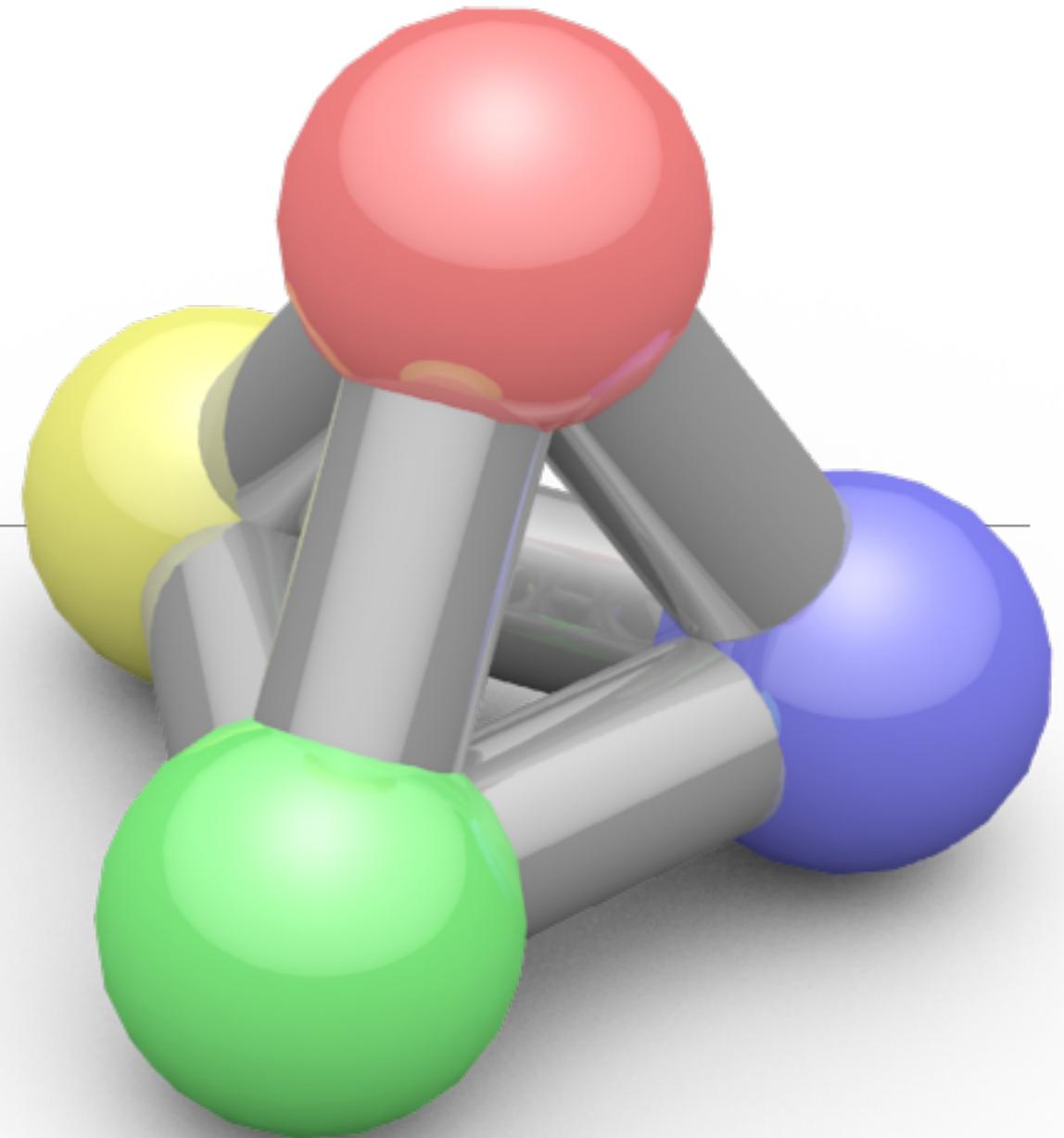


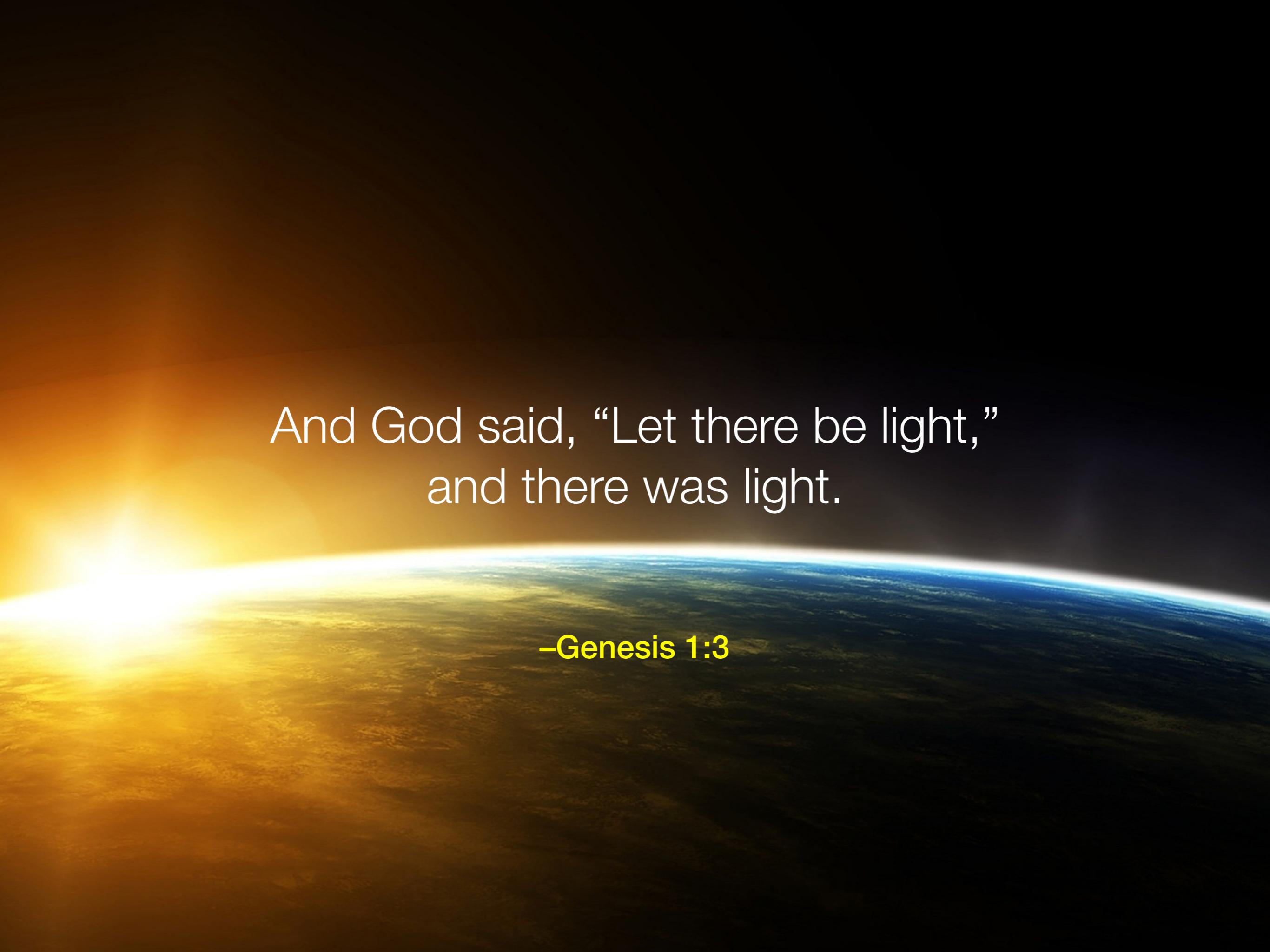
# Light & Colour

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CPSC 453 – Fall 2016

Sonny Chan





And God said, “Let there be light,”  
and there was light.

–Genesis 1:3

# Our first curiosity

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- What are these “temperature” settings we keep seeing on our cameras and displays?



camera settings



display settings

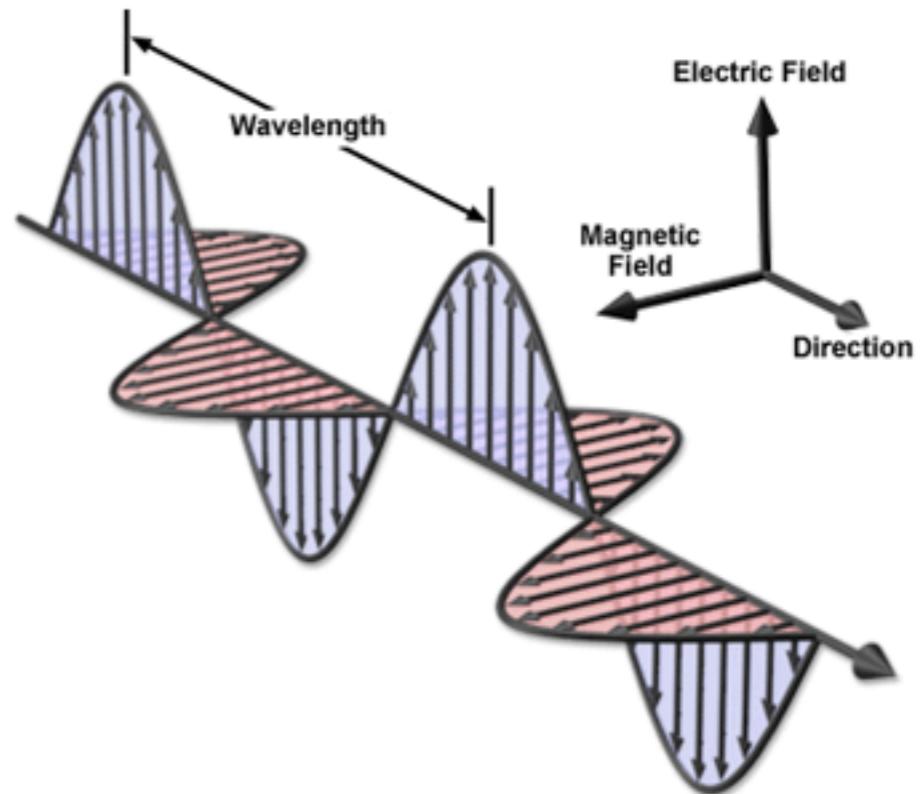
**What is  
light?**

# James Clark Maxwell

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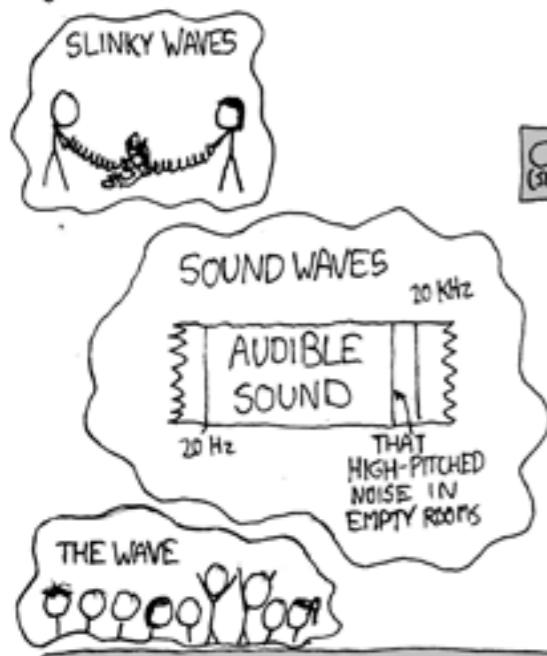
**Electromagnetic Wave**



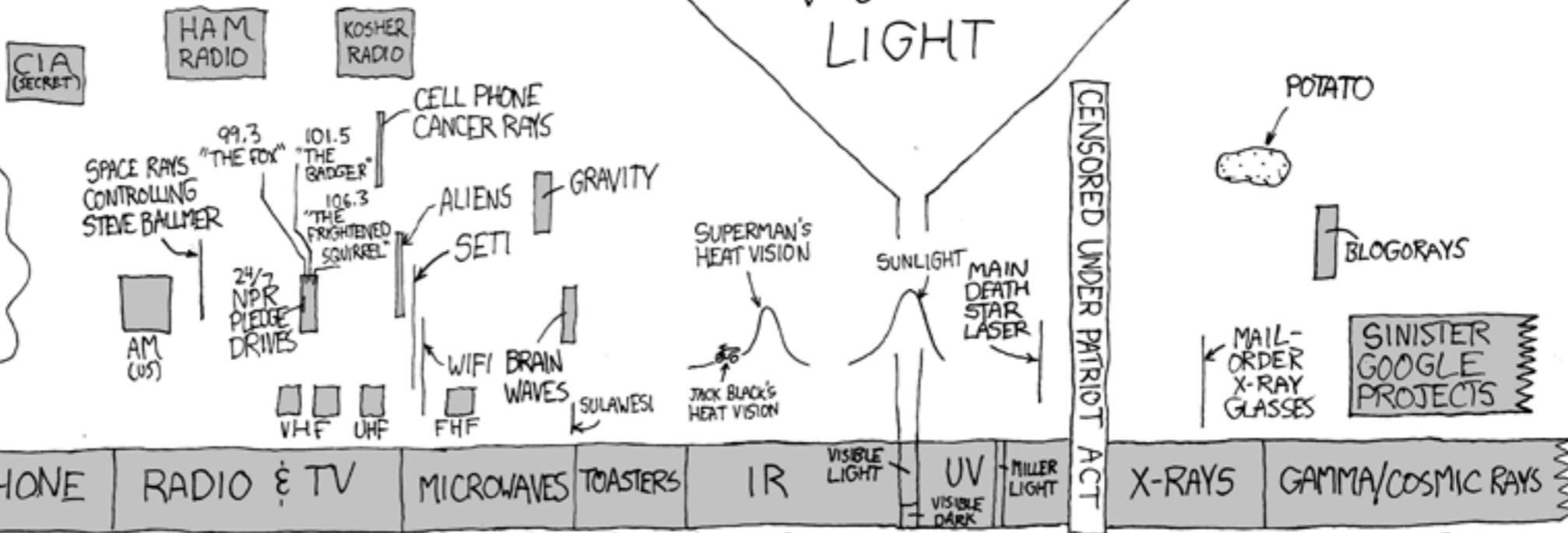
# THE ELECTROMAGNETIC SPECTRUM

THESE WAVES TRAVEL THROUGH THE ELECTROMAGNETIC FIELD. THEY WERE FORMERLY CARRIED BY THE AETHER, WHICH WAS DECOMMISSIONED IN 1897 DUE TO BUDGET CUTS.

OTHER WAVES:



SHOUTING CAR DEALERSHIP COMMERCIALS



$\lambda$  (m)  $10^3 \ 10^2 \ 10^1 \ 10^0 \ 10^{-1} \ 10^{-2} \ 10^{-3} \ 10^{-4} \ 10^{-5} \ 10^{-6} \ 10^{-7} \ 10^{-8} \ 10^{-9}$

100Mm 10Mm 1Mm 100km 10km 1km 100m 10m 1m 10cm 1cm 1mm 100nm 10nm 100nm 10nm 1nm 100pm 10pm 1pm 100fm

f (Hz)  $10^0 \ 10^1 \ 10^2 \ 10^3 \ 10^4 \ 10^5 \ 10^6 \ 10^7 \ 10^8 \ 10^9 \ 10^{10} \ 10^{11} \ 10^{12} \ 10^{13} \ 10^{14} \ 10^{15} \ 10^{16} \ 10^{17} \ 10^{18} \ 10^{19} \ 10^{20} \ 10^{21} \ 10^{22}$

1Hz 10Hz 100Hz 1KHz 10KHz 100KHz 1MHz 10MHz 100MHz 1GHz 10GHz 100GHz 1THz 10THz 100THz OTHER ENTERTAINING GREEK PREFIXES LIKE PETA- AND EXA- AND ZAPPA-

Q ( $\text{Gal}^2/\text{Coulomb}$ )  $17 \ 117 \ \pi \ 42 \ \phi \ e^{\pi - \text{rr}} \ -2 \ 5 \cdot 10^{50} \ 12 \ 11^2$

## ABSORPTION SPECTRA:

HYDROGEN:



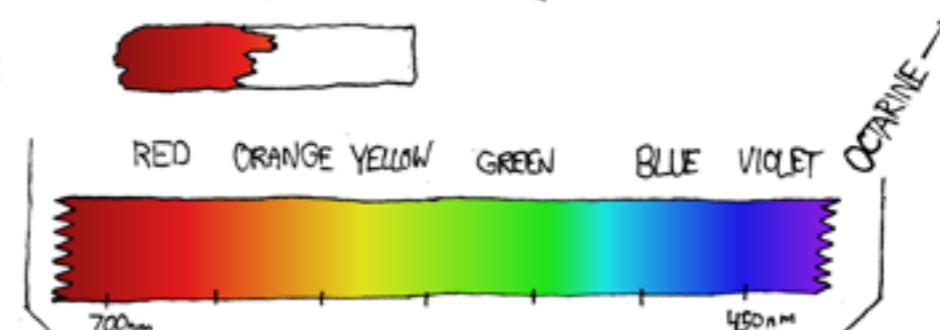
HELUM:



DEPENDS®:

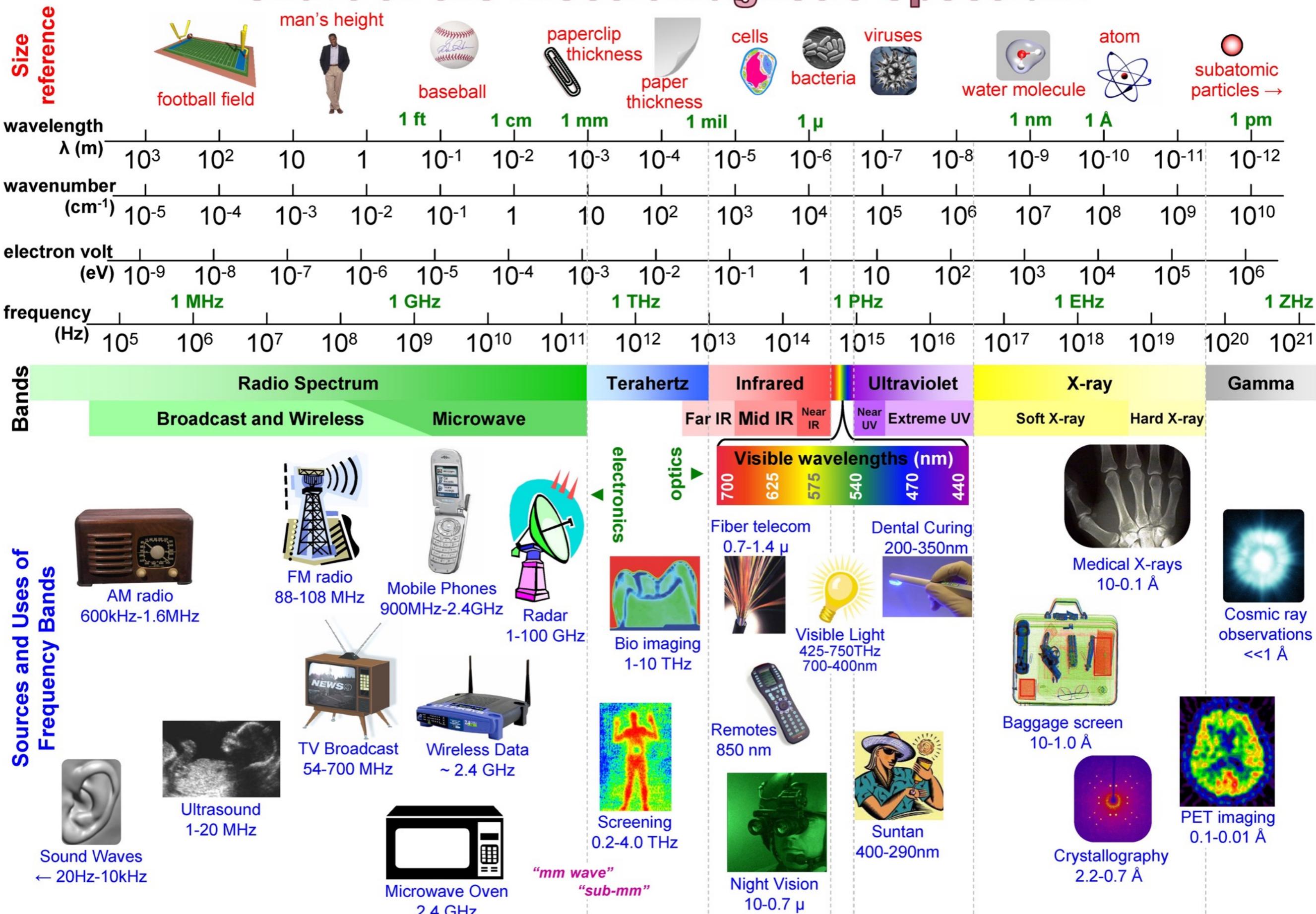


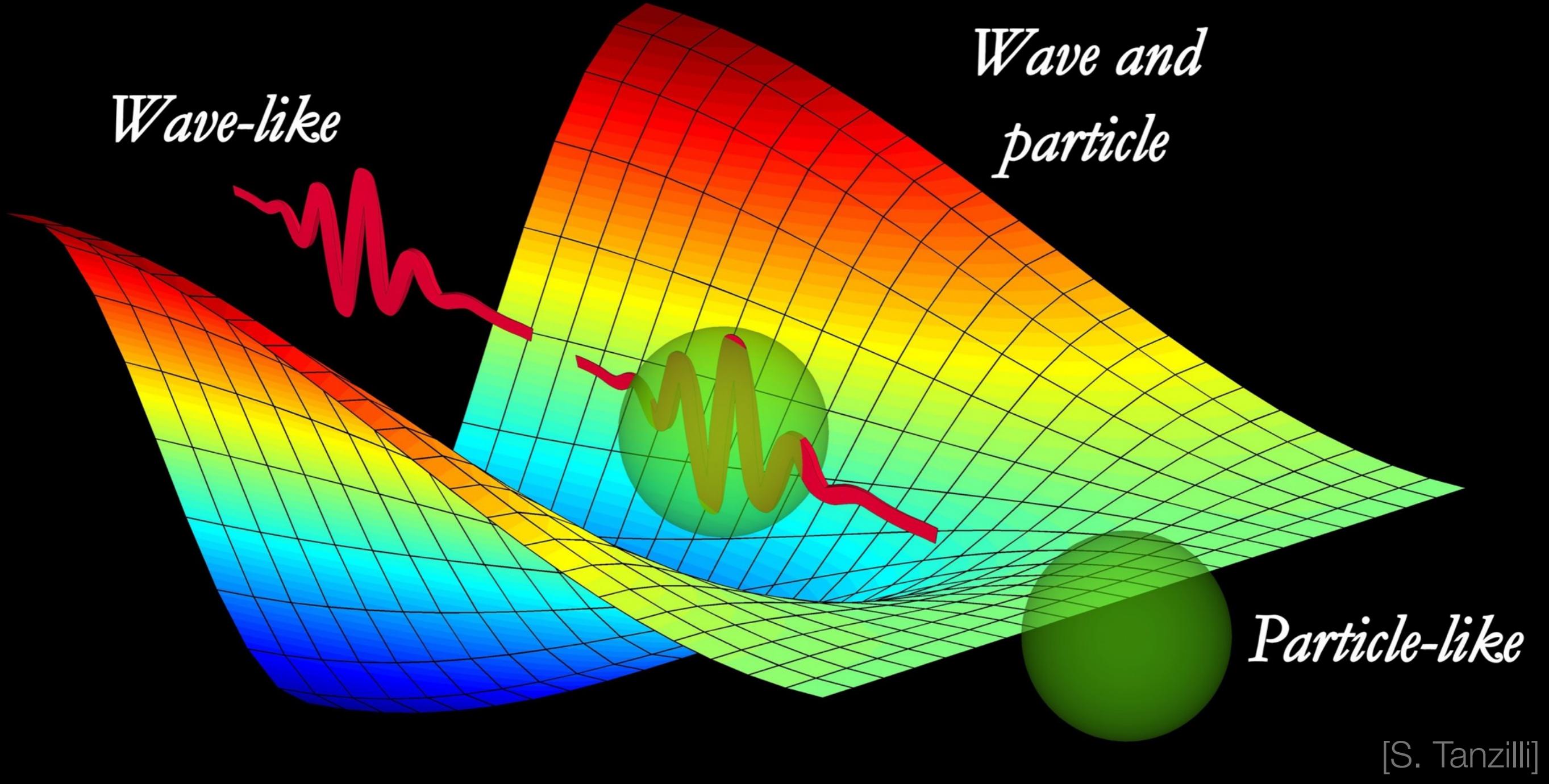
TAMPAX®:



VISIBLE  
LIGHT

# Chart of the Electromagnetic Spectrum





What about photons?

Complicated question...

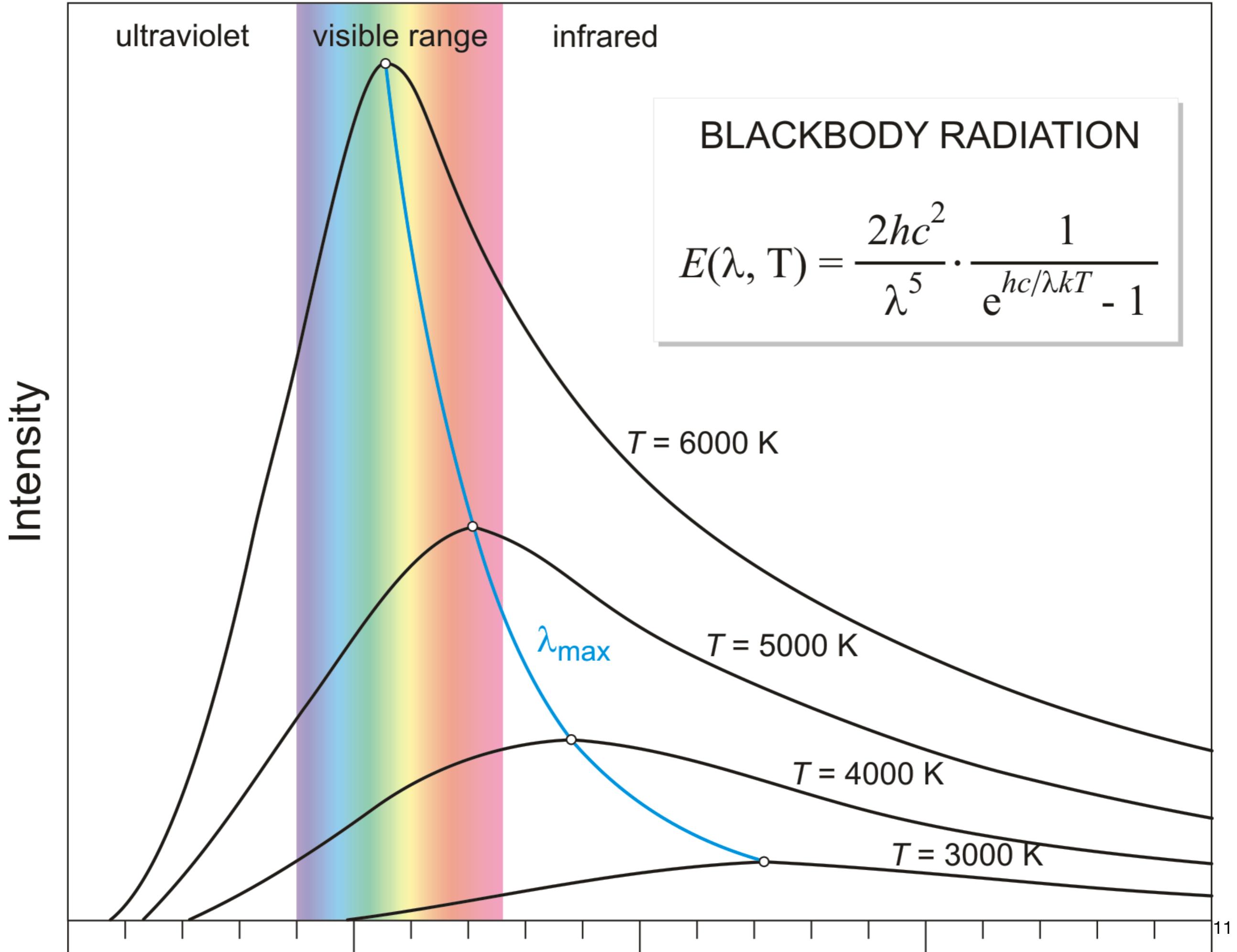
Where does light  
come from?



# Black-Body Radiation

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- An opaque, non-reflective body in thermodynamic equilibrium emits electromagnetic radiation with a spectrum dependent **only on its temperature**
- Planck's Radiation Law



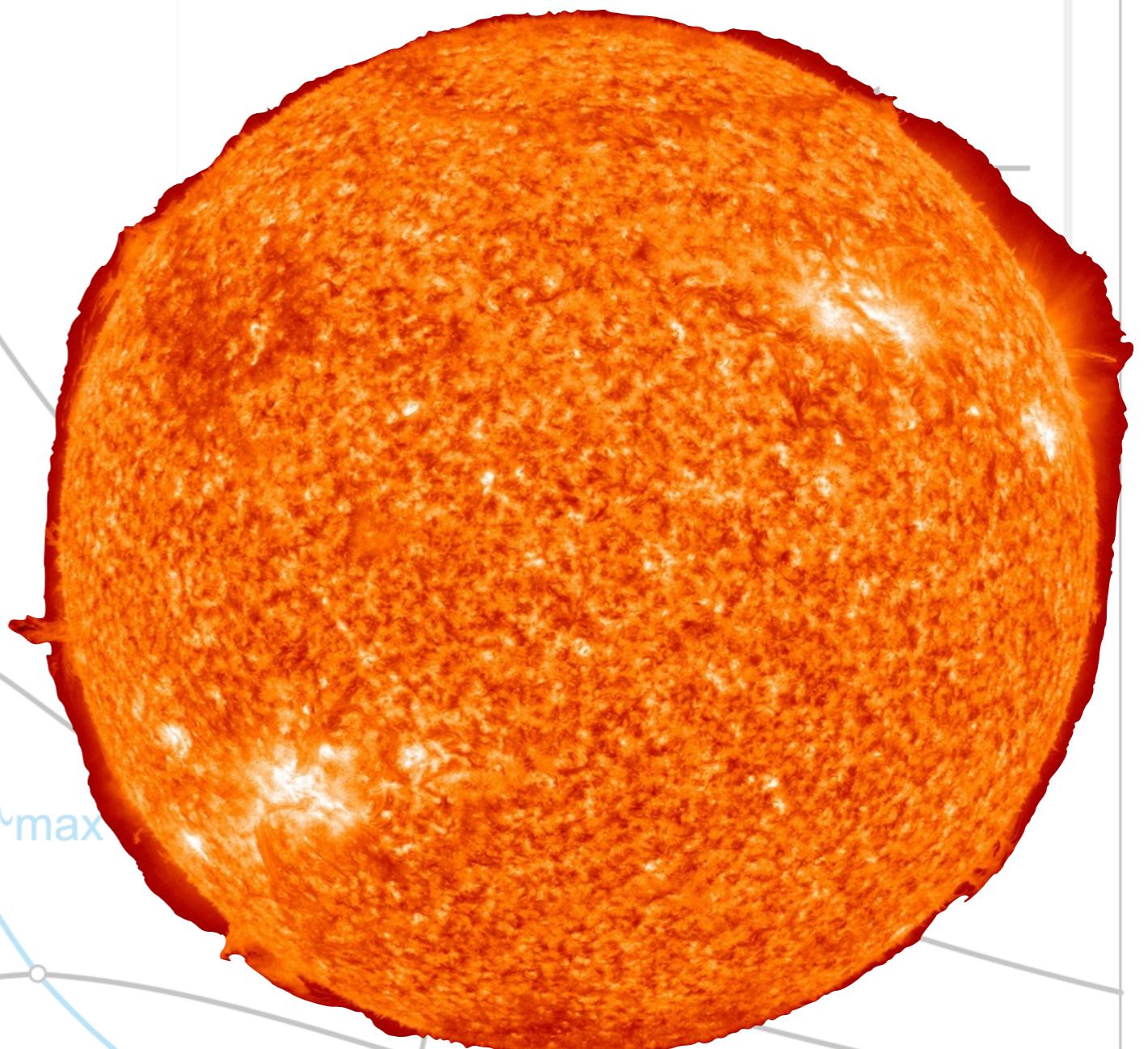
# How hot is the sun?

ultraviolet

visible range

infrared

BLACKBODY RADIATION



$T = 3000\text{ K}$

<b>Light source</b>	<b>Approximate color temperature</b>
Candle	1930 K
Sunlight at dawn	2000 K
Tungsten lamp (incandescent indoor lamp)	2400 K
Typical indoor fluorescent bulb	3000 K
Photographic lamp	3200 K
Photoflood lamp	3400 K
Clear flashbulb	3800 K
Sunlight at noon	5400–5500 K
Blue flashbulb	6000 K
Electronic flashbulb	6000 K
Average daylight	6500 K
Blue sky	12000–18000 K

# Colour



What colour is this ball?





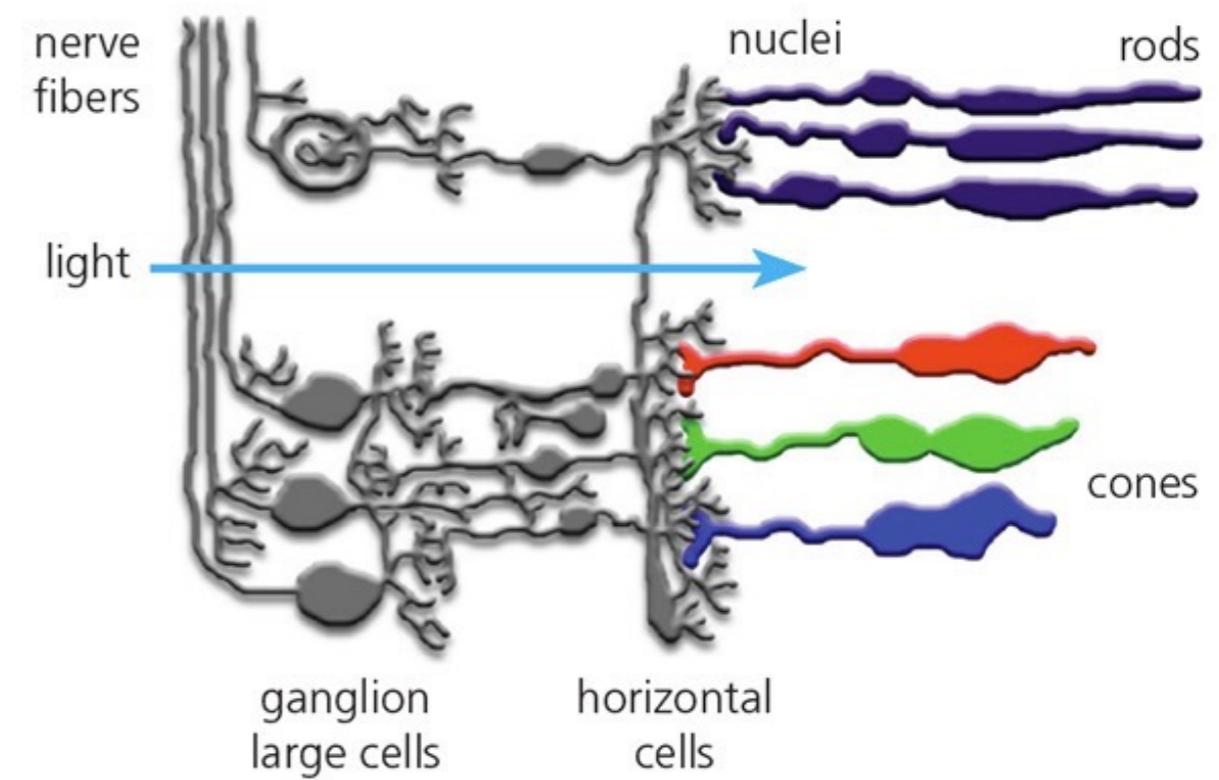
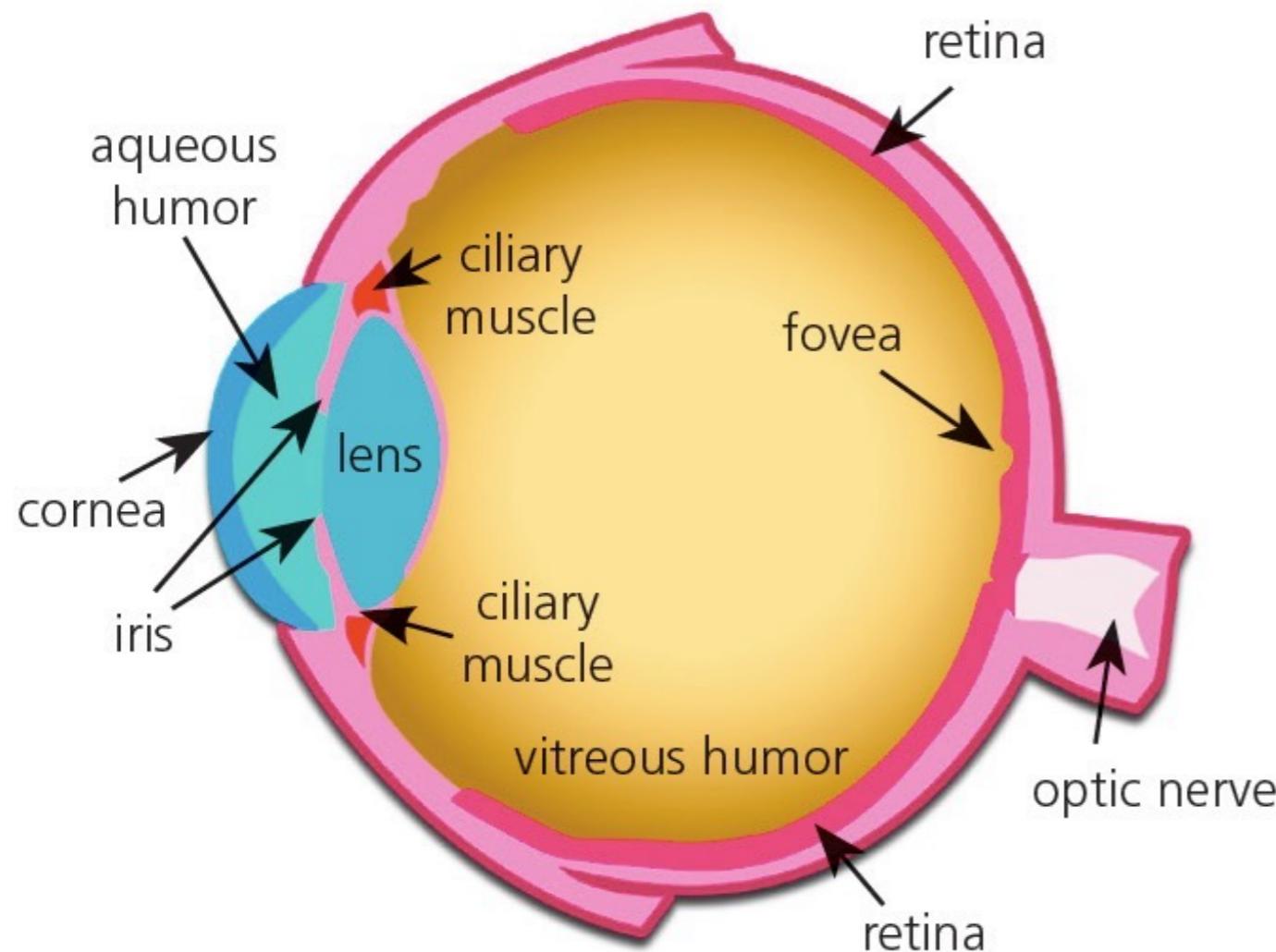
Is it orange?

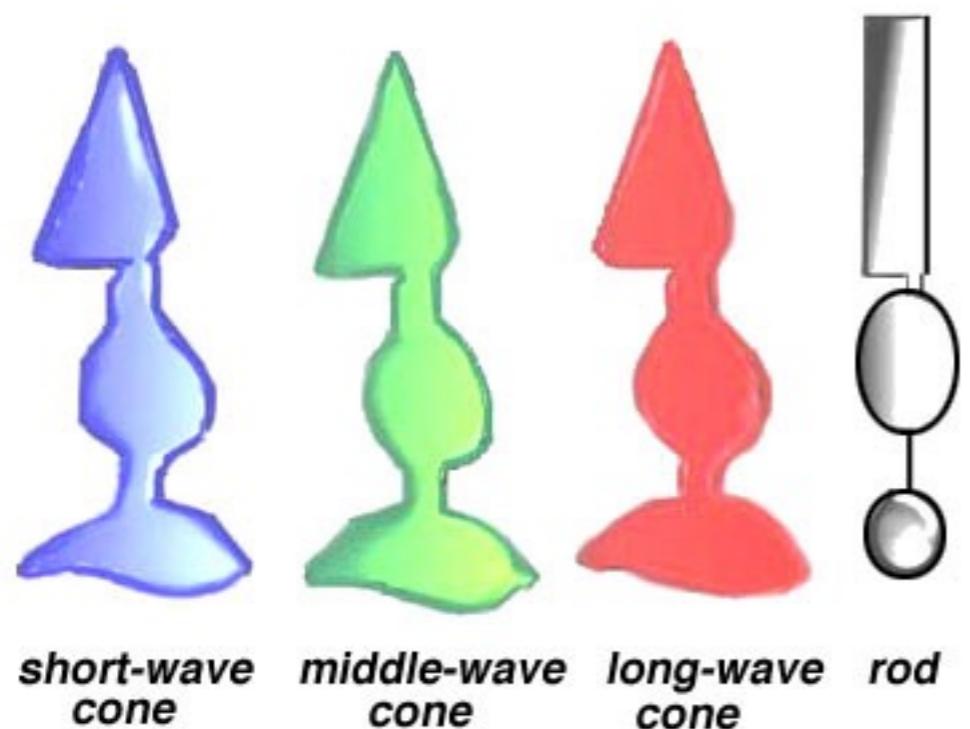


What exactly do we mean by  
“orange”?

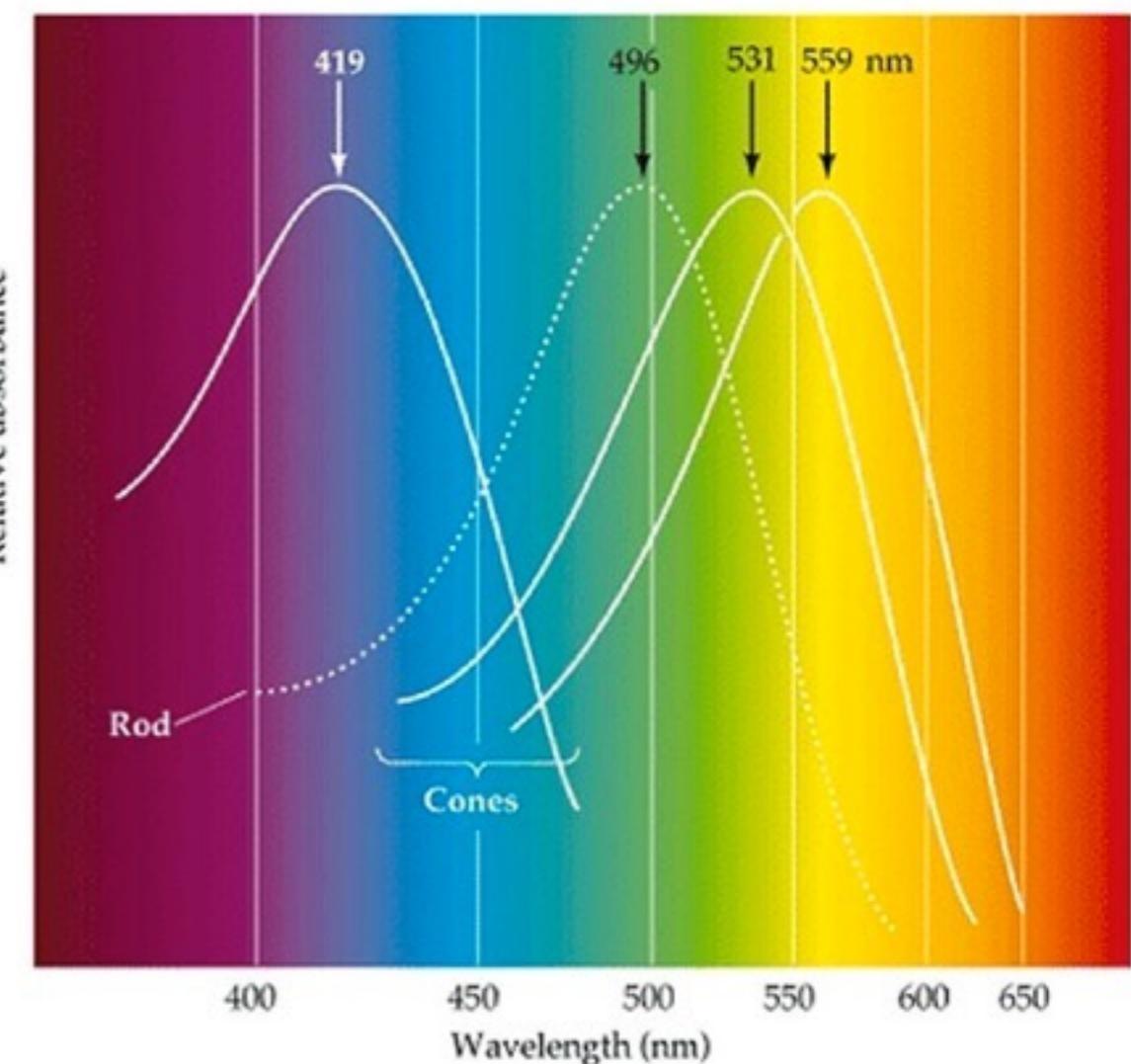
# Human Colour Perception

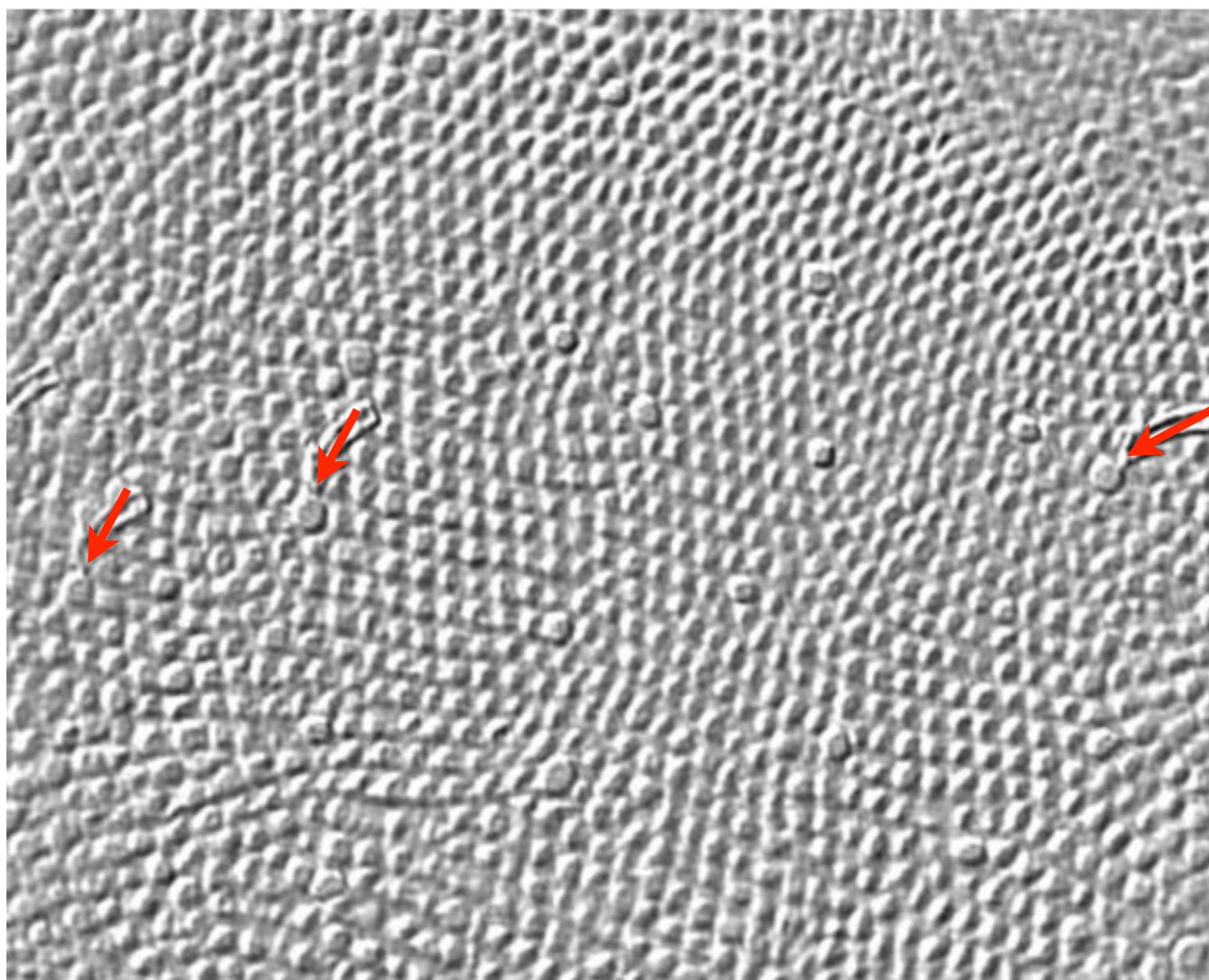
- On our retina, we have two types of photoreceptors, *rods* and *cones*, that are sensitive to electromagnetic radiation



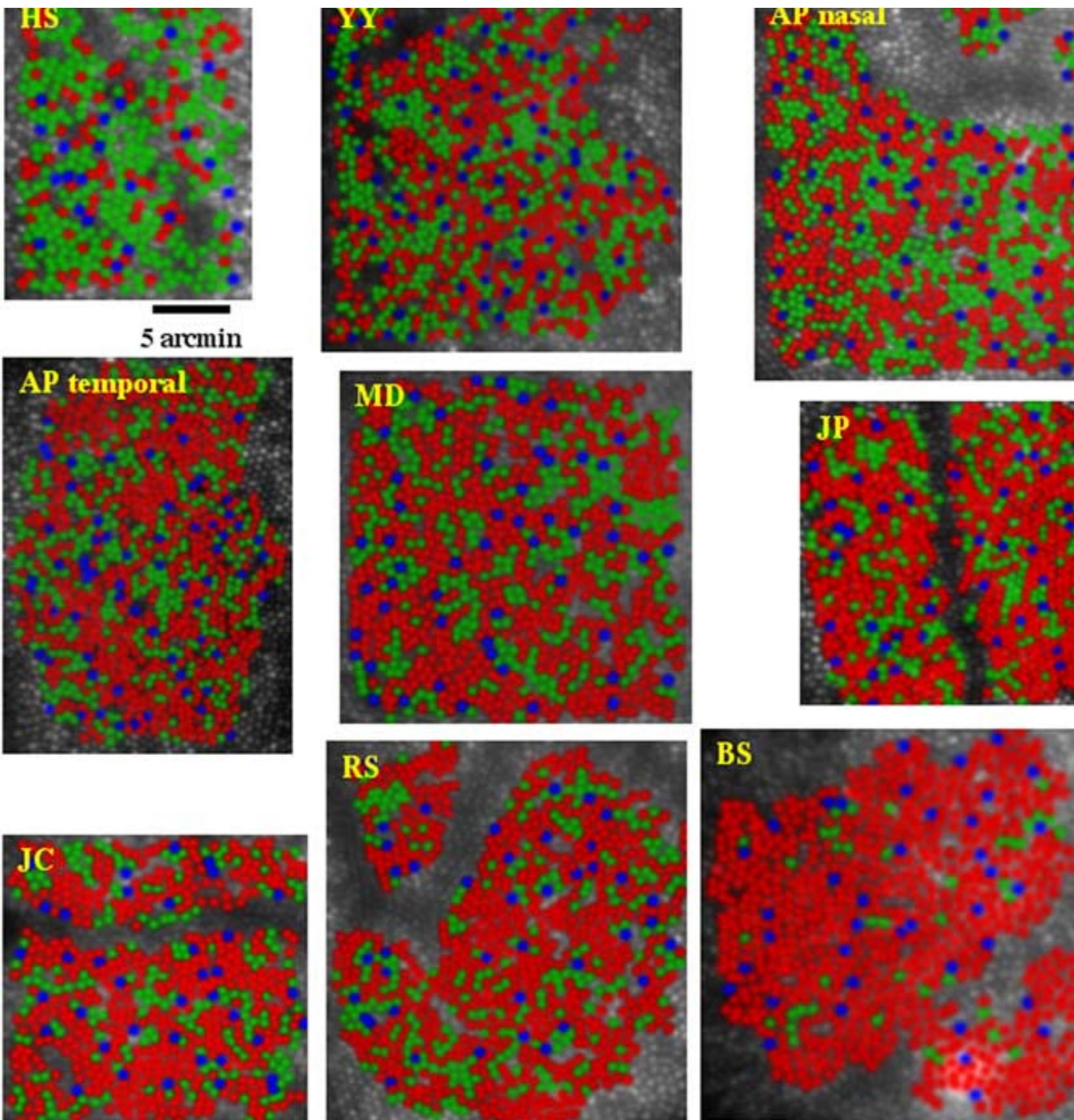


*Fig. 13. There are four photoreceptor types in the human retina. Short-wavelength cones (blue), medium wavelength cones (green), long wavelength cones (red) and rods.*



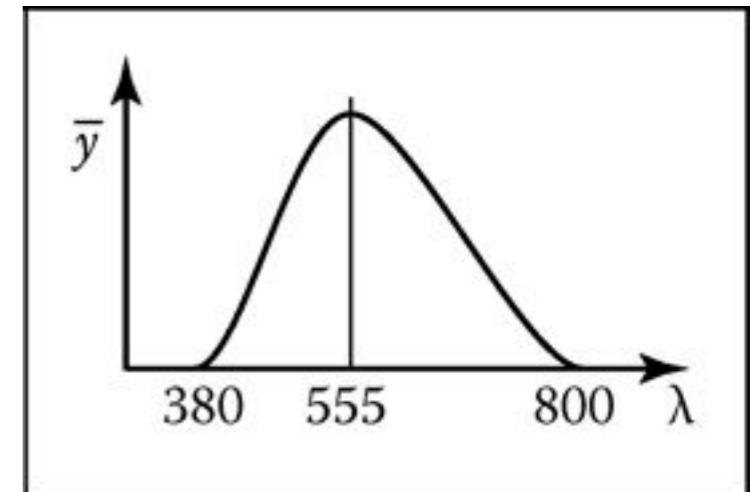


**Fig. 13. Tangential section through the human fovea.  
Larger cones (arrows) are blue cones. From Ahnelt et al. 1987.**



# Luminous Efficiency

- Humans are not equally sensitive to all wavelengths of light!



420nm



450nm



590nm

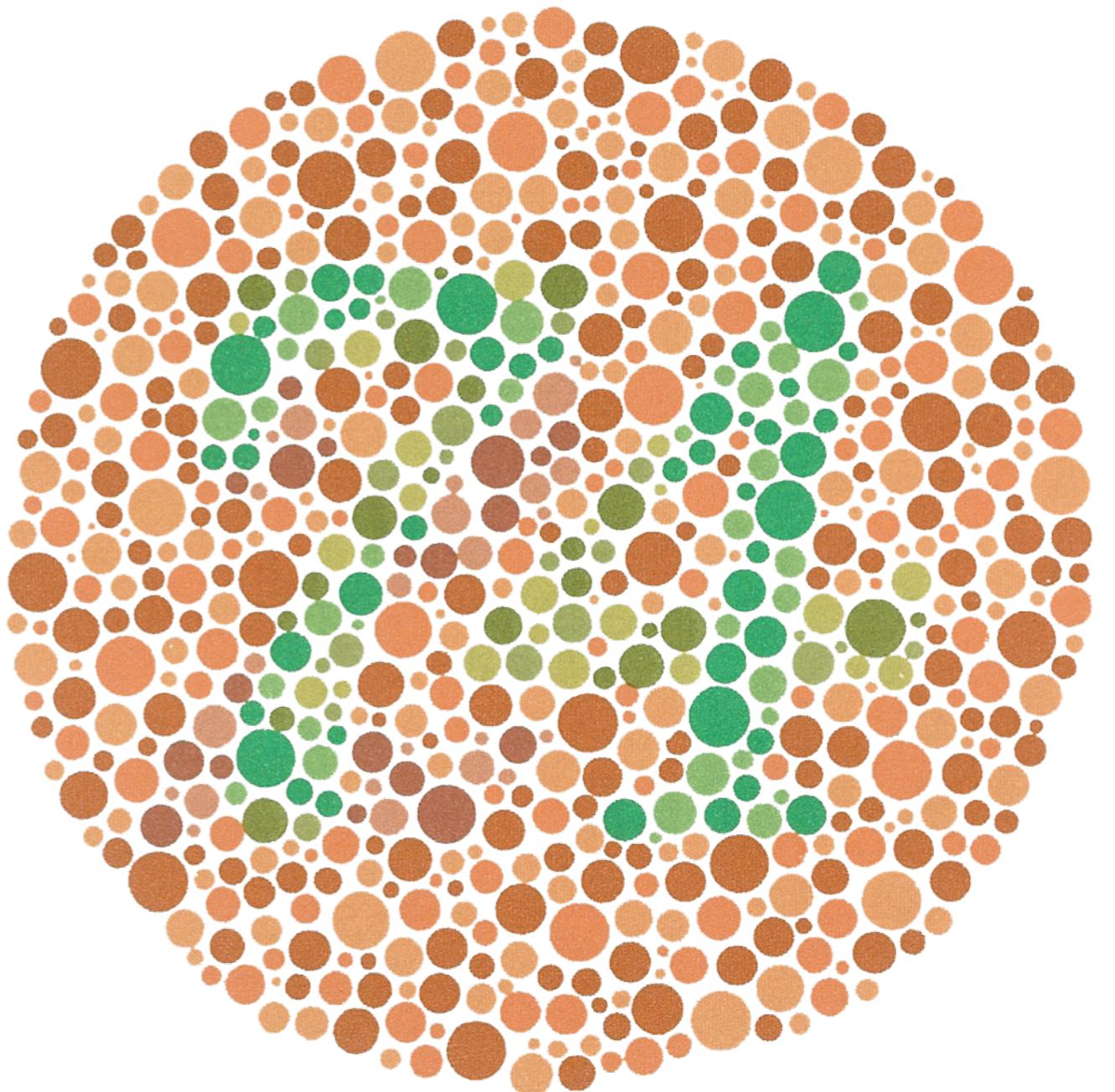


620nm

# Colour Blindness

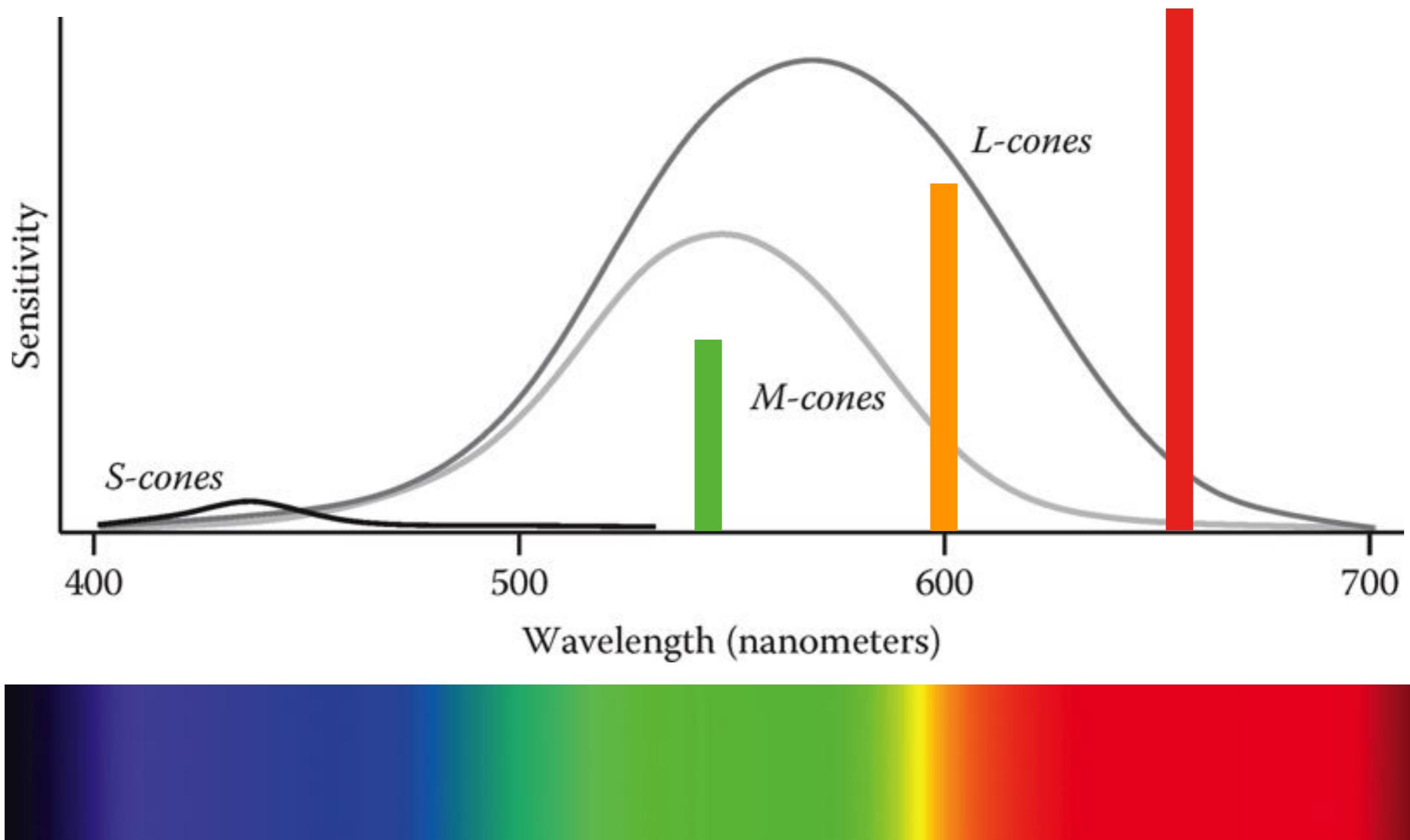
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Ishihara test for cone defect



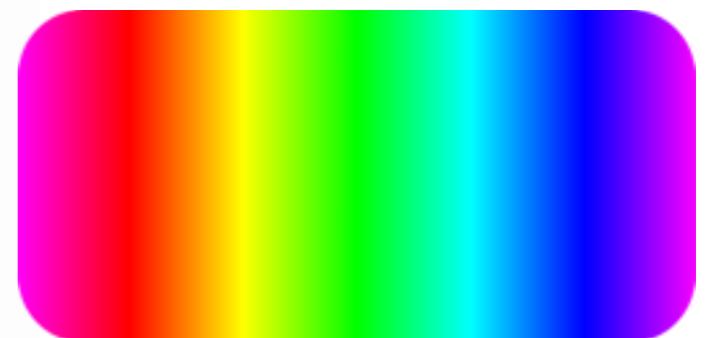
# Perception of Colour

- Revisiting our original question: what is “**orange**”?

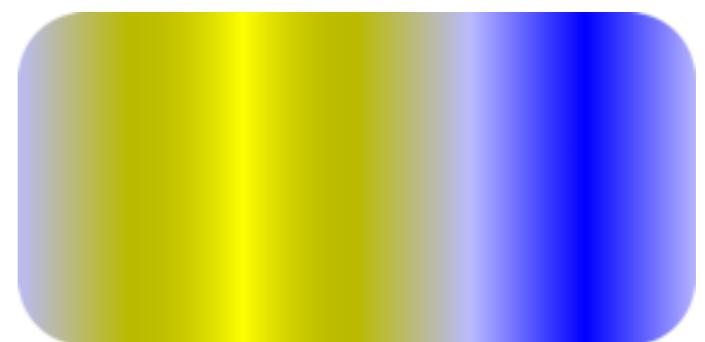




Do we perceive  
the same  
colour?



No.



# Things to Remember

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- Light is just another form of electromagnetic radiation
  - It mainly comes from black-body radiation
- Colour is in the eye of the beholder
  - Humans and animals see colour differently
  - Our perceptual system can be tricked!