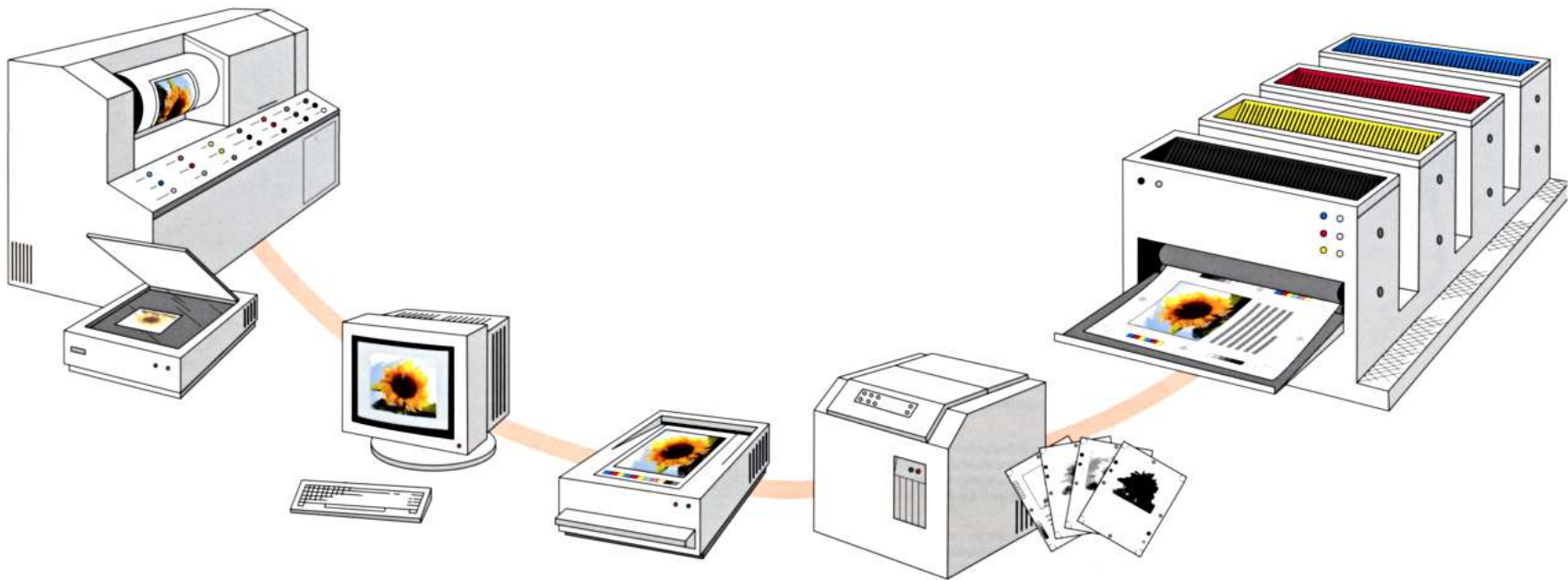


A photograph of a mosque interior, likely the Blue Mosque in Istanbul. The scene is dimly lit, with the primary light source coming from large, arched windows on the left. These windows are filled with intricate, multi-colored stained glass featuring geometric and floral patterns in shades of red, blue, green, and yellow. The light passing through these windows casts vibrant, colorful patterns onto the floor. The floor is covered with a large, ornate carpet that has a complex floral and geometric design in red, blue, and green. Several large, dark, fluted columns support the high, vaulted ceiling. The ceiling itself is dark and features subtle geometric patterns. The overall atmosphere is one of quiet reverence and architectural grandeur, with the interplay of light and color being the central focus.

Color and Light

Color - Why Do We Care?

- Computer Graphics output is number of colored pixels
- Understand how/why color is represented

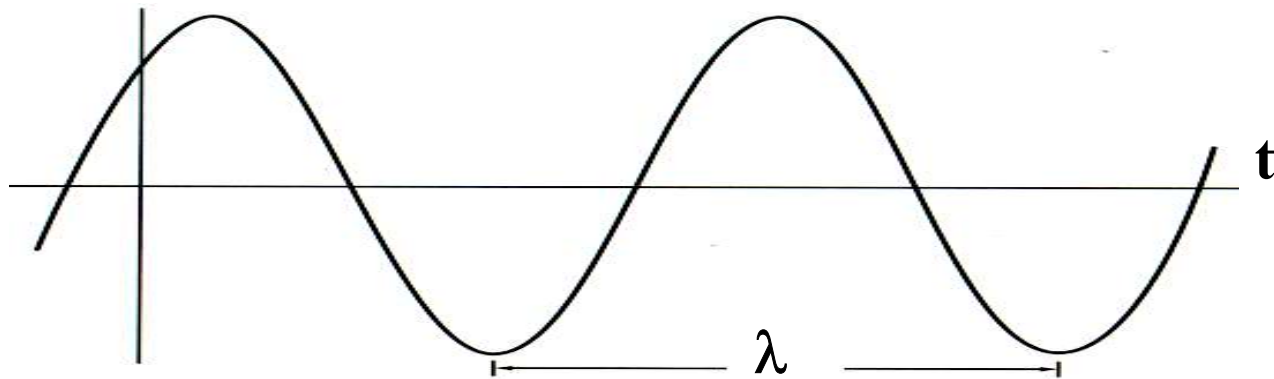




Light

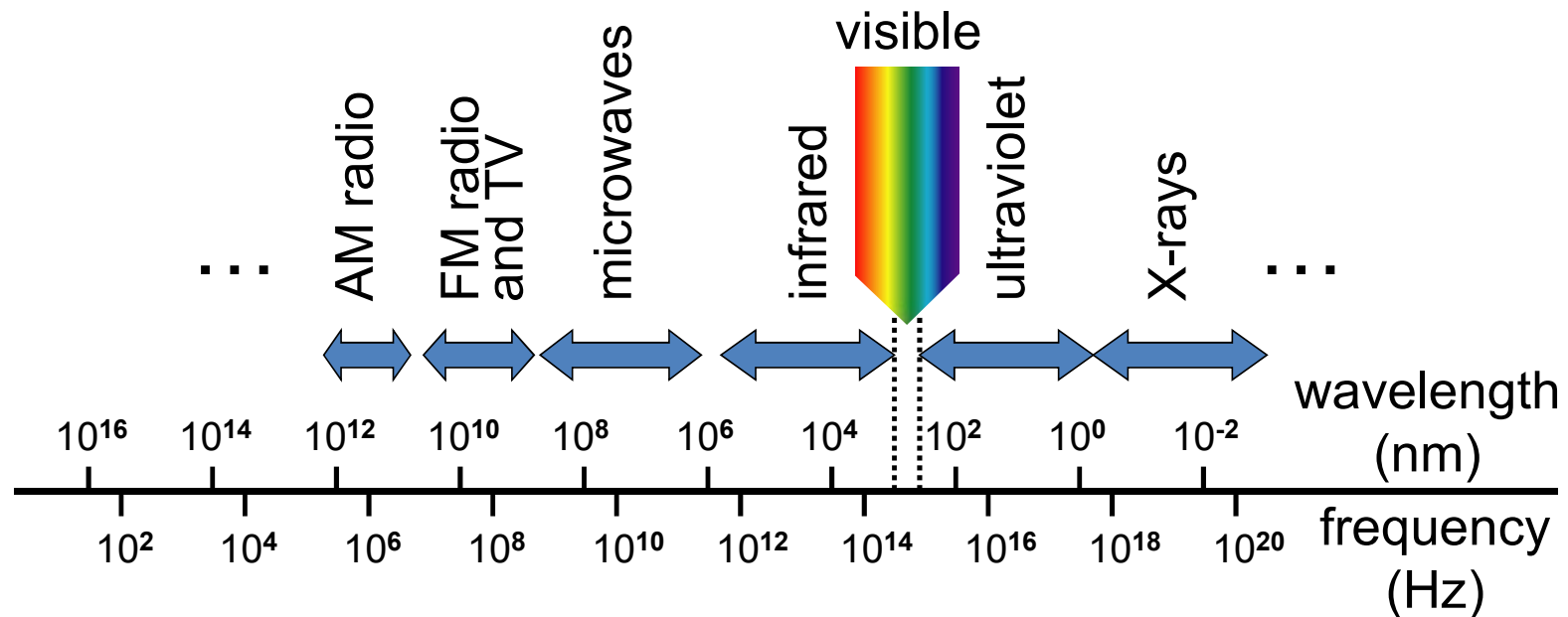
What is Light?

- Light is an electromagnetic Wave
- Monochrome light (e.x.: laser) has a single frequency f or wavelength λ
- $c = \lambda f$ (c = speed of light in medium)
 - Shorter wavelength equals higher frequency



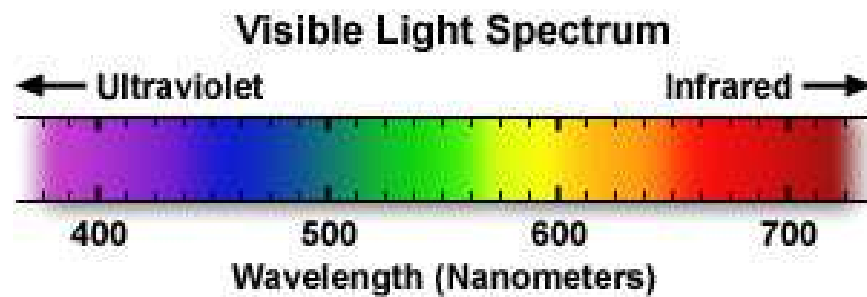
Light – An Electromagnetic Wave

- Frequency band of electromagnetic spectrum



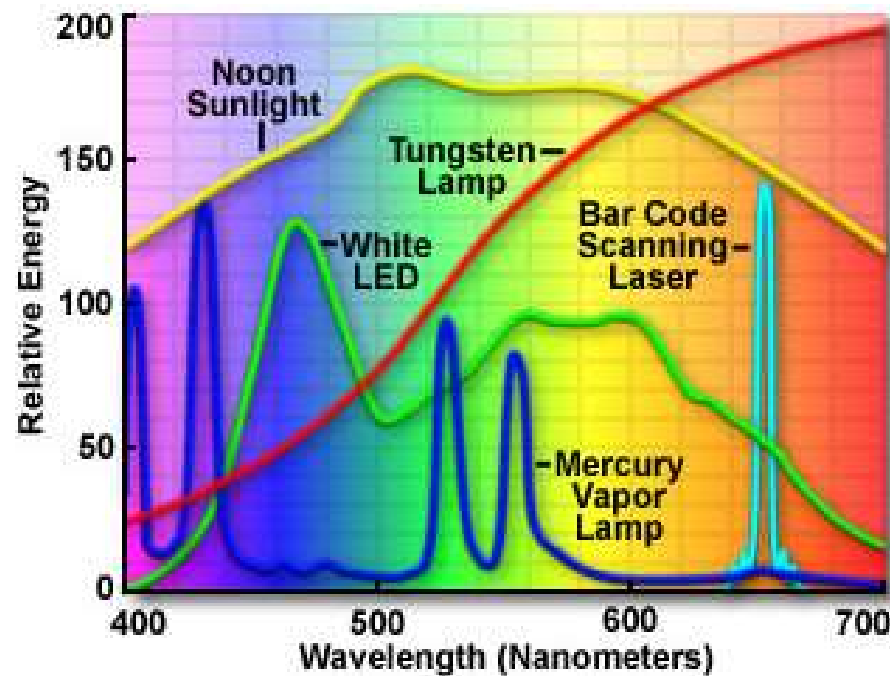
Light – An Electromagnetic Wave

- Frequency band of electromagnetic spectrum



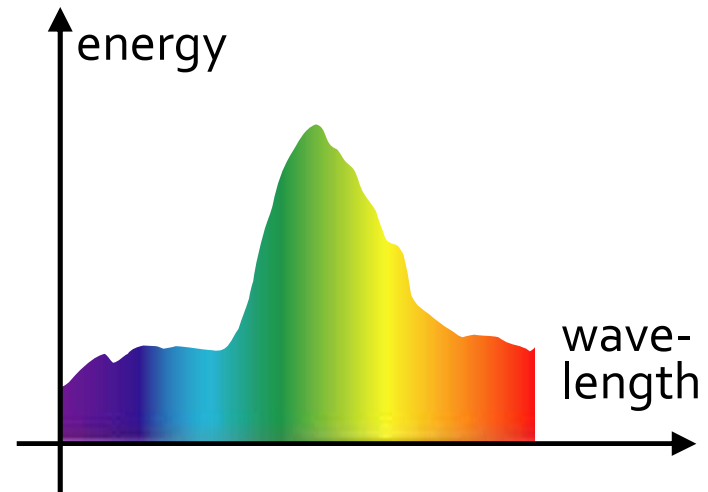
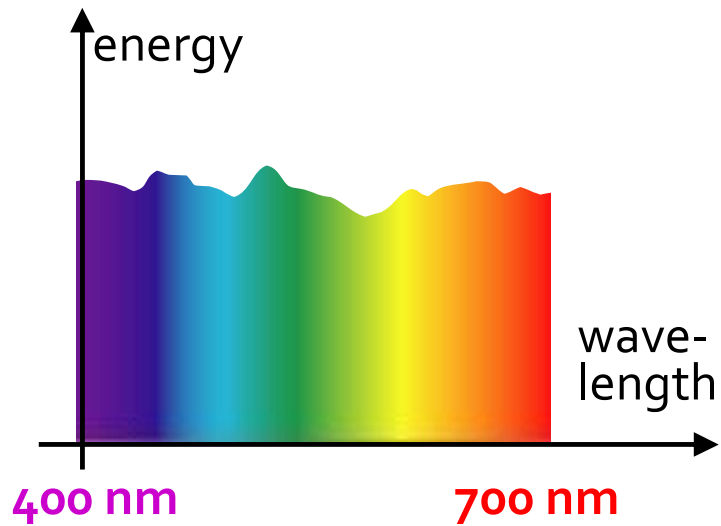
Light – Spectrum

- Normal light mixture of different frequencies
- Distribution of wavelength intensities is called *spectrum*



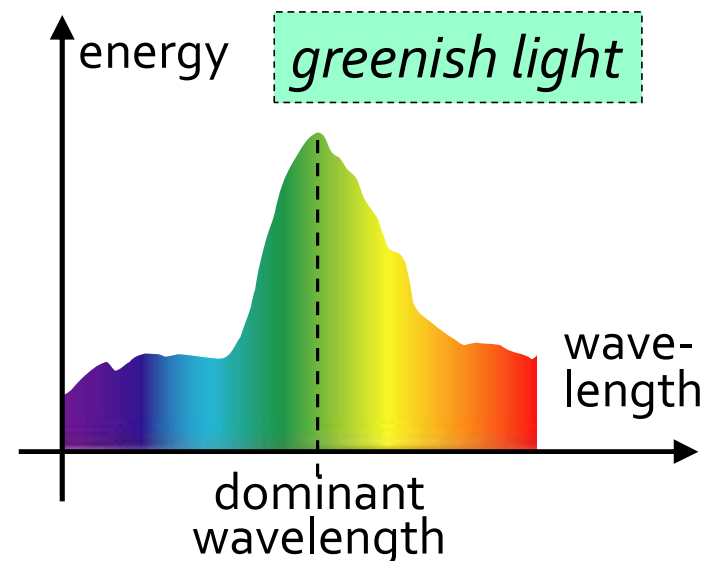
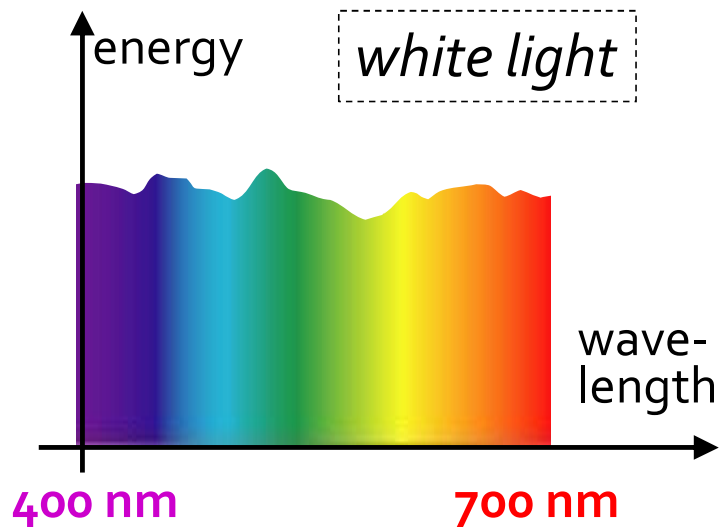
Brightness

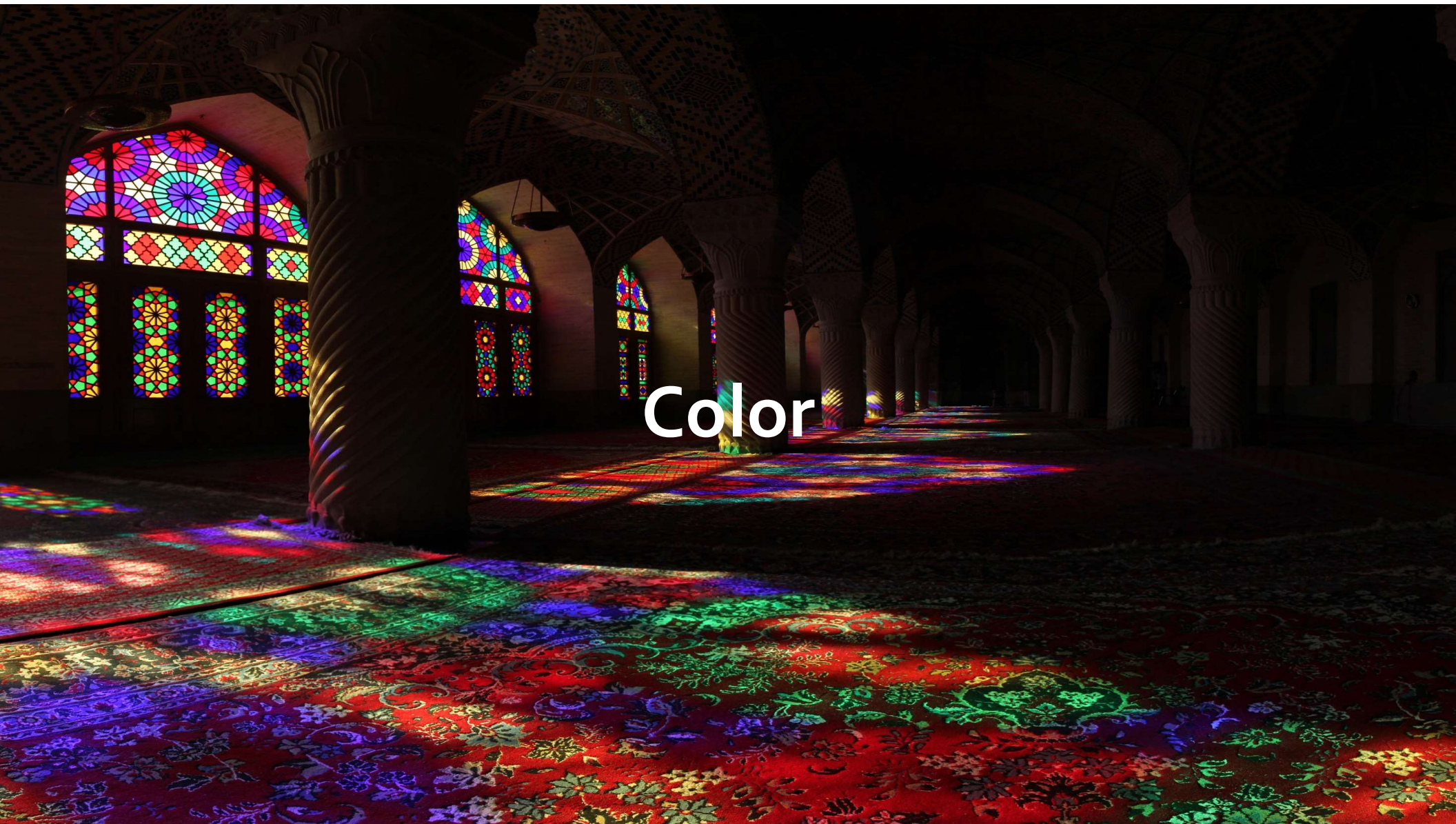
- Area under the curve



Dominant Wavelength

- Main frequency (hue, color)

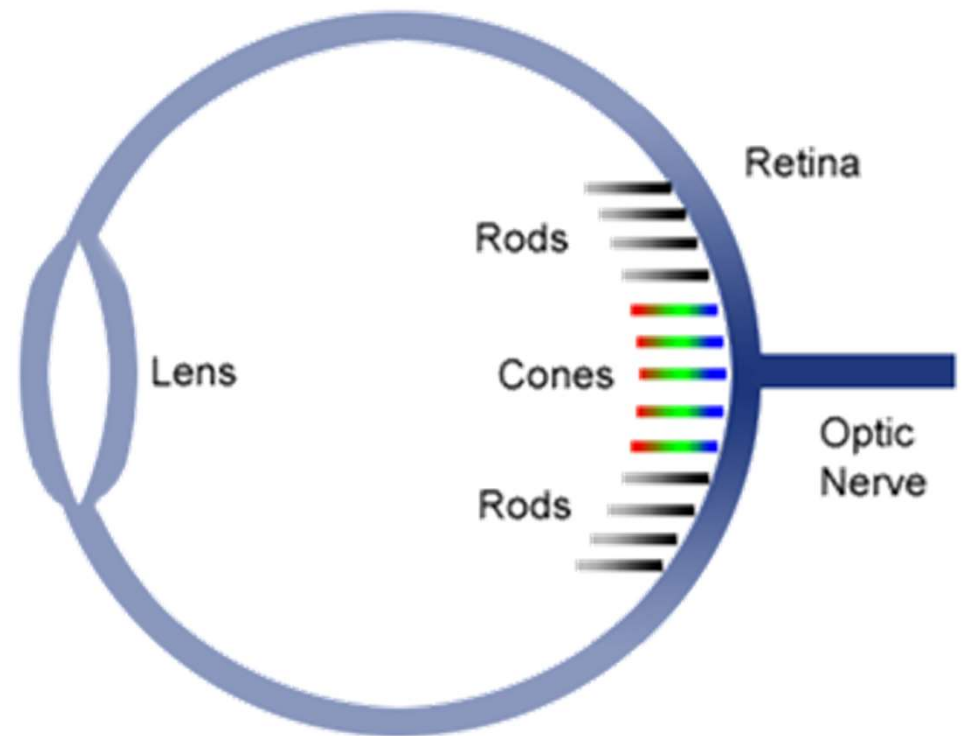




Color

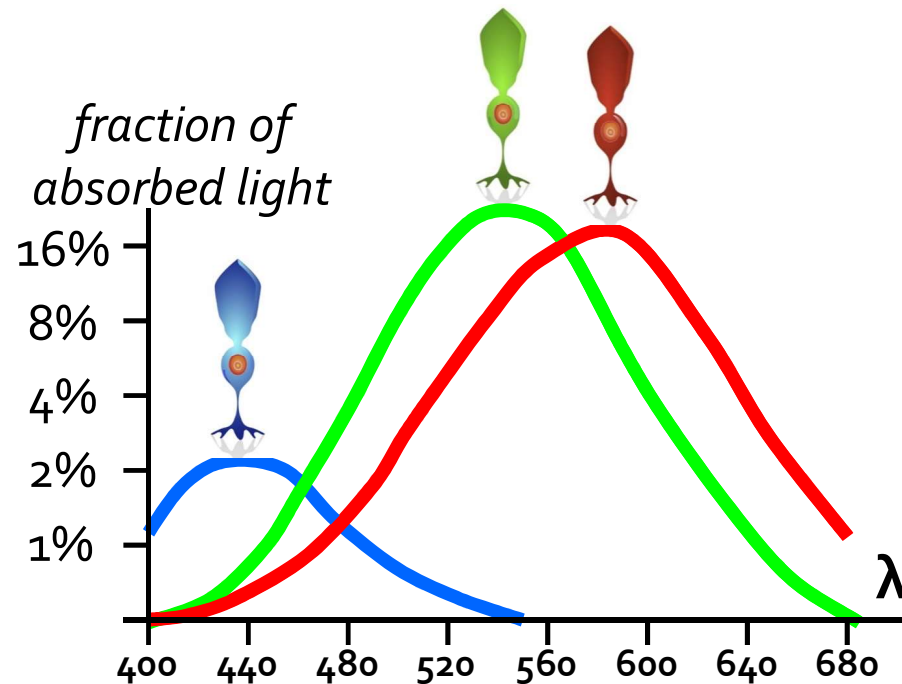
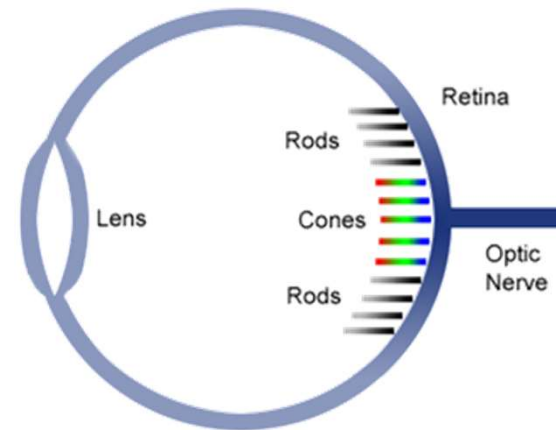
What is Color?

- Characteristic of human visual perception
- Created through stimulation of cone cells in the human eye by light
- Described through color categories, like *red*, *yellow*, ...
- Other species quite different



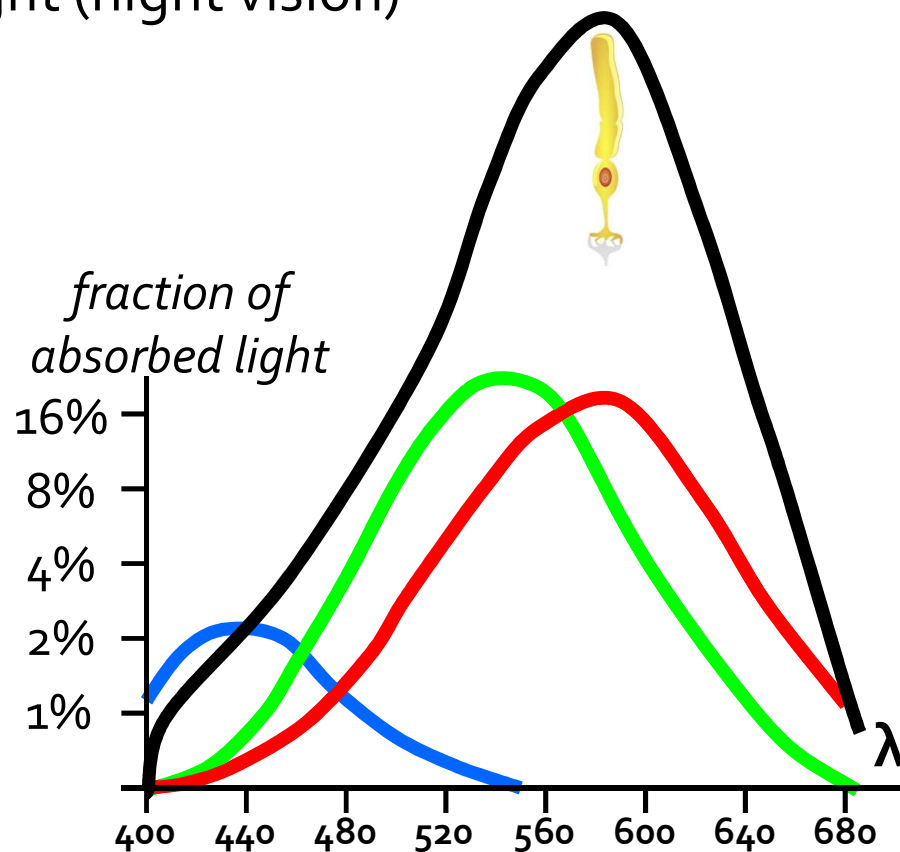
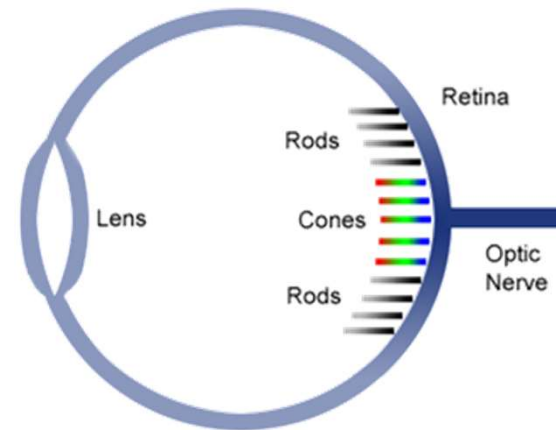
The Human Eye – Cones

- 3 types
- Different wavelength sensitivities (tristimulus)
 - Red
 - Green
 - Blue



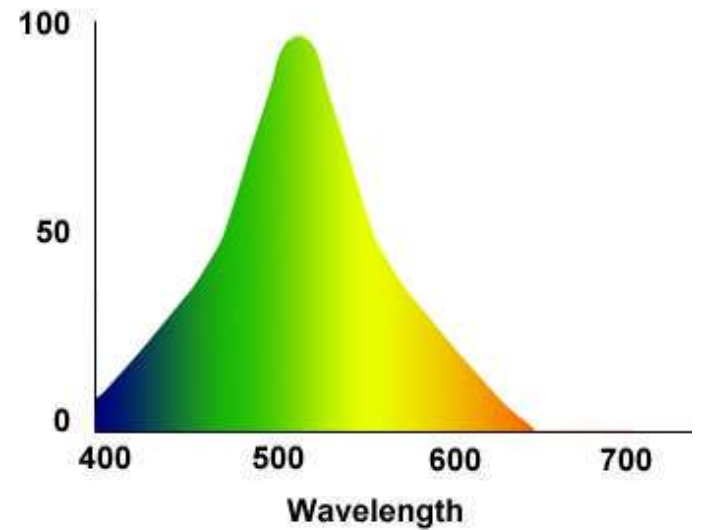
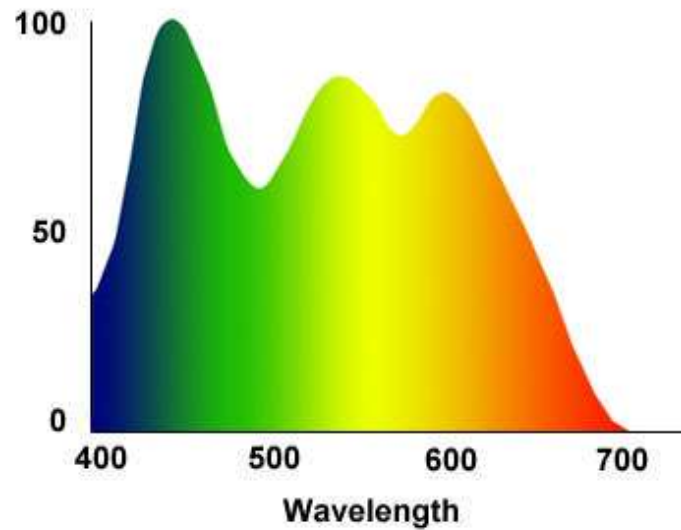
The Human Eye – Rods

- For less intense light (night vision)
- Peripheral vision



The Human Eye - Adaptation

- Daylight-adapted human eye
- Dark-adapted human eye



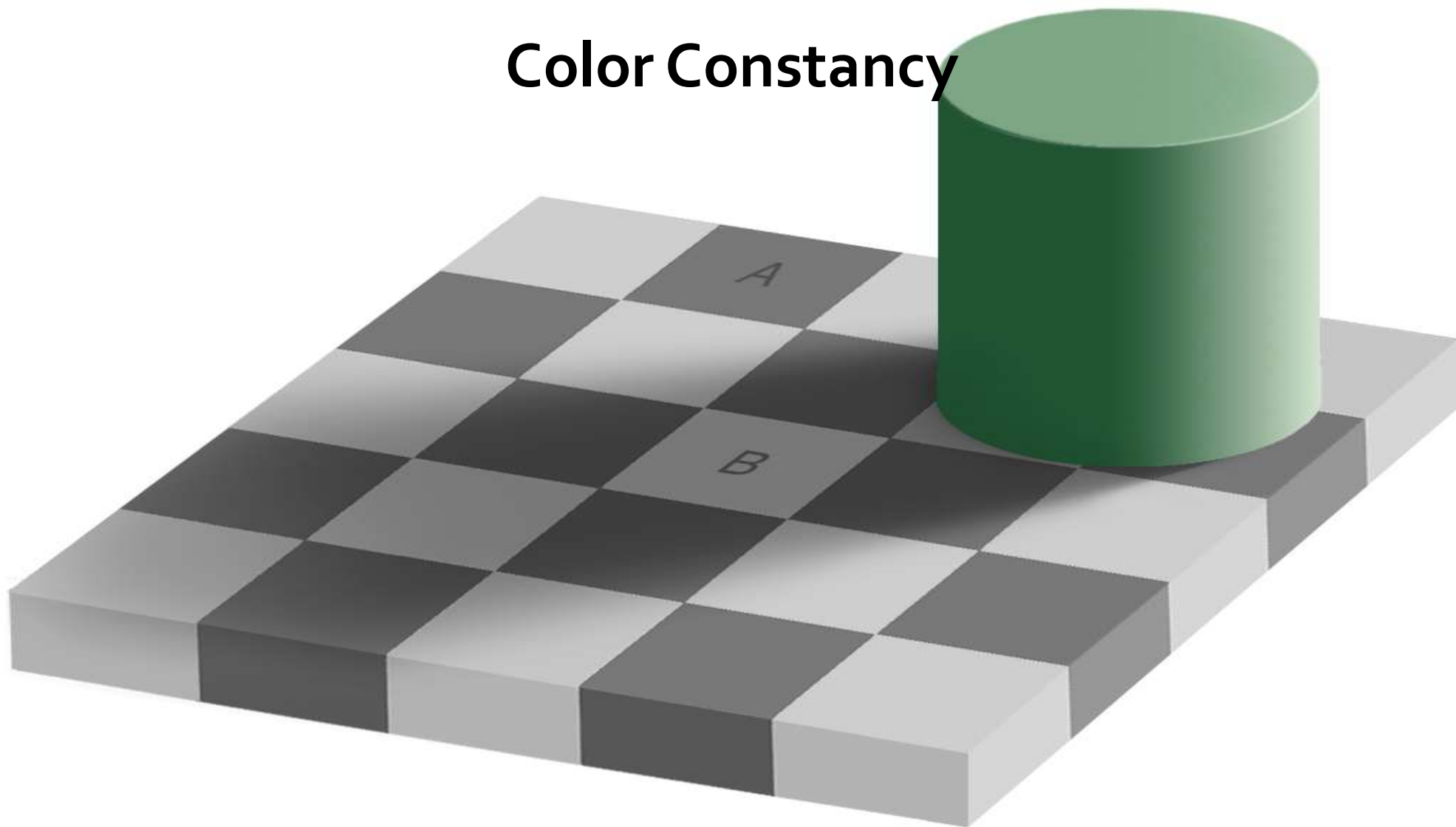


Color Constancy

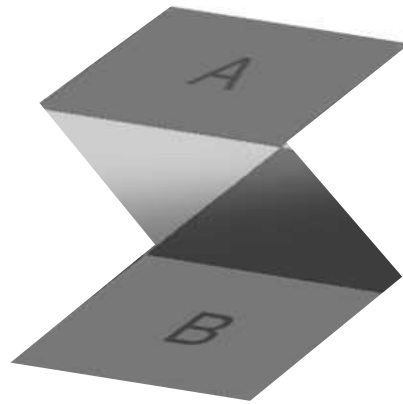
- Feature of the human color perception system
- Perceived color remains relatively constant under varying illumination conditions

red+white image

Color Constancy



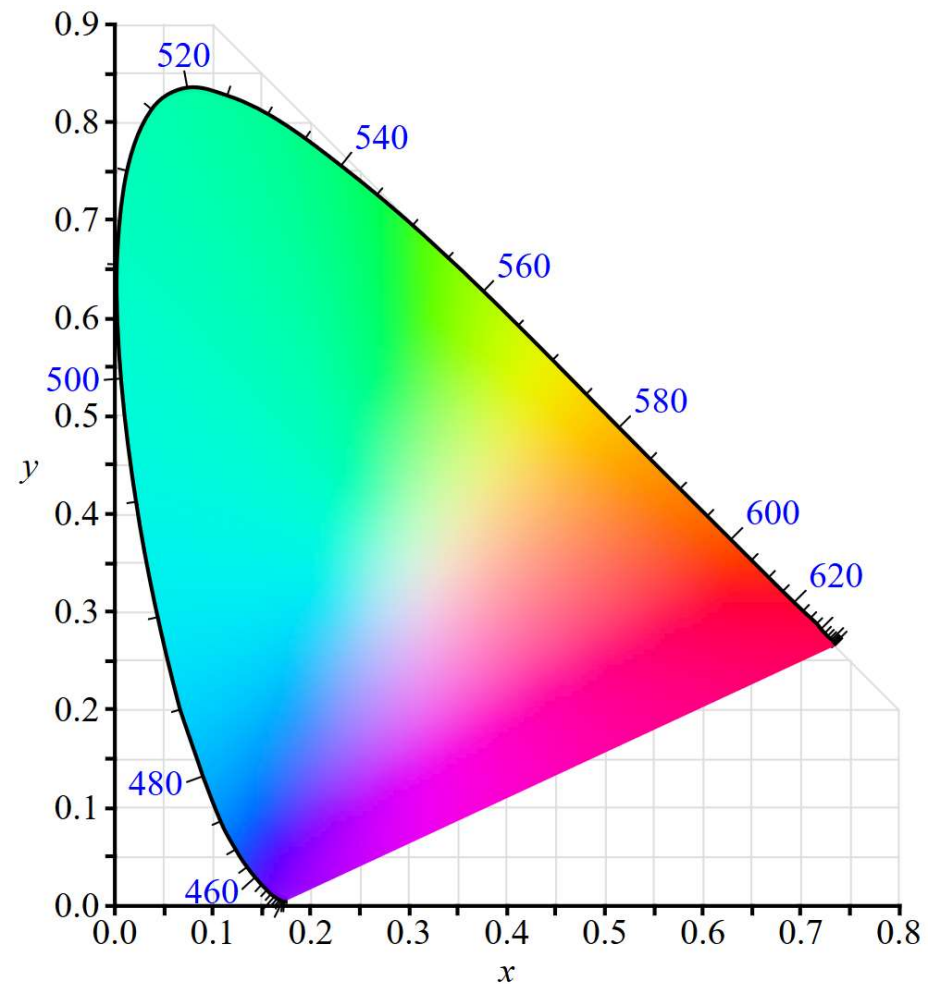
Color Constanc



Color Spaces/*Systems*

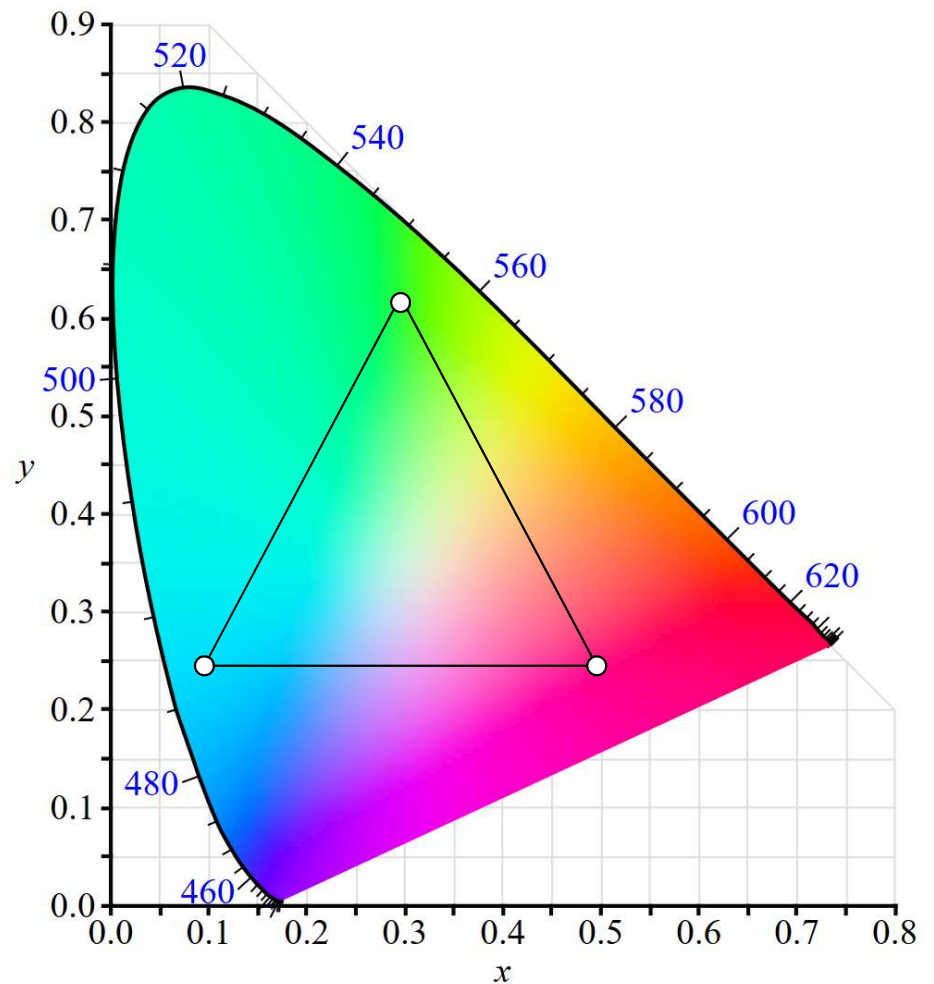
Range of Human Color Perception

- Projected slice is shown
 - CIE 1931 color space chromaticity diagram



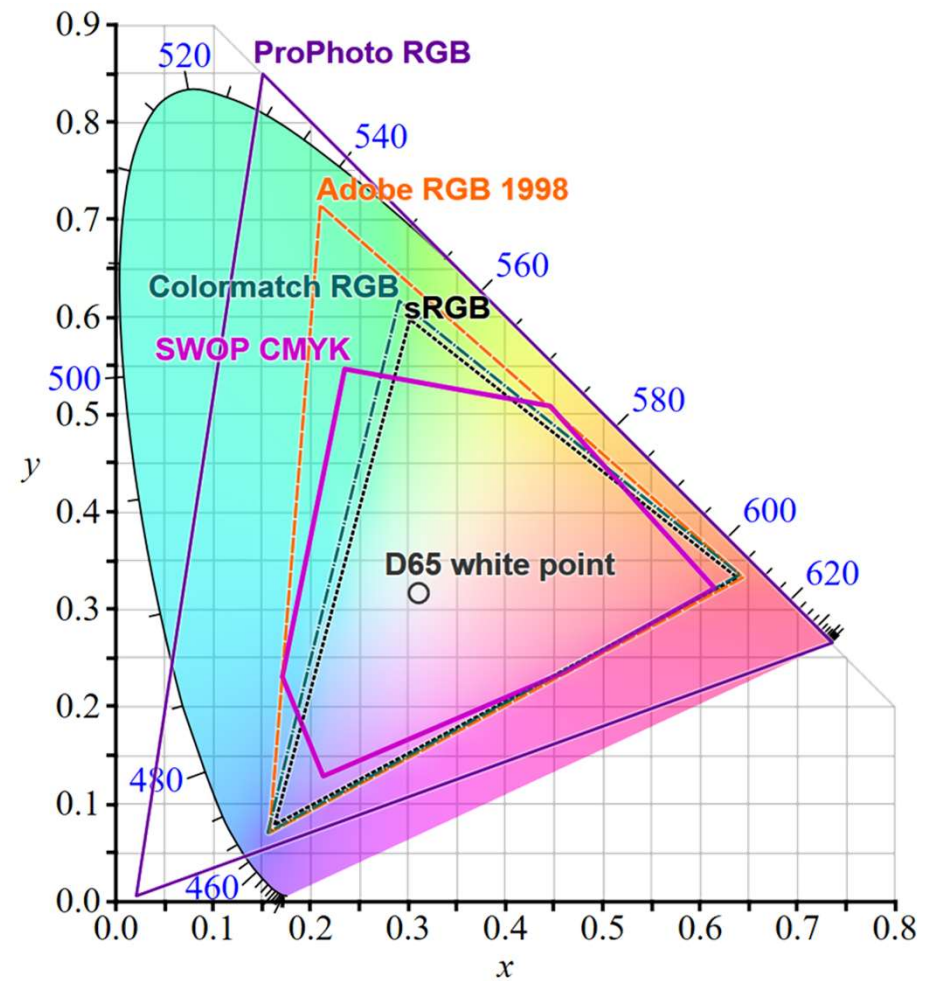
Color Model/Space

- Specific organization of colors
- Identify colors numerically by coordinates
- Pick primaries
- Can describe area between primaries



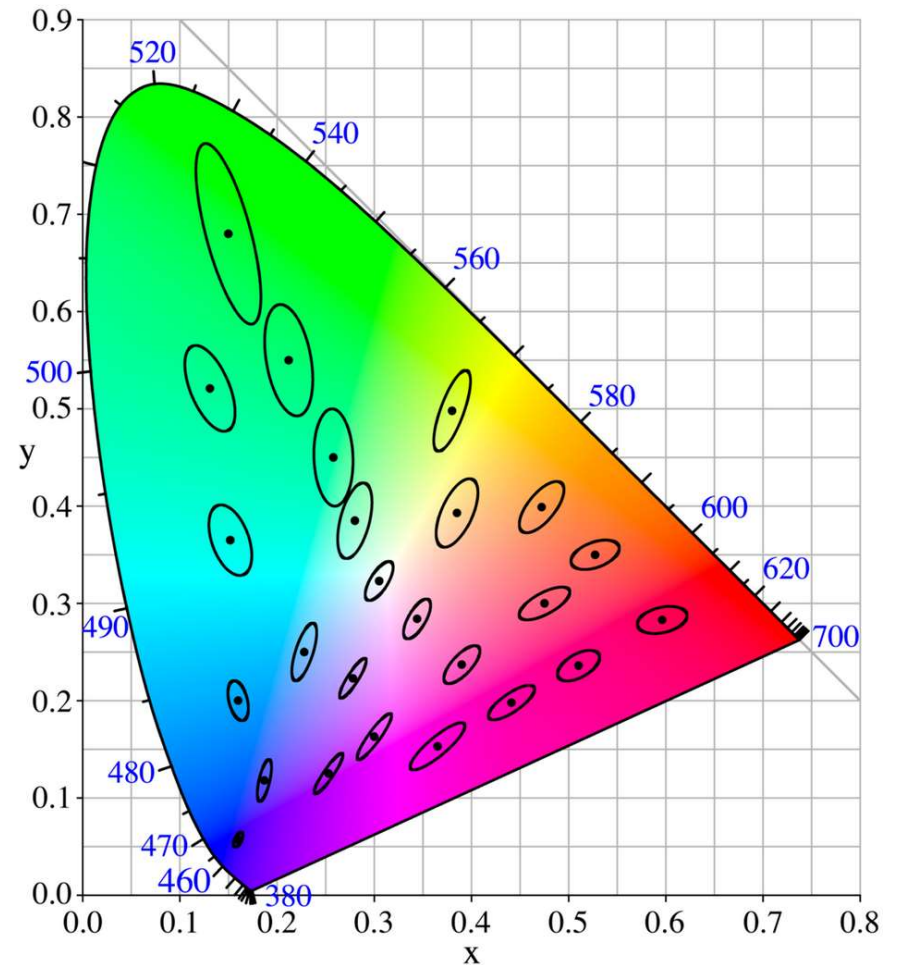
Color Spaces

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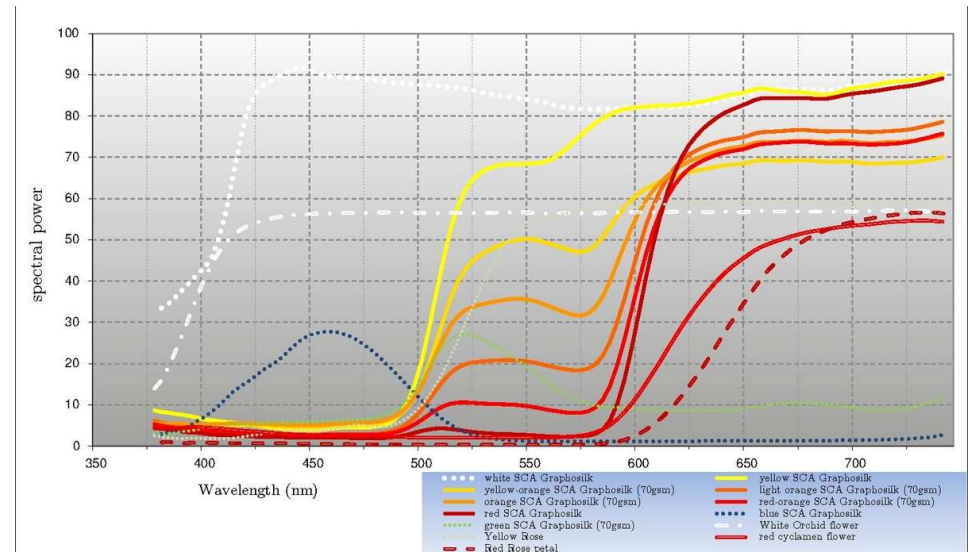
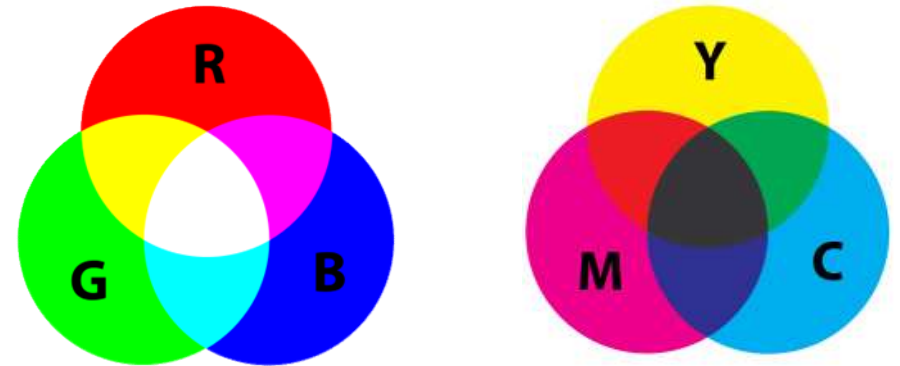
Color Metric Spaces

- CIE XYZ
 - Detect metamers
- CIE L*a*b*
 - Perceptually uniform
- Colorimetry



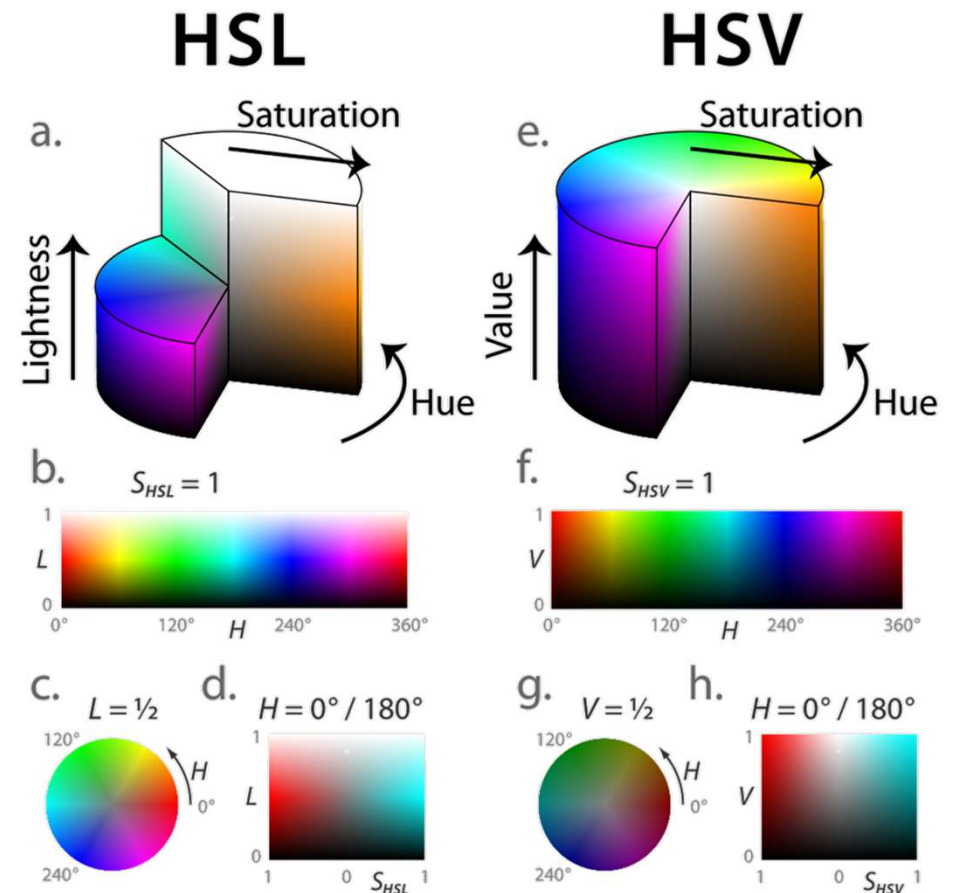
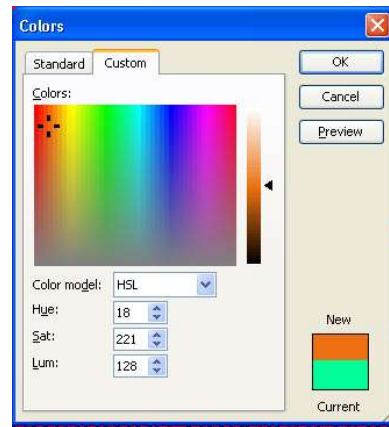
Device Color Spaces

- RGB, CMY(K)
- Additive or subtractive
- Device specific
- Paper specific



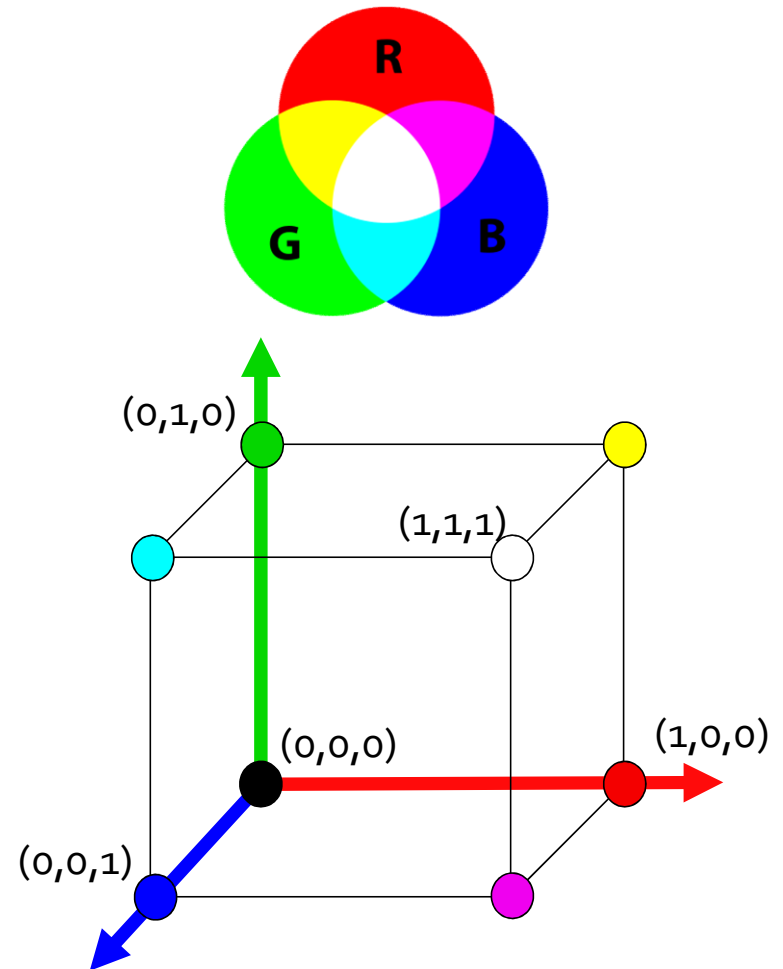
Color Ordering Spaces

- HSV, HLS
- Enable user to intuitively choose colour values according to certain criteria



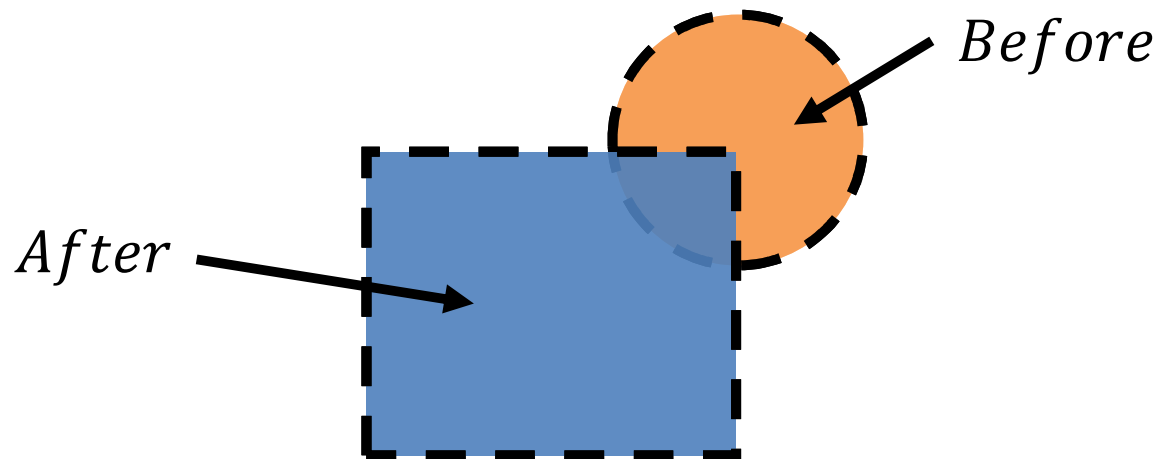
RGB Color Space

- Based on tristimulus theory
- Standardised version – sRGB
- Additive color model (monitors)
- $0 \leq R, G, B \leq 1$
- Channels independent
 - Calculations / channel

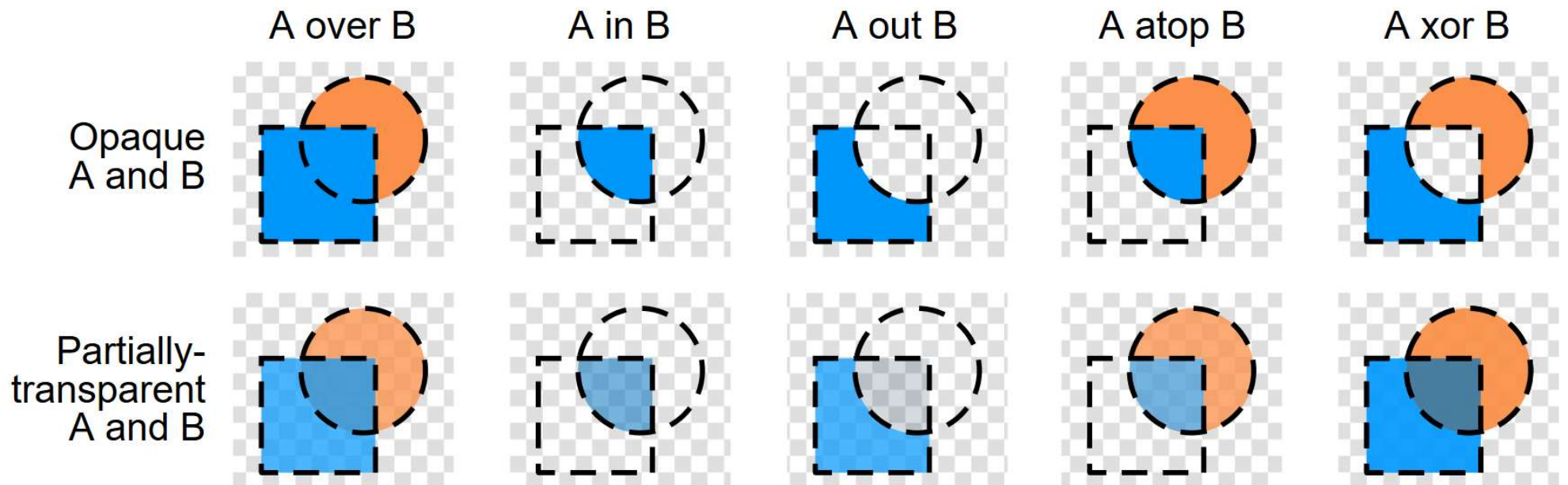


RGBA Color space

- Extension of RGB with extra alpha channel information
- Alpha channel stores opacity information
 - Alpha = 0.x: background shows through; like glass, ...
 - Alpha = 0: transparent
 - Alpha = 1: opaque

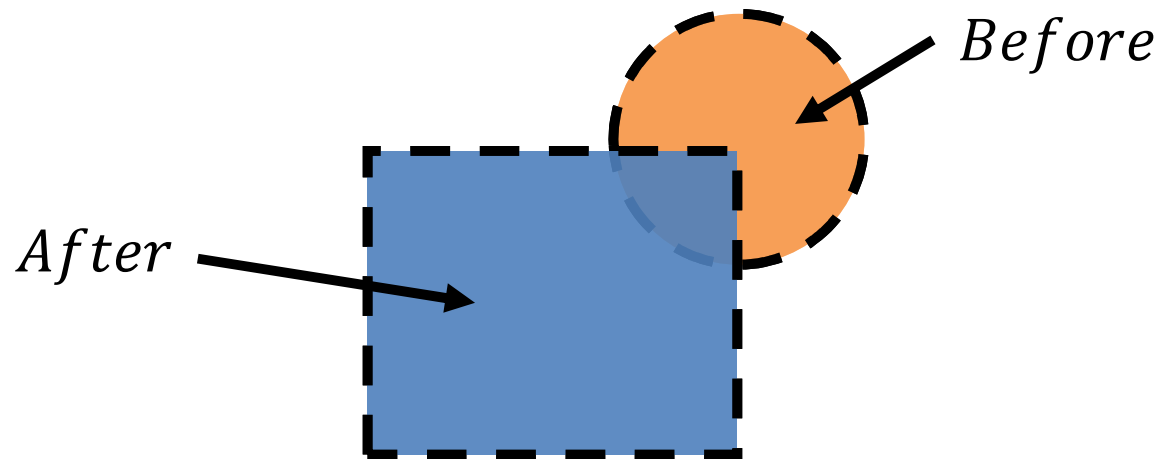


RGBA Color space – Alpha Compositing

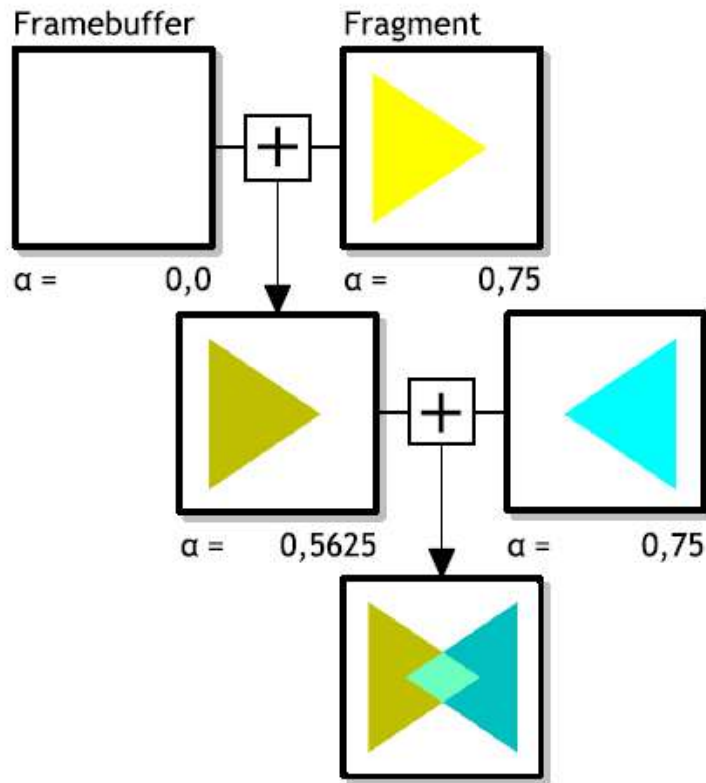


RGBA Color space – Transparency

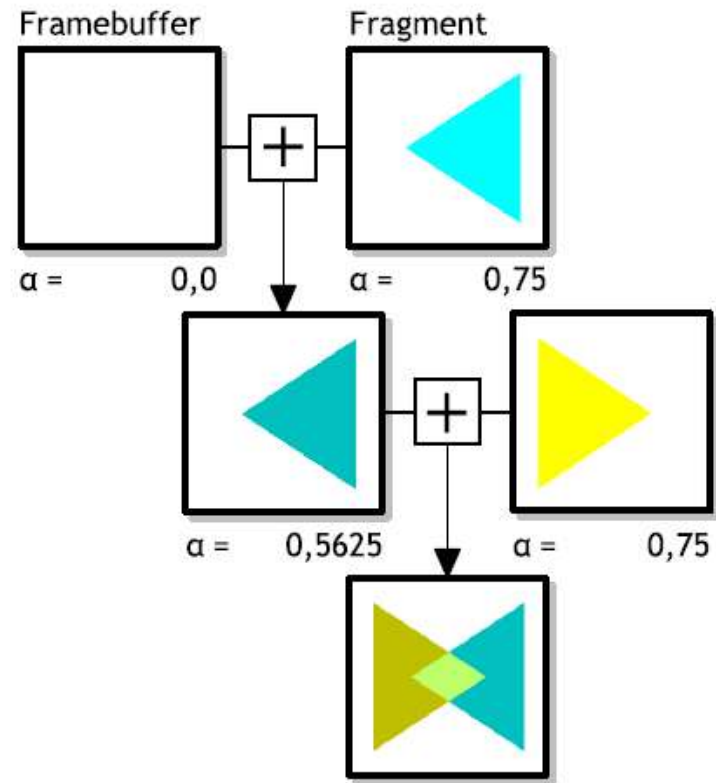
- $After = Before * (1 - \alpha) + New * \alpha$



Order is Important



(a) Gelb \rightarrow Cyan



(b) Cyan \rightarrow Gelb