

# Colour Essentials

Tony Wright, 20<sup>th</sup> September 2019

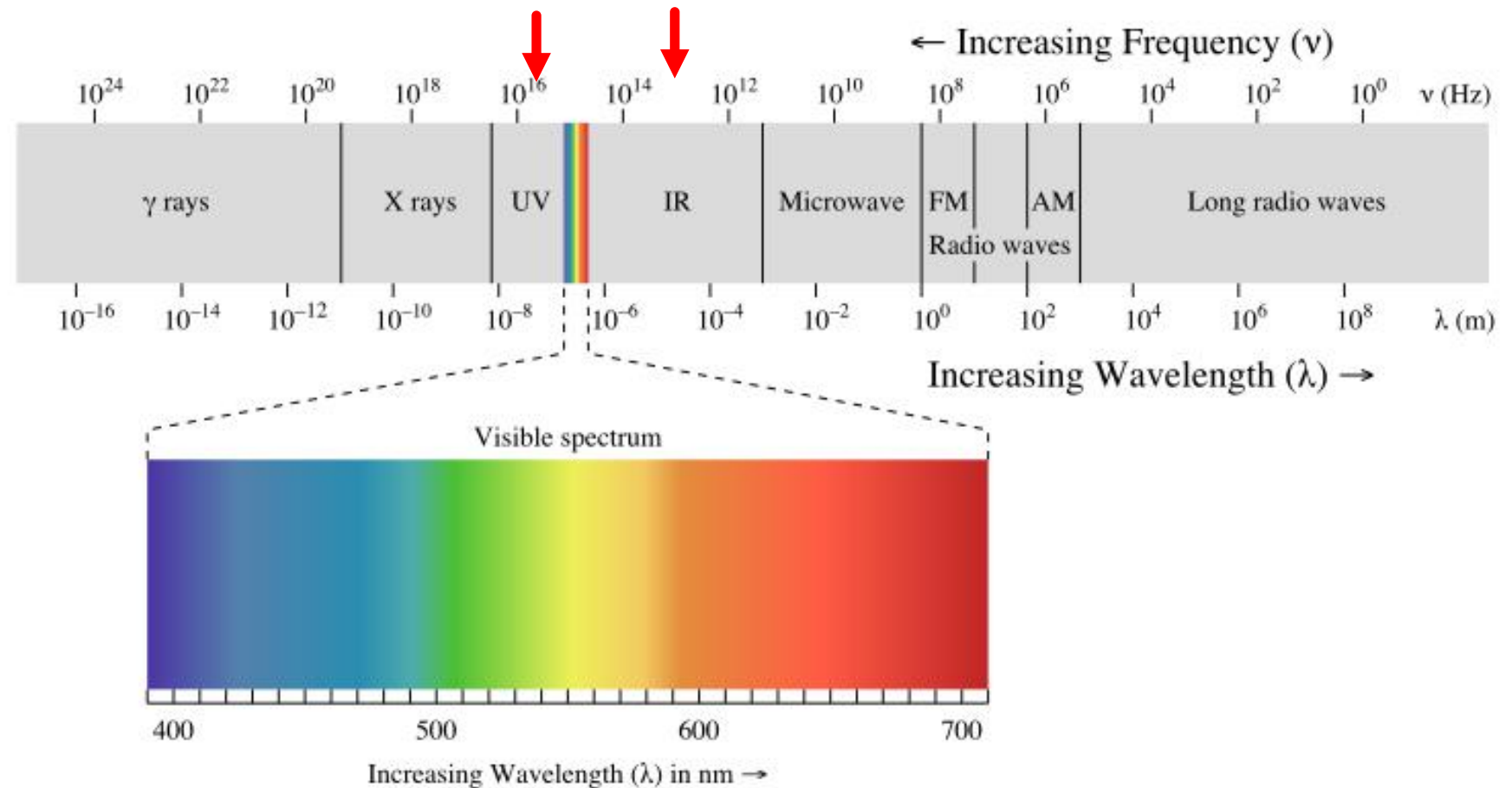
# Where does light come from?

- Sun – Emission of electromagnetic energy
- Terrestrial - Incandescent sources e.g. fire and lightbulbs
- Biological sources – Photoluminescence e.g. glow worms

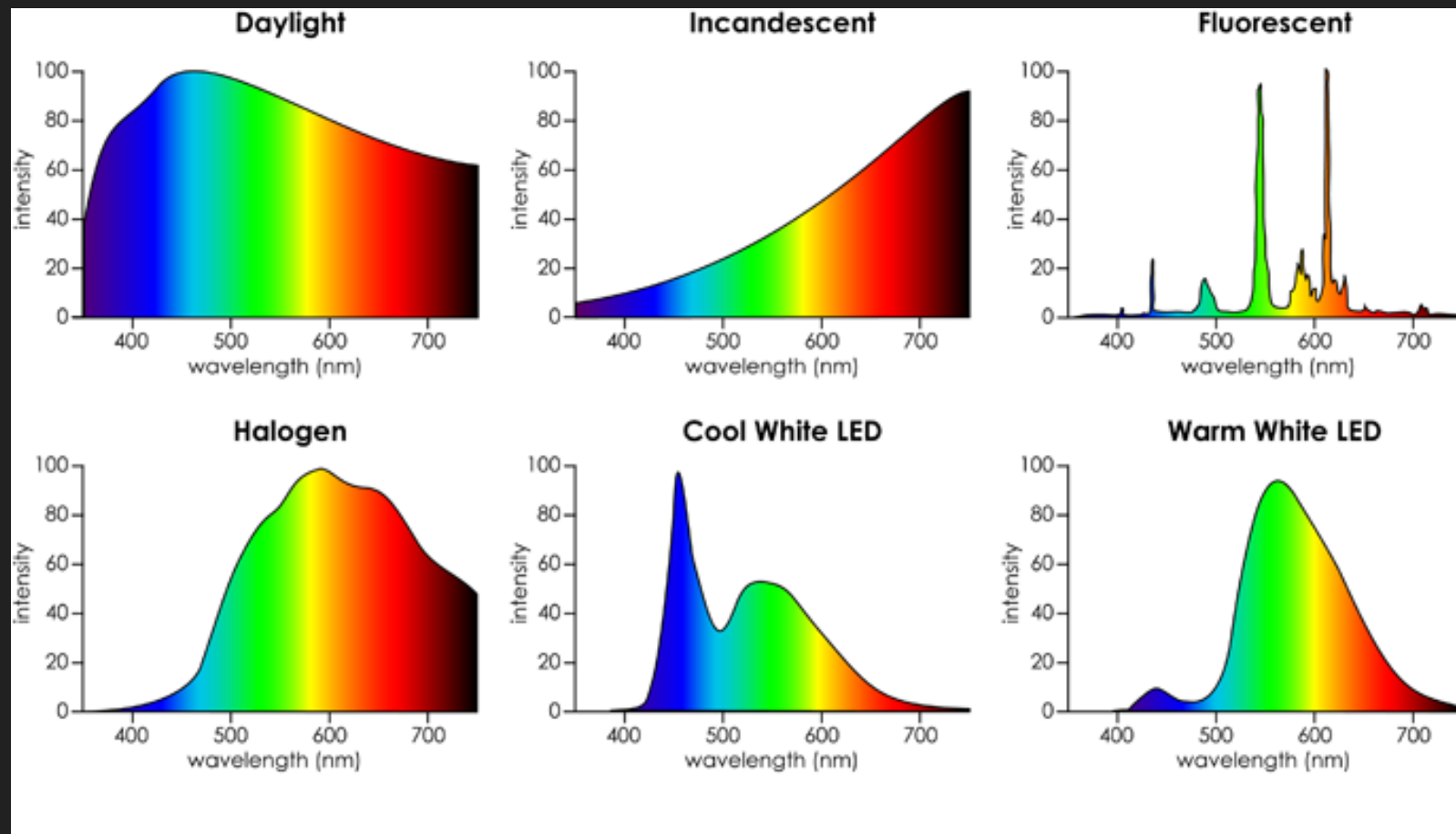
# What is Light?

- Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum.
- The word usually refers to visible light, which is the visible spectrum that is visible to the human eye and is responsible for the sense of sight.
- Visible light is usually defined as having wavelengths in the range of 400–700 nanometres

# Light and the Electromagnetic Spectrum



# Relative Intensity

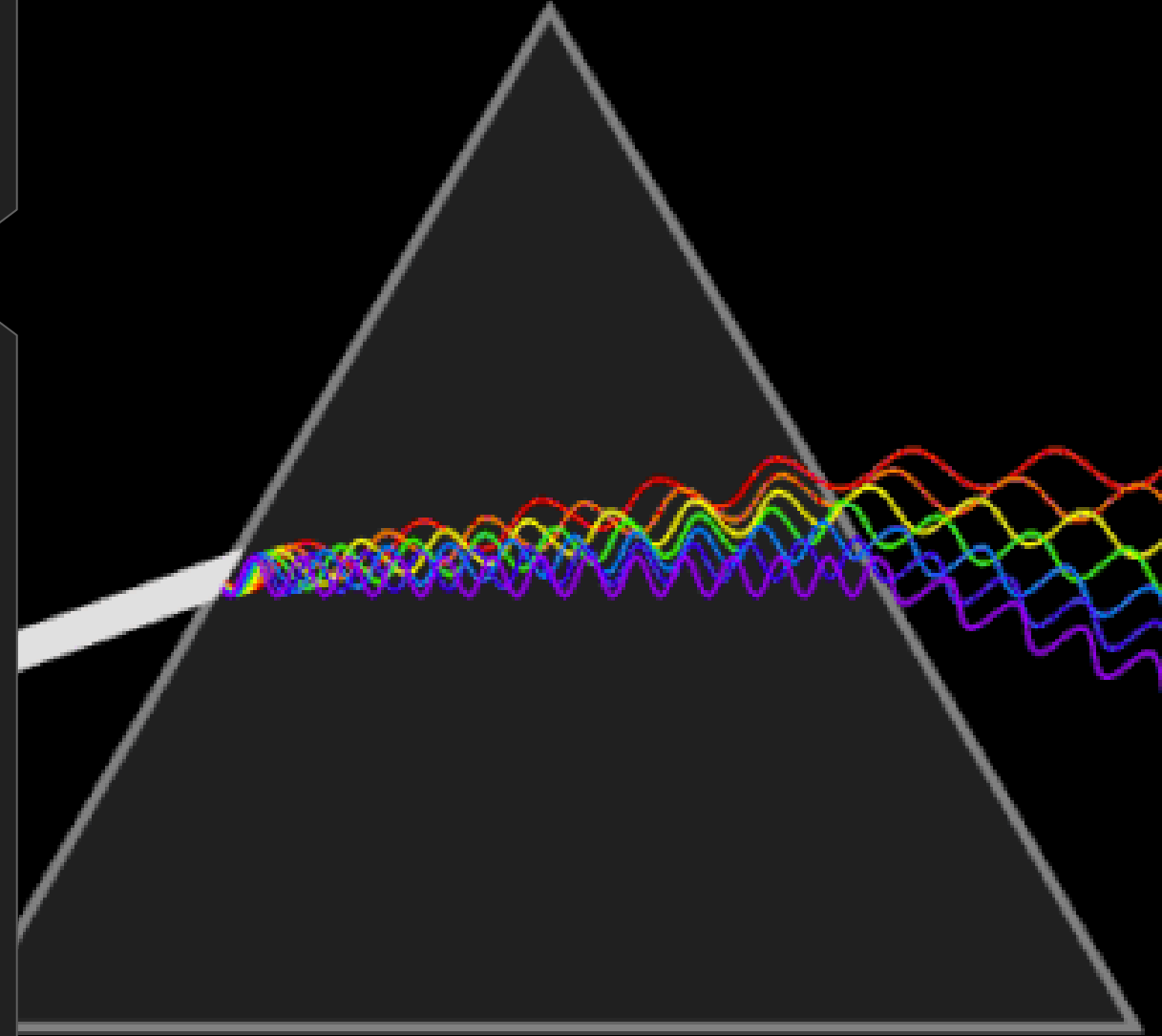


# That covers Waves - What about Photons?

- Like all types of EM radiation, visible light propagates as waves.
- However, the energy imparted by the waves is absorbed at single locations the way particles are absorbed.
- The absorbed energy of the EM waves is called a photon, and represents the quanta of light.
- When a wave of light is transformed and absorbed as a photon, the energy of the wave instantly collapses to a single location, this location is where the photon "arrives."

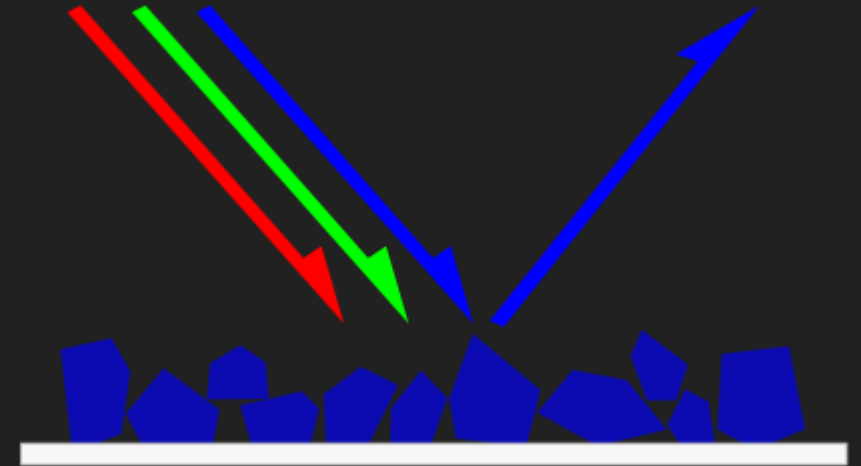
# Back to colour

- Visible light is a range of wavelengths which are perceived as colour by the observer and his photometric devices



# How does light turn to colour?

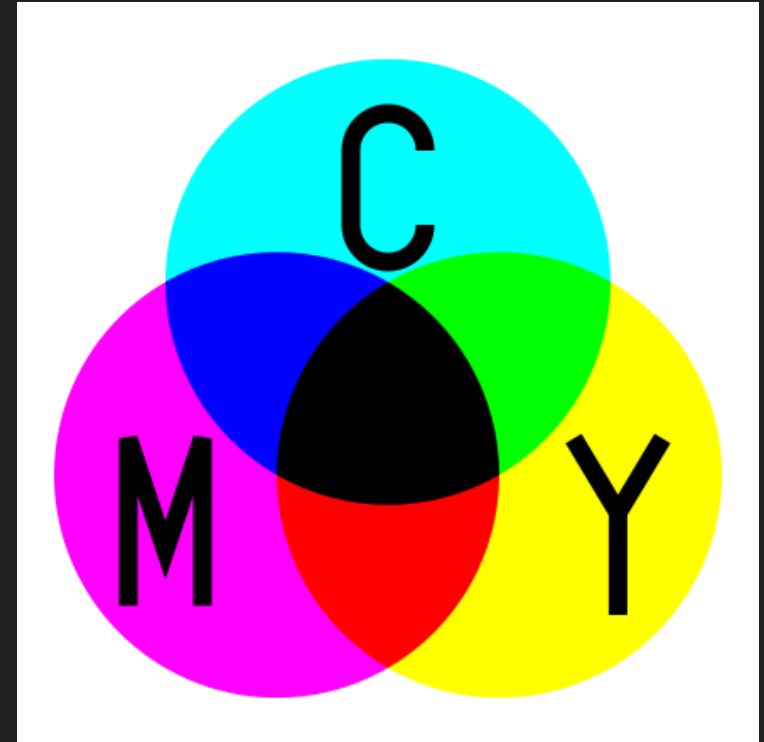
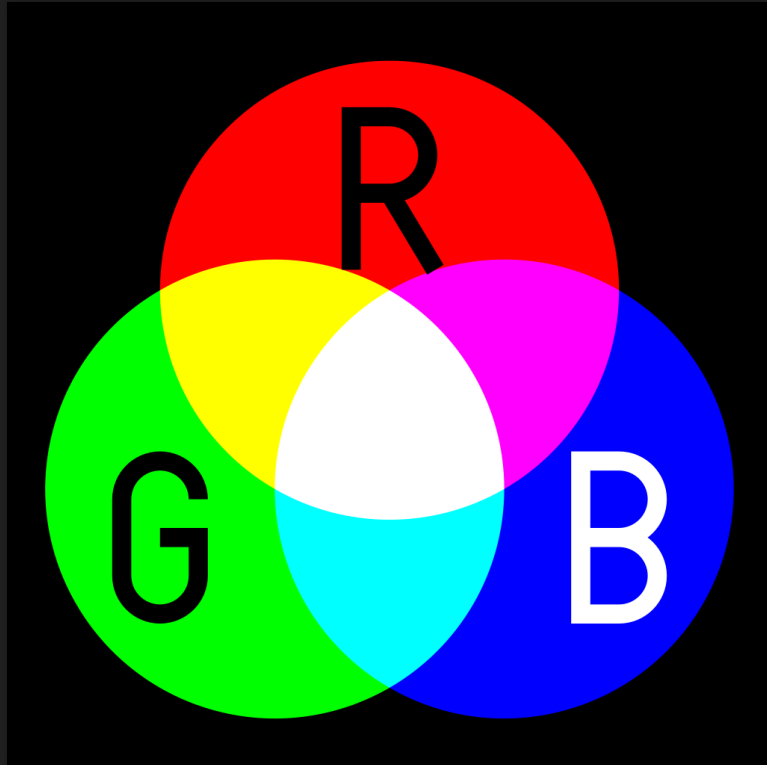
- Colour categories and physical specifications of colour are associated with objects through the wavelength of the light that is reflected from them or through which it passes.
- This reflection is governed by the object's physical properties such as light absorption, emission spectra, etc.



# Light becomes colour as it is reflected or absorbed



# Additive or Subtractive Colour?



# Subtractive Colour



# Subtractive Colour



# Additive Colour

- 1855 – James Clerk Maxwell proposed an additive theory of colour perception based on “red, “green” and “blue”



# The first scientific colour photograph?

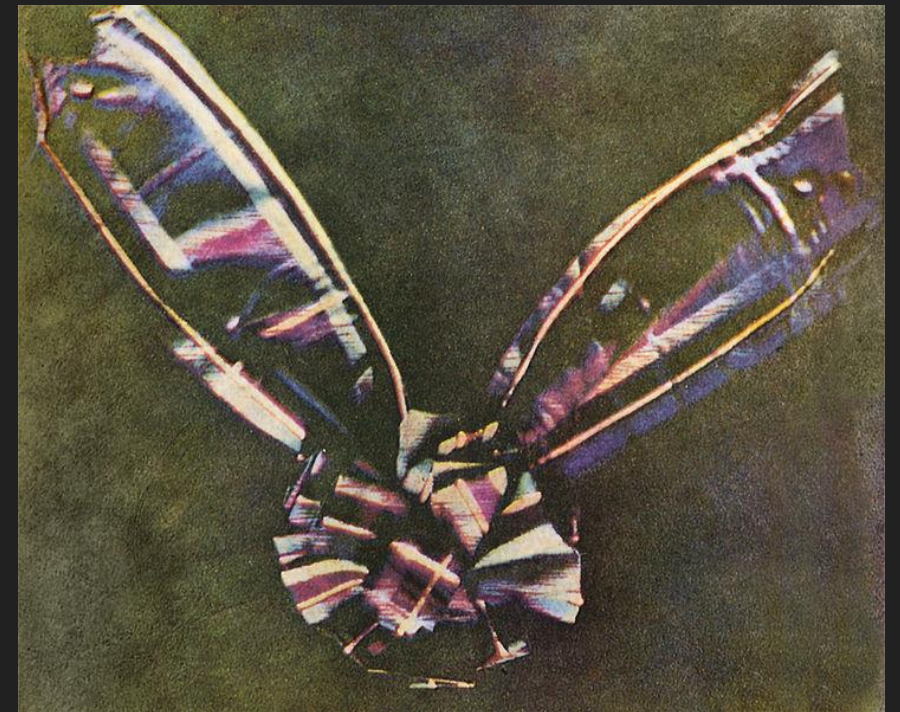
- 1861 – Maxwell demonstrated the additive theory of colour in the “Tartan Ribbon” experiment performed by Thomas Sutton, (first reflex camera and panoramic lens)



THOMAS SUTTON, B.A.  
FROM A PHOTOGRAPH BY MR. A. L. MENDELSON.

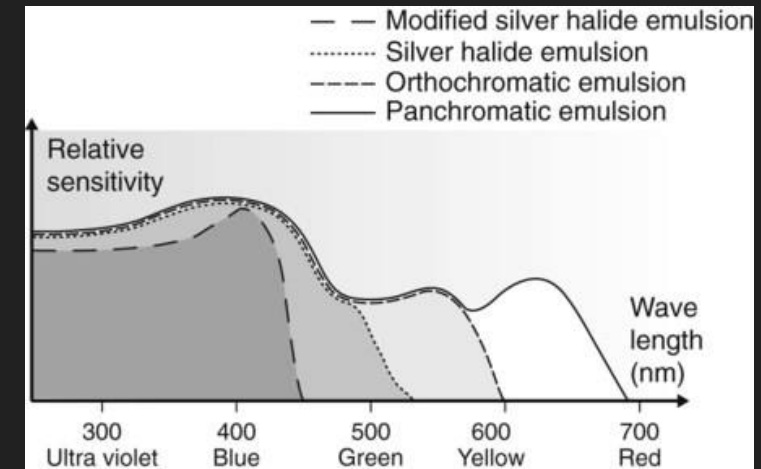
# The Tartan Ribbon

- Sutton took three separate black-and-white photographs of a multicoloured ribbon, one through a blue filter, one through a green filter, and one through a red filter.
- Using three projectors equipped with similar filters, the three photographs were projected superimposed on a screen

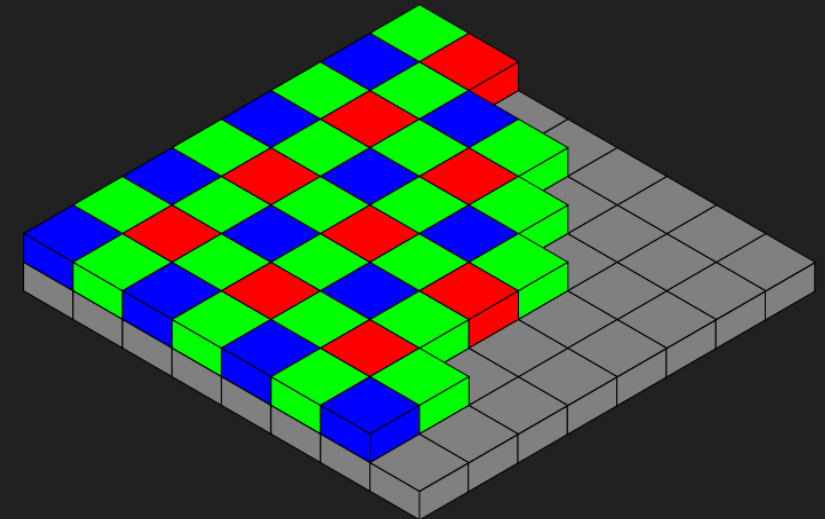
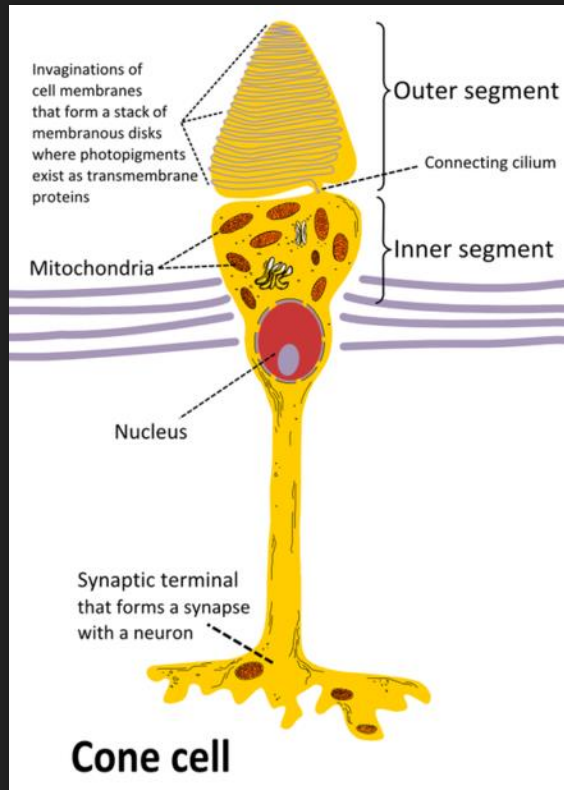


# The “Tartan Ribbon” fallacy

- Sutton's photographic plates were insensitive to red and barely sensitive to green
- Success of the red-filtered exposure was due to ultraviolet light

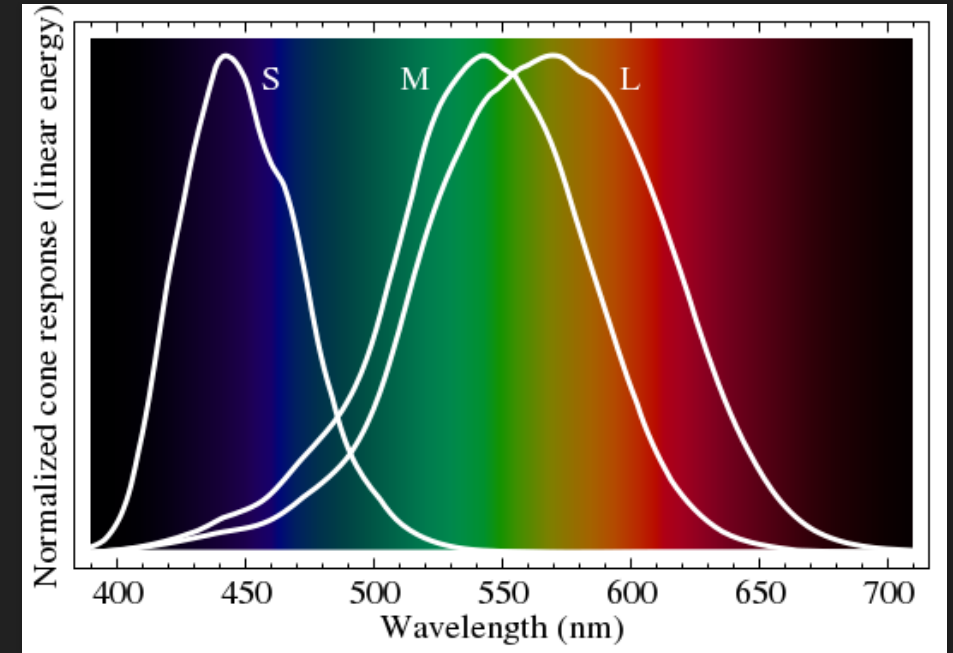


# How do we perceive and measure colour?



# Are you a Normalised Observer?

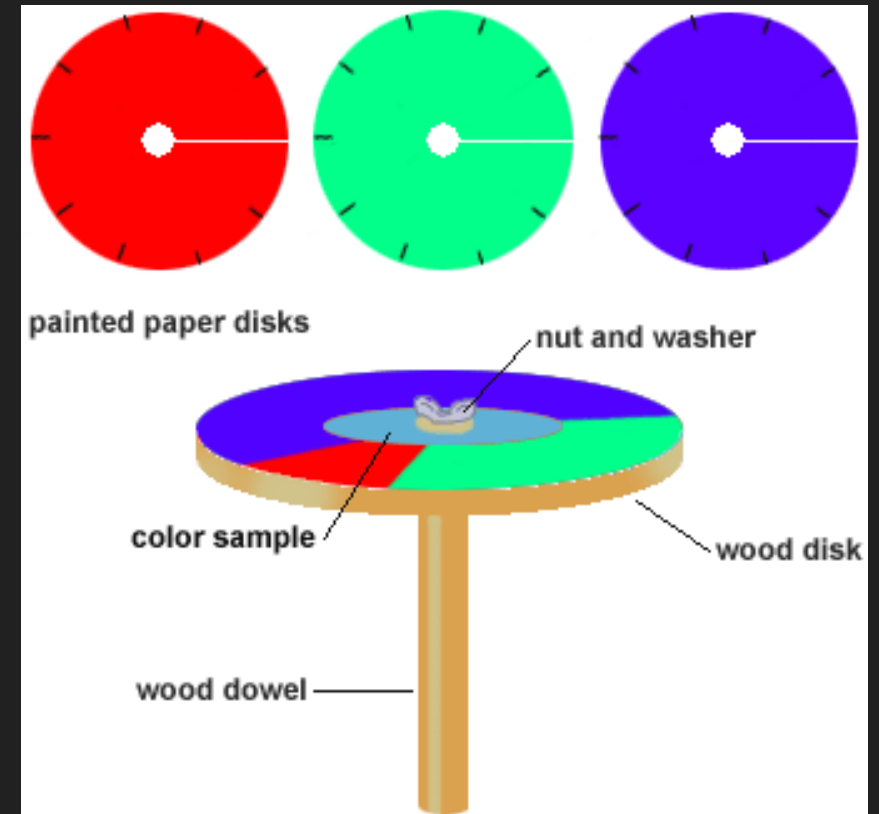
- The model is an extension of the CIE 2006 physiological observer function and incorporates eight physiological parameters in addition to "age" and "field size" inputs of the CIE 2006 model. The equation is shown below.



$$lms - CMFs = f(age, fs, d_{lens}, d_{macula}, d_L, d_M, d_S, s_L, s_M, s_S)$$

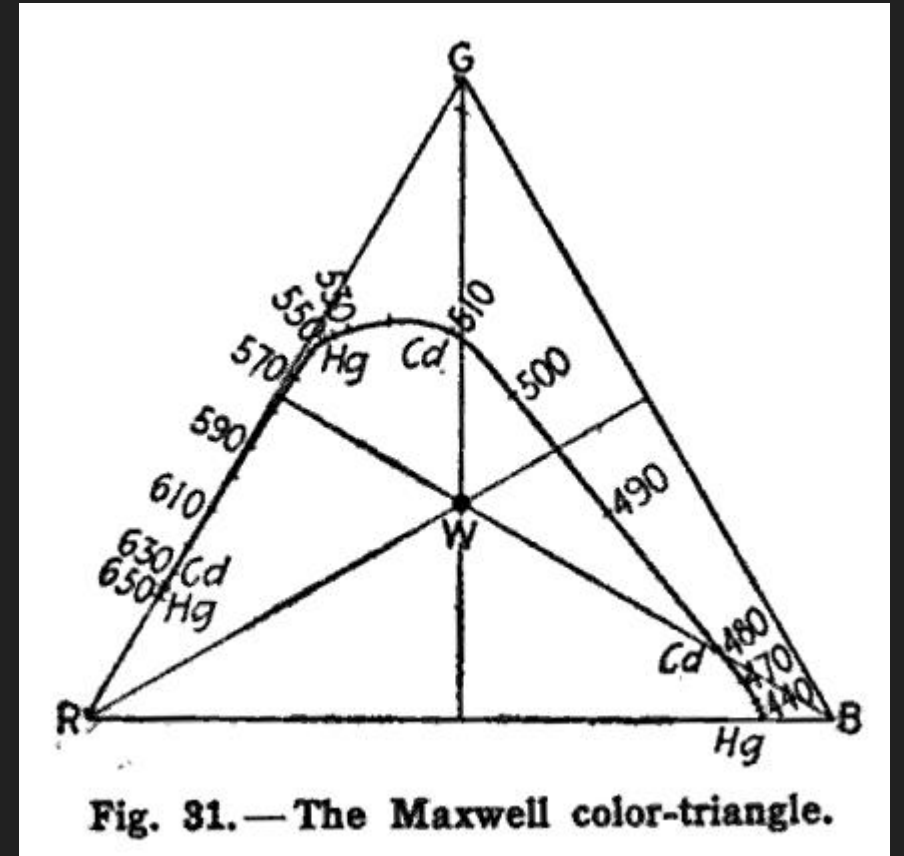
# But back to Maxwell and his Disk

- Spinning the disk creates the illusion of a single colour that is a mixture of the three primaries
- He mounted a pair of white and black papers in an inner circle, thereby creating shades of grey.



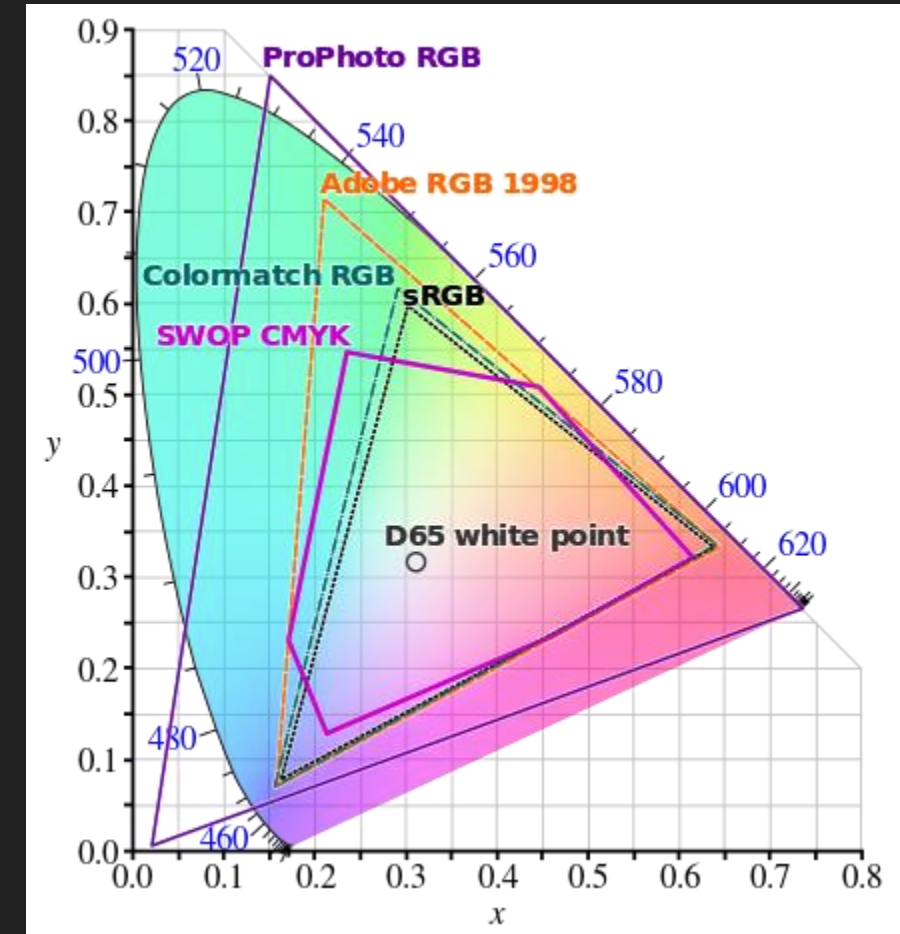
# And from this he created the colour triangle

- A colour triangle is an arrangement of colours within a triangle, based on the additive combination of three primary colours at its corners.



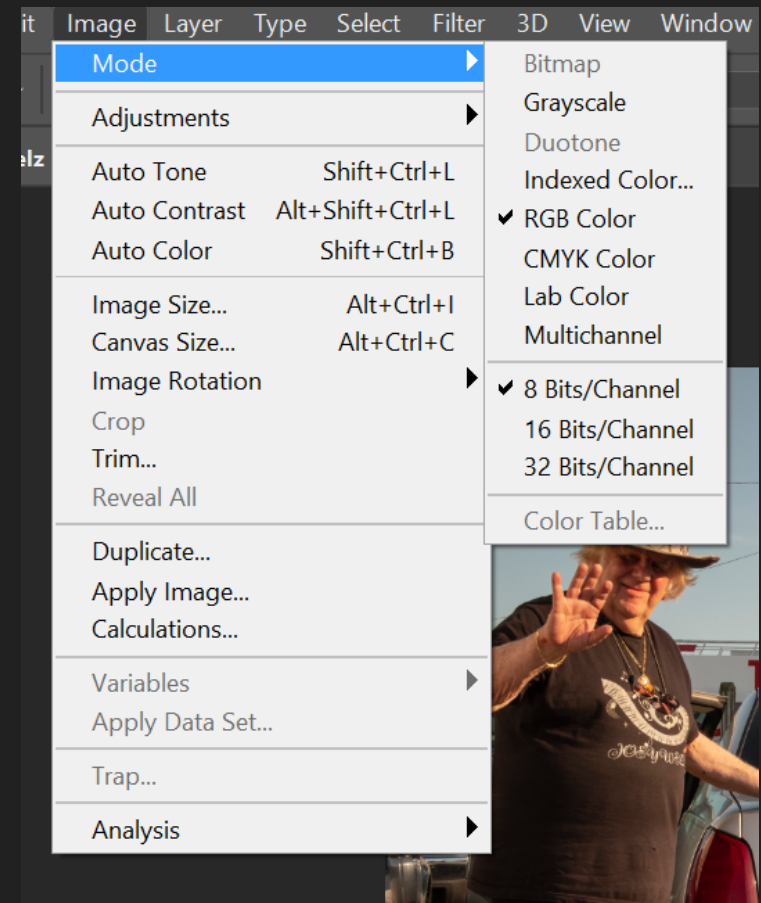
# Which we know today as Colour Space

- A colour space is a specific organization of colours. In combination with physical device profiling, it allows for reproducible representations of colour, in both analog and digital representations.



# What about RGB, CYMK, 8, 16, 32 bit?

- The colour mode or image mode determines how colours combine based on the number of channels in a colour model.
- Different colour modes result in different levels of colour detail and file size.



# 18% Grey mythology

- 1880 printing - the ink flow to an 18% halftone was the same darkness as the 18% card.
- “mid-point between black and white on a logarithmic or exponential curve.”
- Ansel's Zone V
- Colour of the sky in Rochester NY
- Average scene when scrambled
- 119, 119, 119

