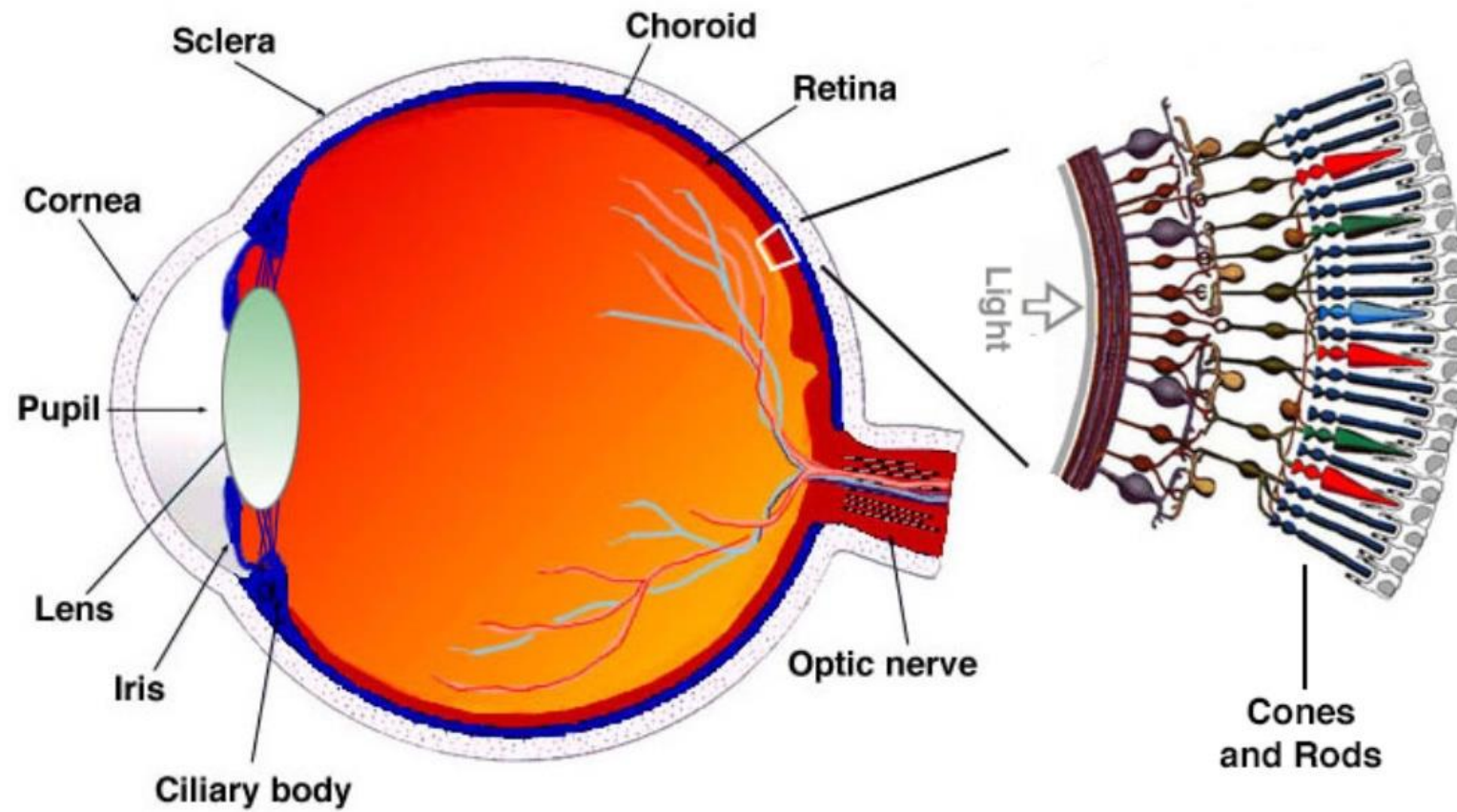
How much **blue** light do we need at night?

Can we have our cake and eat it too?



Human Health and Artificial Light at Night

- Sleep Disturbance universal but variable
- Obesity ↑20% via leptin
- Diabetes ↑ 20-300% (elderly)
- Cardiovascular disease ↑20%
- Macular degeneration ↑ 50%
- Mental Disorders
 - Bipolar ↑20%
 - Depression "SAD"
- Cancer - Breast, ↑47%* (30 yr follow up 5%- 7.5%)
 - Prostate ↑100% bedroom light
 - Colo-rectal ↑60%



*Anatomy of the eye and retina
(Sarno, 2018)*

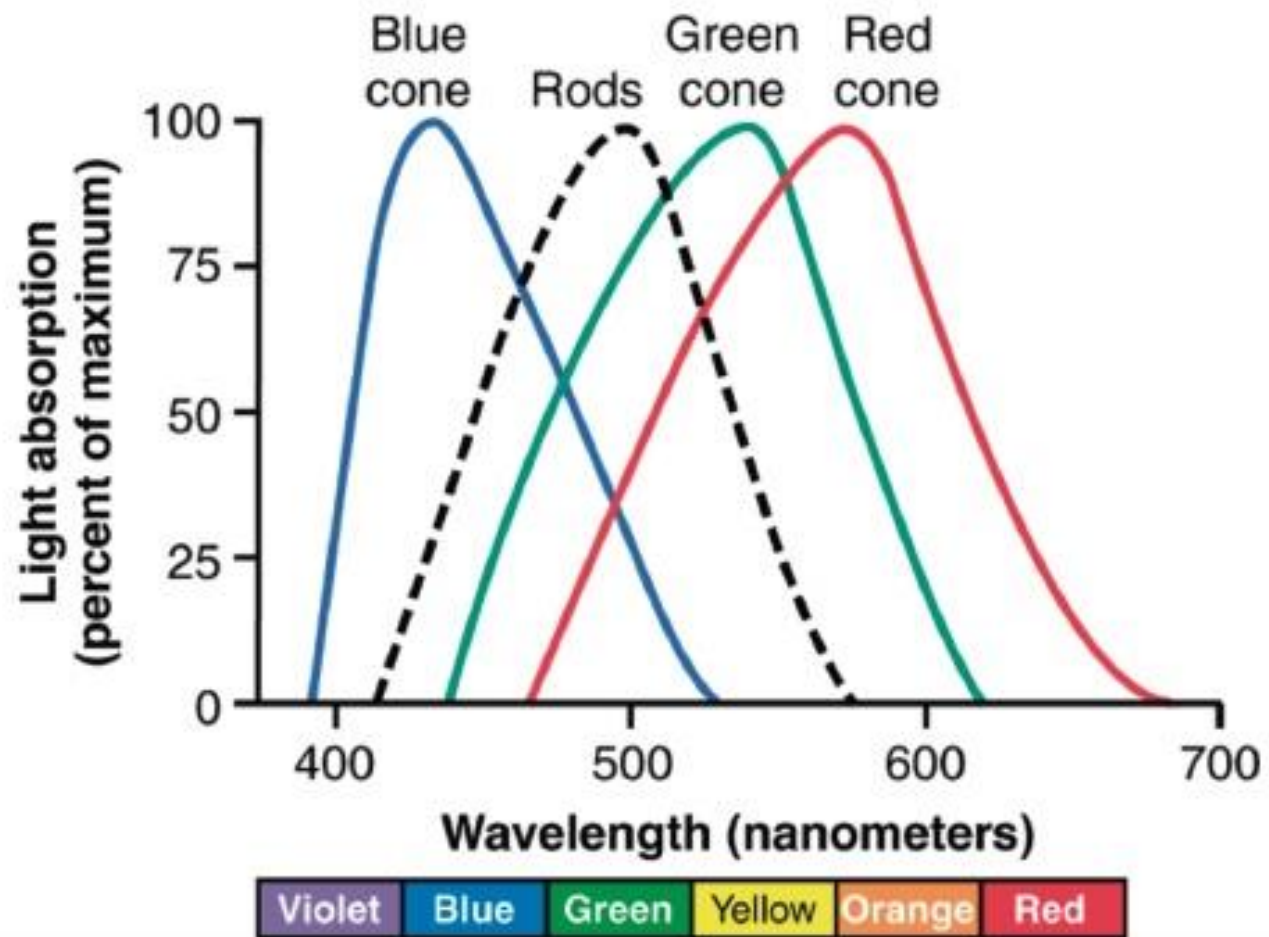


Figure 1
Relative Spectral Sensitivity of photoreceptors in the human eye
(Hall, 2011b)

Rod Sensitivity

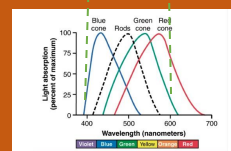
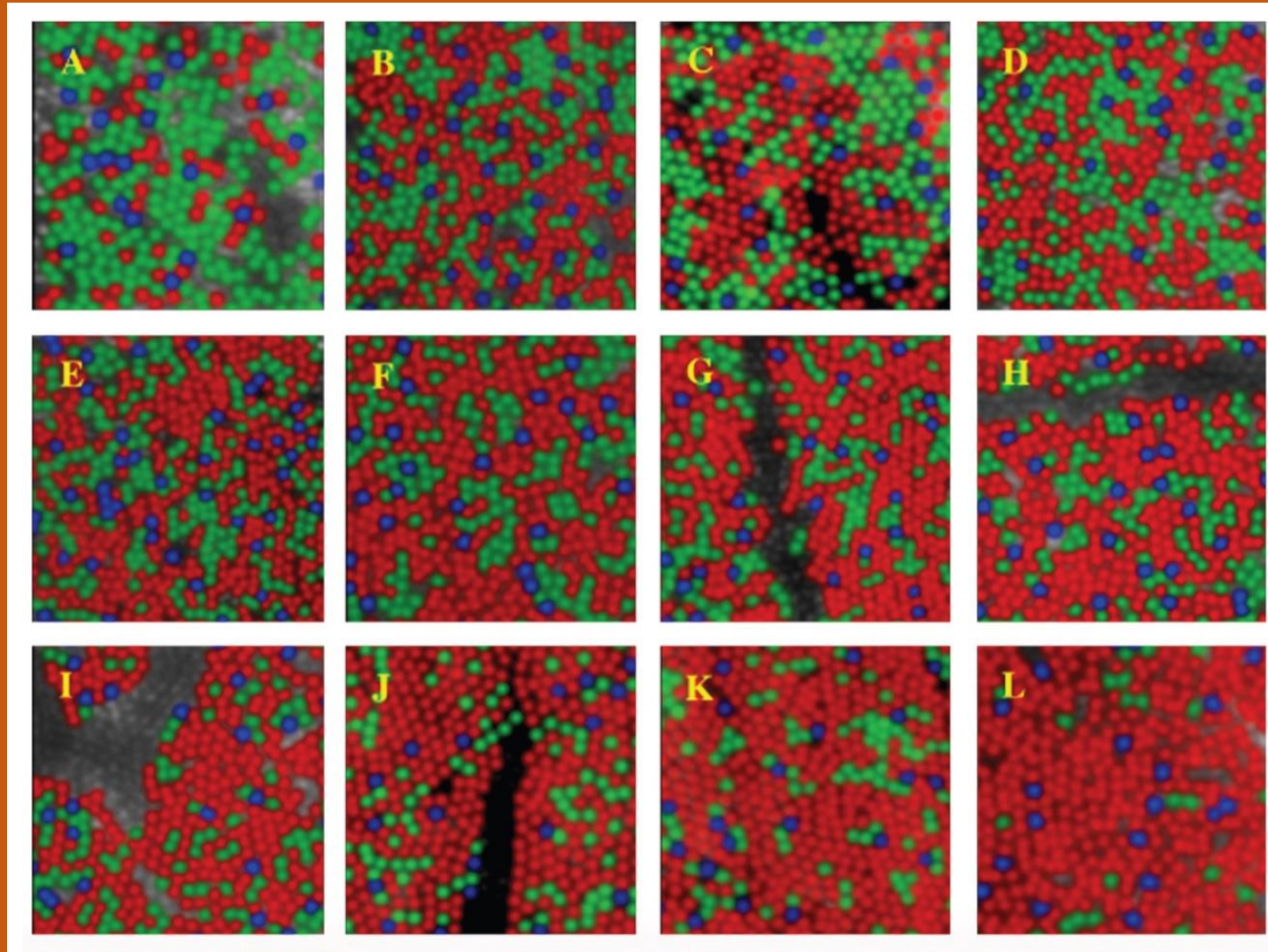


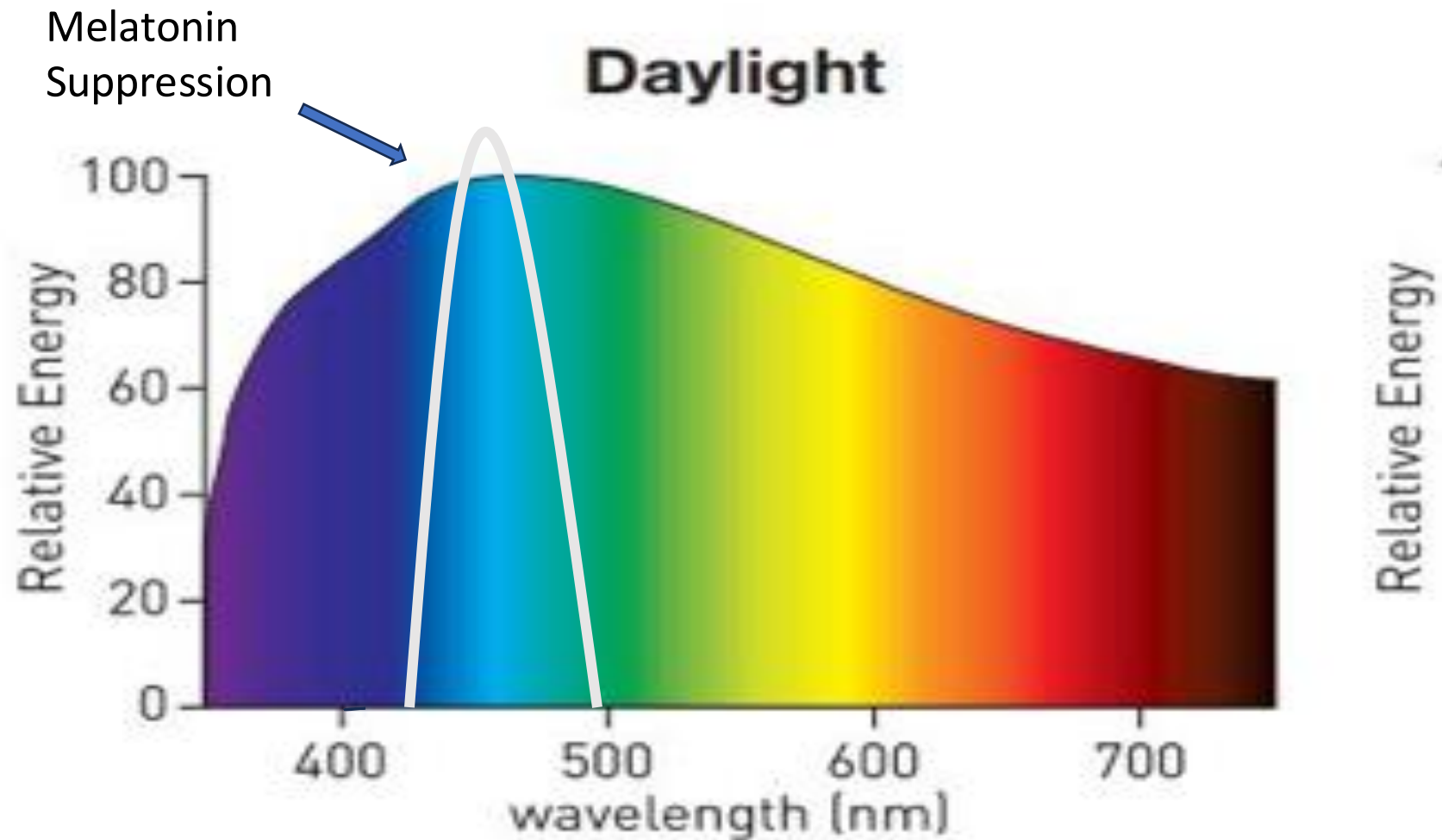
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Relative Spectral Sensitivity of photoreceptors in the human eye
(Hill, 2011b)

Cone Sensitivity

Retinal Cone Mosaic



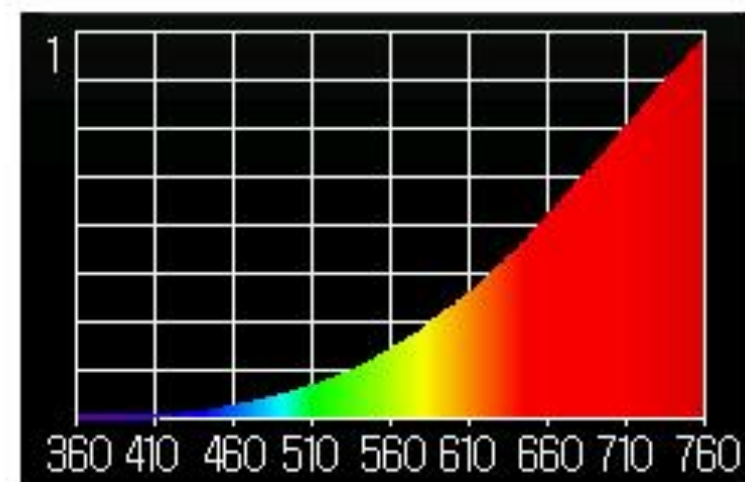
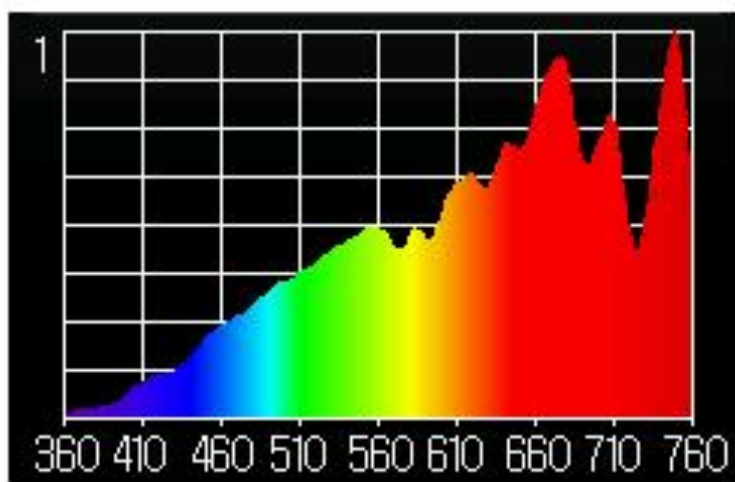
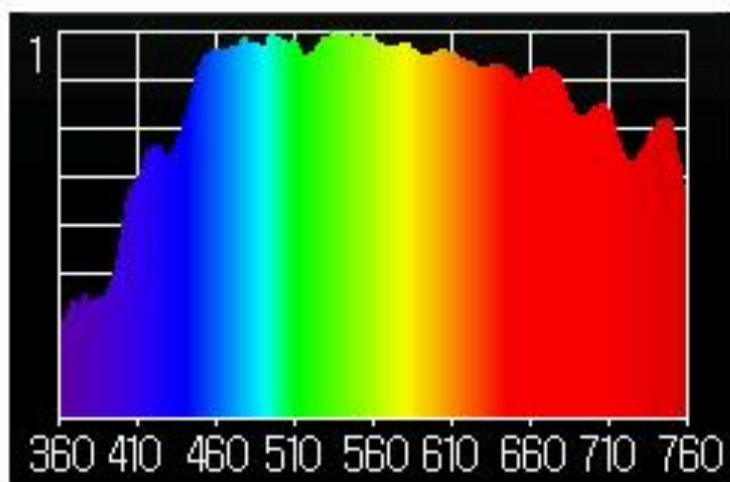
Power spectrum curve



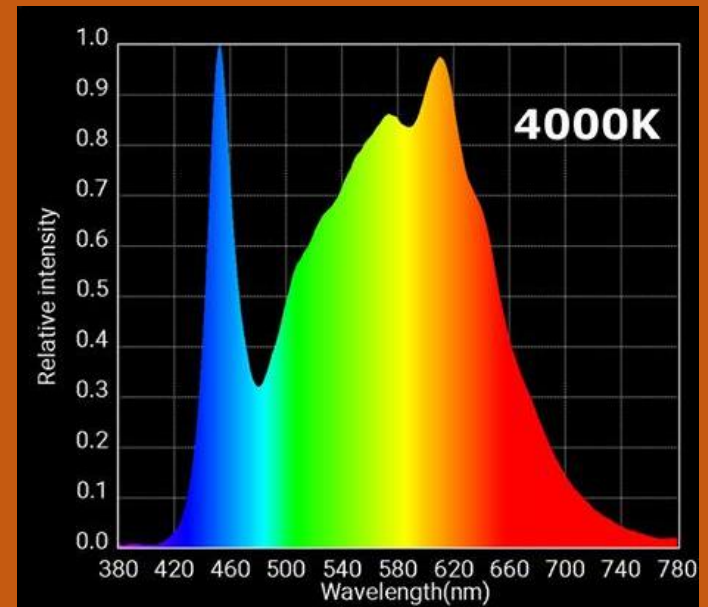
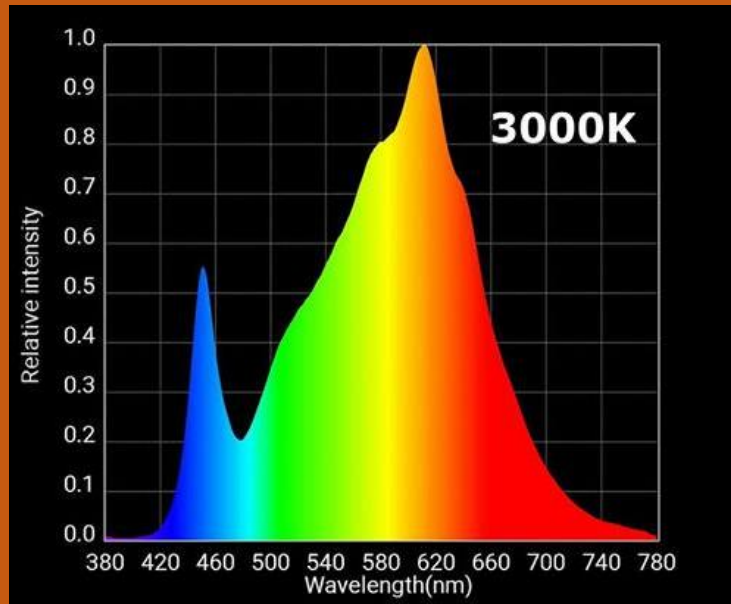
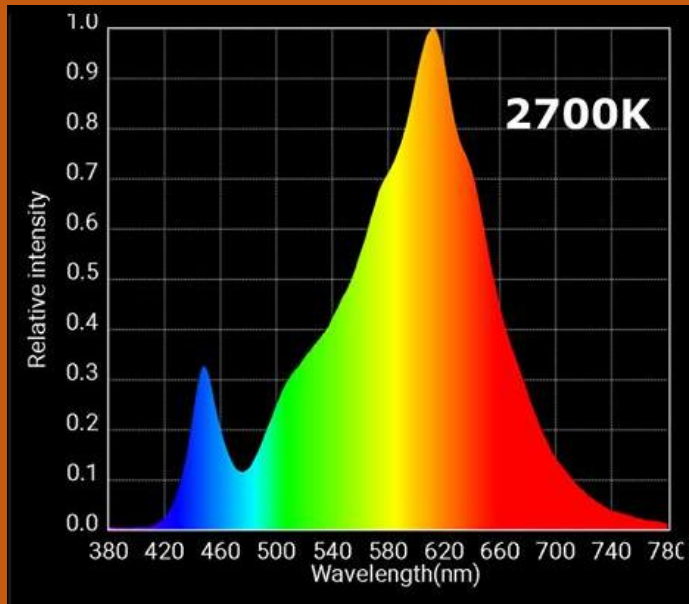
noon

evening

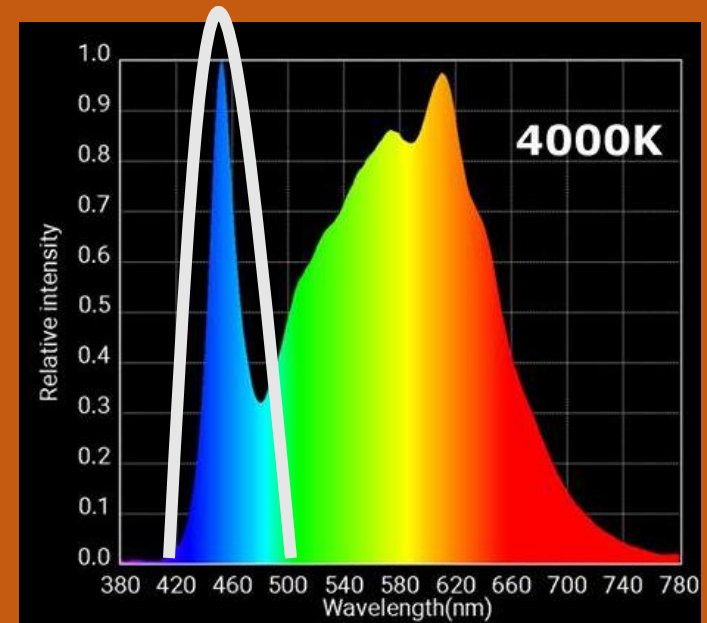
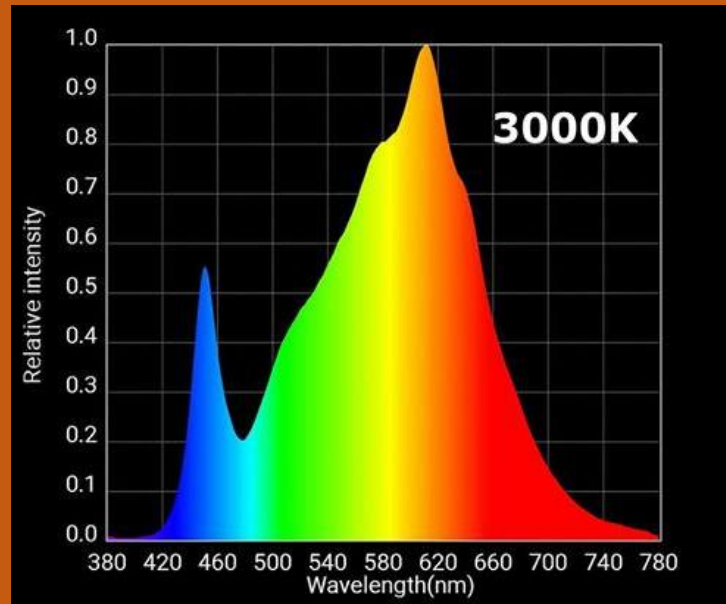
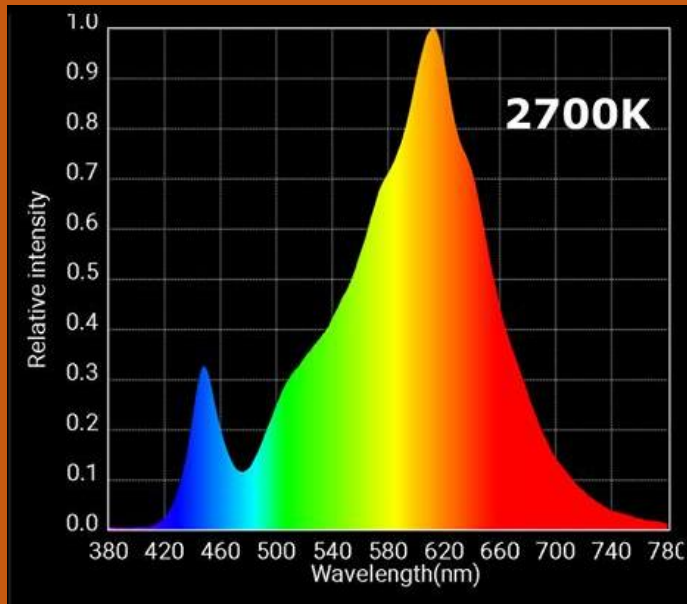
night

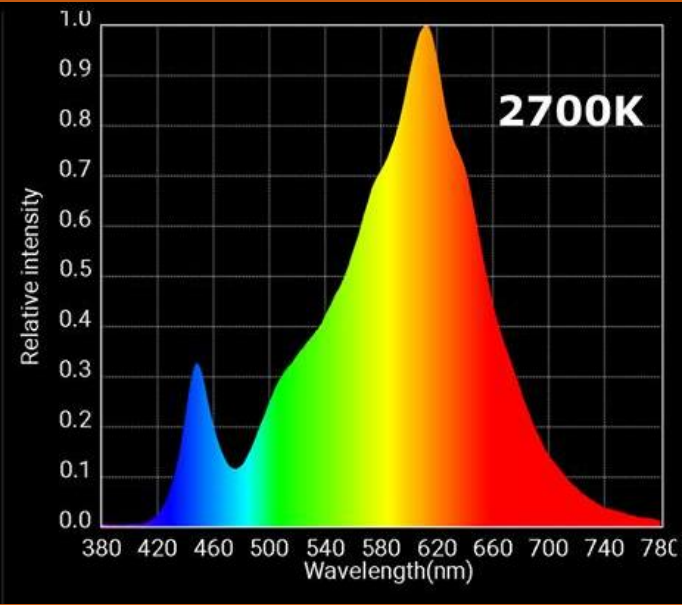


2400K 2700K 3000K 4200K 6200K



2400K 2700K 3000K 4200K 6200K





2700K CRI 100



2700K CRI 90



2700K CRI 80

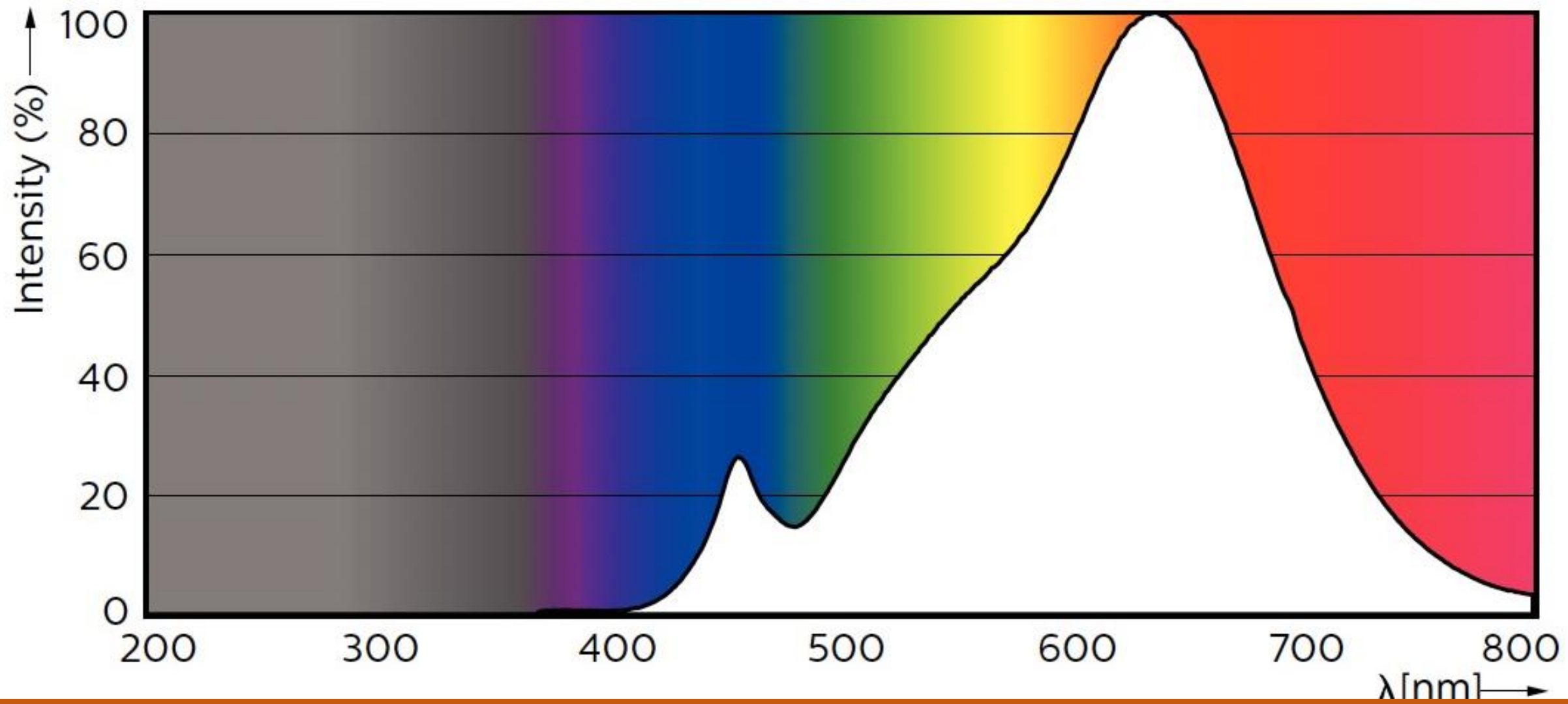


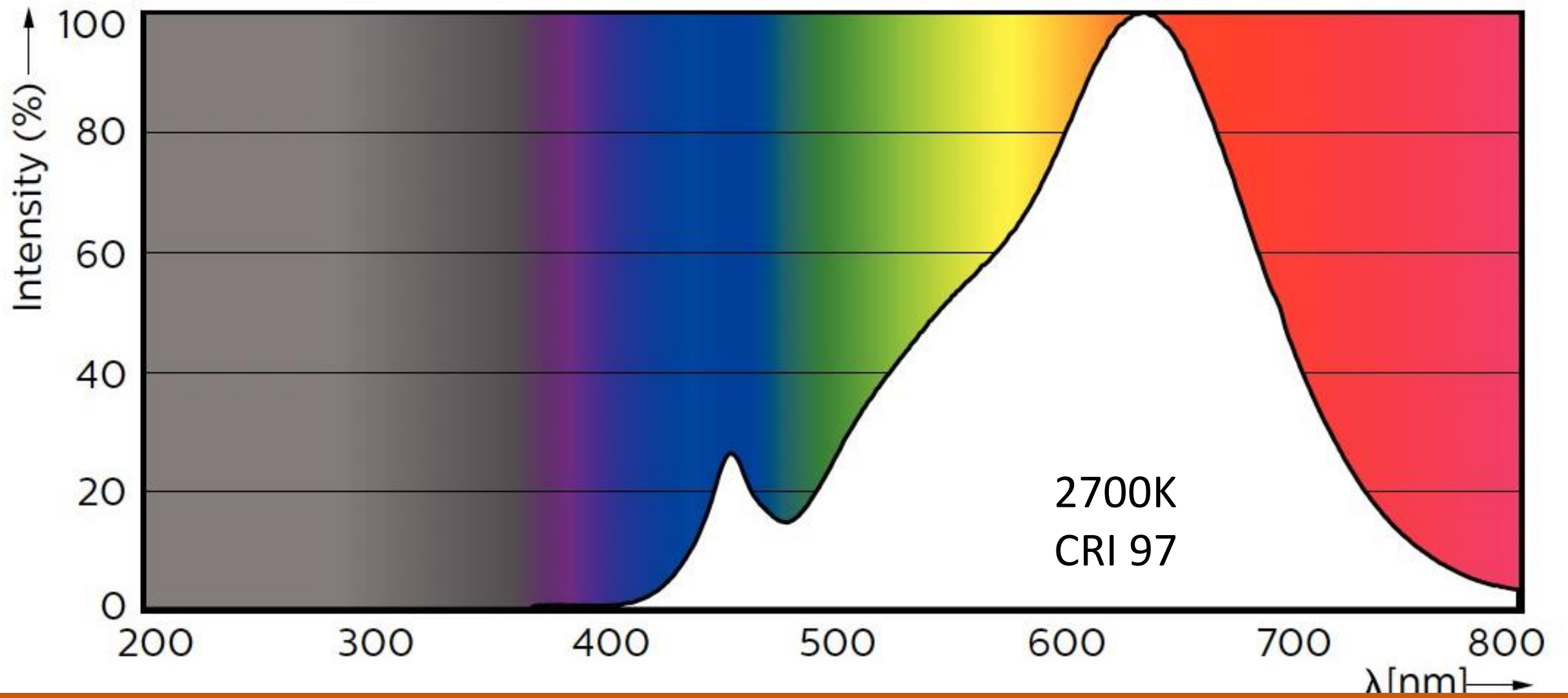
2700K CRI 70

**Good Spectrum trumps
brightness or blueness.**

Optimal Stimulus Theory
Robert Dick 2016

Night light spectrum should
optimally trigger all rods and cones.





Philips MASTER LED Expert Color LED
5.5-50W GU10 927 24D
2700k CRI 97

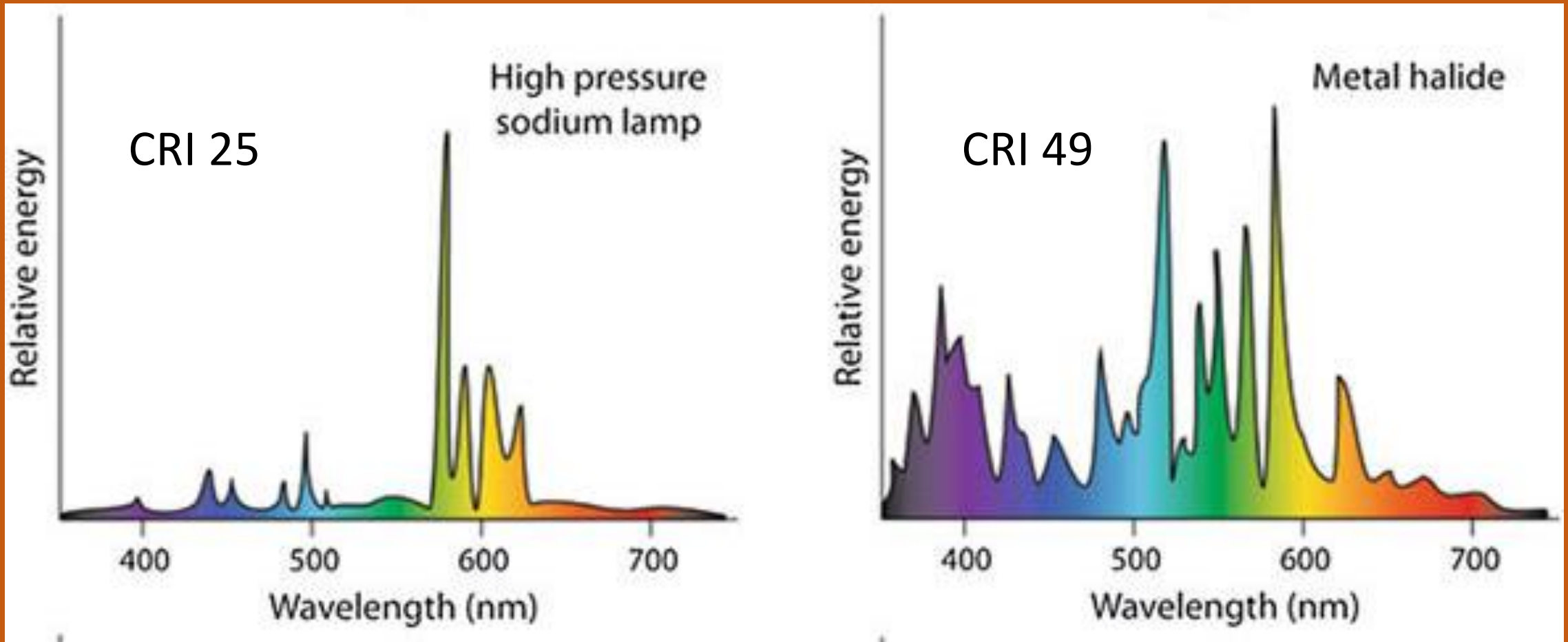
Red Light

The author tested the effect of several colors of light and confirmed that the conventional wisdom of using red at night needs to be revisited.

Field Test



Older Technology Outdoor & Street Lights



LED streetlight studies

European and Chinese studies

2700K - 3000K better (and driver preferred) than 4000K

The Impact of LED Colour Rendering on Reaction Time of Human Eyes in Tunnel Interior Zone
Li-Li Dong , Qi Lou , Peng Liu , and Wen-Hai Xu
School of Information Science and Technology, Dalian Maritime University, Dalian 116026, China

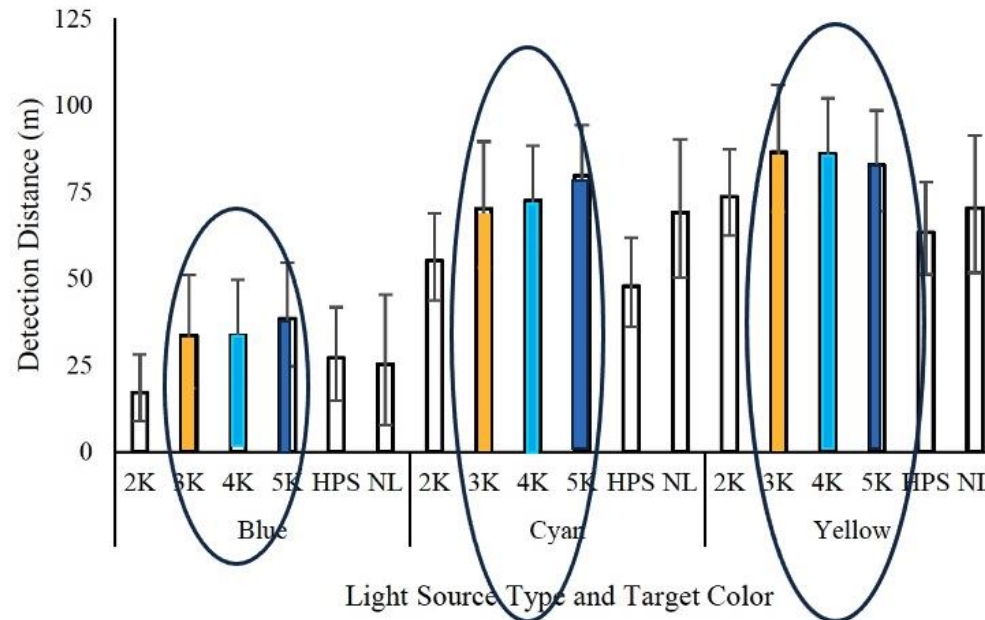
Drivers' Preference for the Color of LED Street Lighting
MARKO DAVIDOVIC¹, LIDIJA DJOKIC², ALEKSANDRA CABARKAPA², ANDREJ DJURETIC³, VLADAN SKEROVIC⁴, AND MIOMIR KOSTIC ¹

LED streetlight studies

US studies

LED lighting superior to old technology

No significant difference between 3000K, 4000K and 5000K



INVESTIGATING THE HEALTH IMPACTS OF
OUTDOOR LIGHTING
Sponsored by the US Department of Energy
Under Contract: DE-EE0008207
Project Final Report
Virginia Tech Transportation Institute
Dr. Ronald Gibbons
Dr. Rajaram Bhagavathula
Dr. George Brainard
Dr. John Hanifin
Benjamin Warfield
Andrew Kassing

Figure 27. Detection distance of Landolt-C targets by color across all light types. The error bars represent a 95% confidence interval of the true mean detection distance.



Los Angeles - Los Angeles is switching to LED street lights, reducing light pollution in the same time. Soon you will be able to see some constellations in the sky. Before and after pix.



The effect of reduced street lighting on road casualties and crime in England and Wales: controlled interrupted time series analysis

Rebecca Steinbach,¹ Chloe Perkins,² Lisa Tompson,³ Shane Johnson,³
Ben Armstrong,¹ Judith Green,⁴ Chris Grundy,¹ Paul Wilkinson,¹ Phil Edwards²

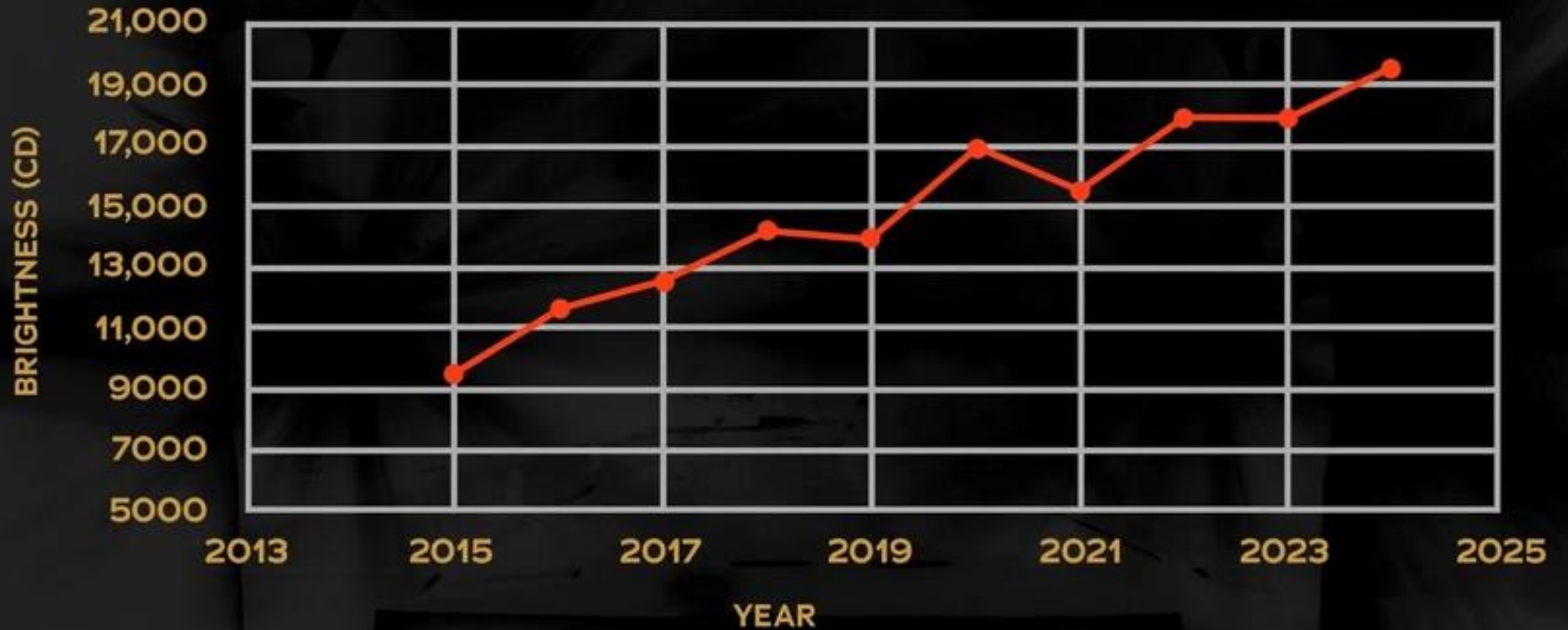
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Conclusions This study found little evidence of harmful effects of switch off, part-night lighting, dimming, or changes to white light/LEDs on road collisions or crime in England and Wales.



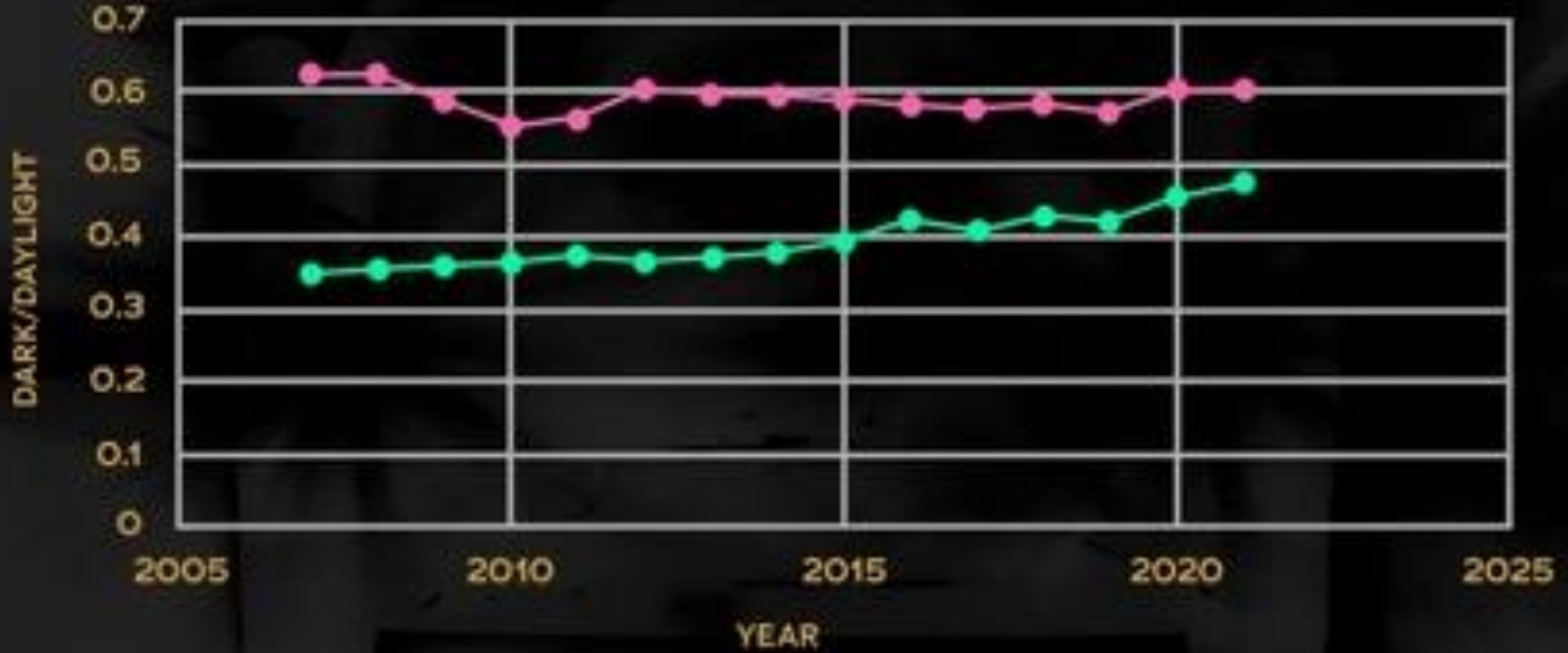
AVERAGE HEADLIGHT BRIGHTNESS



Insurance Institute for Highway Safety, USA

FATAL CRASHES IN DARK CONDITIONS

■ DARK: NOT LIGHTED ■ DARK: LIGHTED



**How many scientific studies
does it take**

To change a light bulb?