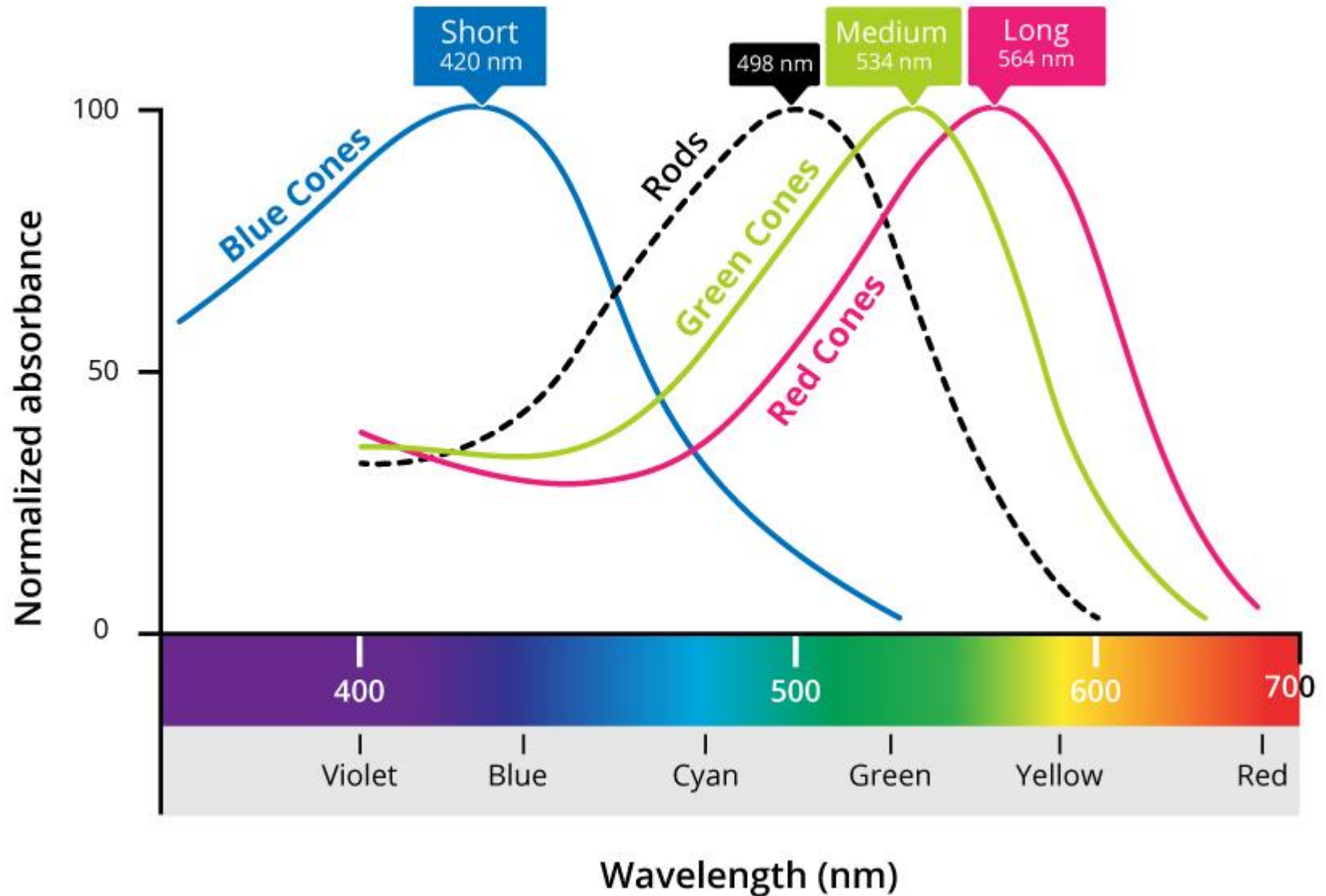
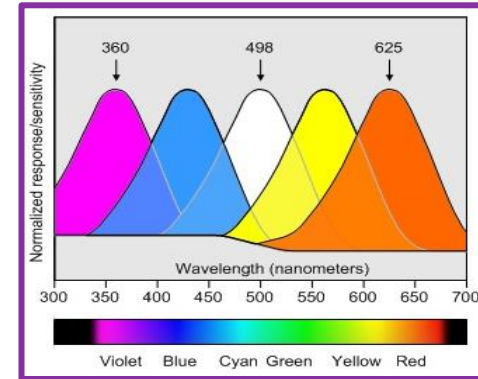
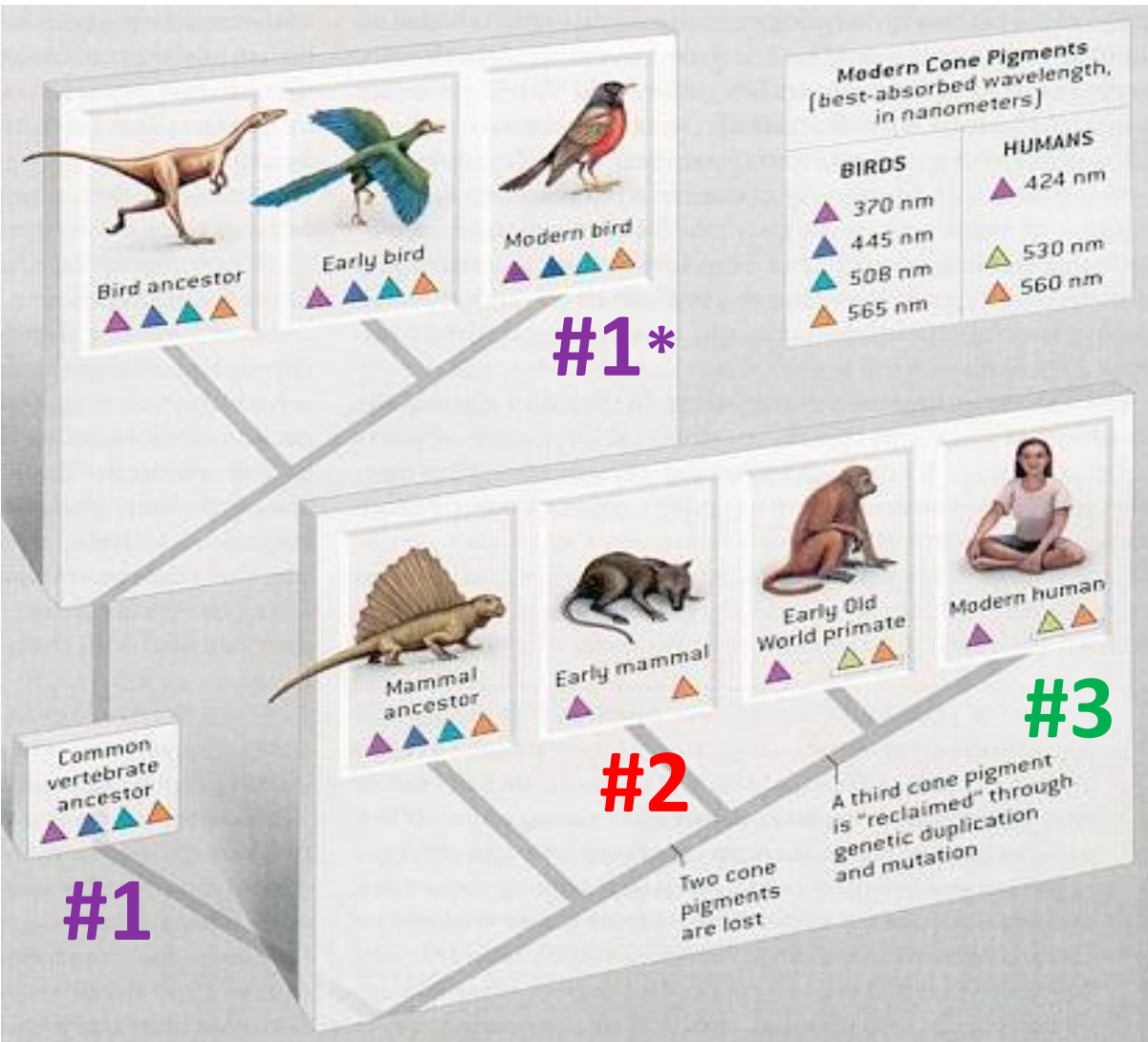


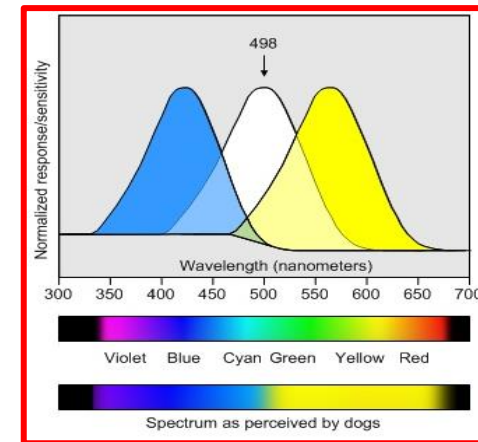
# Human Photoreceptors



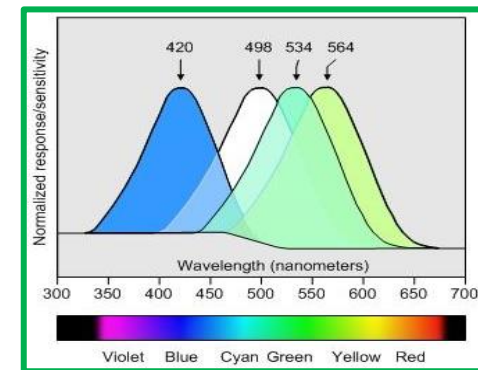
# Evolution of Color Vision



#1



#2



#3

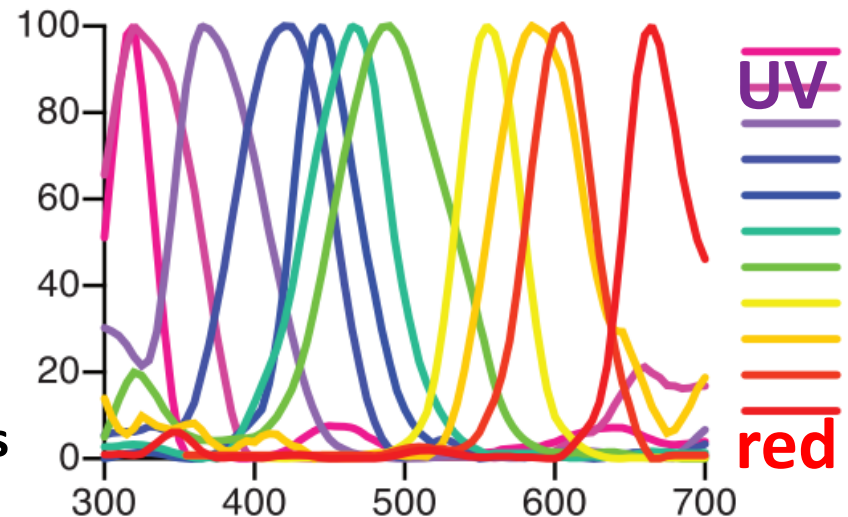
Can there be more?

# Mantis shrimp has **12** distinct photoreceptor types!



- There are more than 500 known species of mantis shrimp, which range in size from less than an inch to over a foot long.
- They mainly live among the coral reefs of tropical oceans — one of the most colorful environments on Earth.
- The mantis shrimp eyes are considered to be the most complex eyes in the animal kingdom.

- With its 12 cones, the mantis shrimp is able to **immediately recognize basic colors** just by scanning an object with their eyes, **rather than using the brain** to distinguish different colors of light.
- While it can make quick and reliable determinations of color, the creature is rather bad at discriminating close colors from one another.

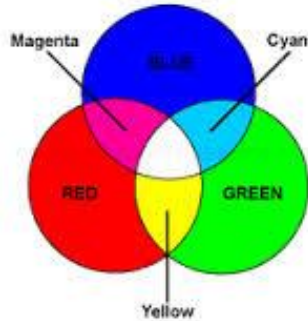




# Color Formation

- The three color receptors in the human eye allow us to see **millions of different colors**.
- Color formation mechanism in the eye is additive.

- The additive primary colors are **red**, **green**, and **blue** (RGB).

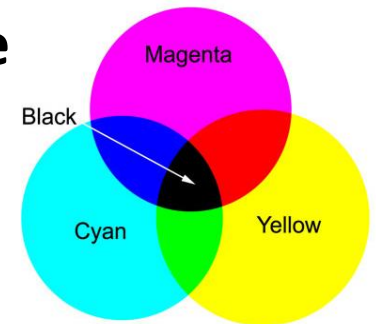


- All the different hues of color that we see can be made by changing the proportions of red, green, and blue light.

Mixing **light** is additive.

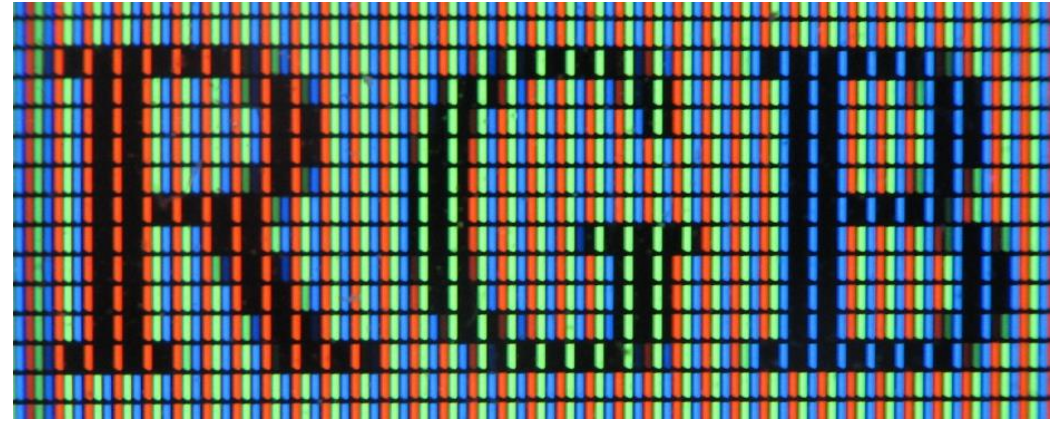
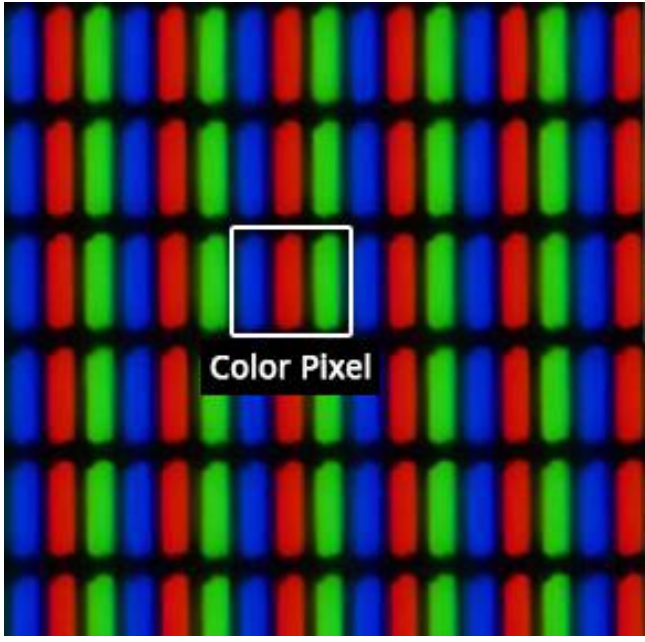
- Inks, dyes, and paints get their color from a subtractive process.
- Chemicals, known as **pigments**, absorb some colors (that is, *subtract from white light*) and allow the rest to be reflected – this reflected light makes the color you actually see.

- The subtractive primary colors are **cyan**, **magenta**, and **yellow** (CMY).

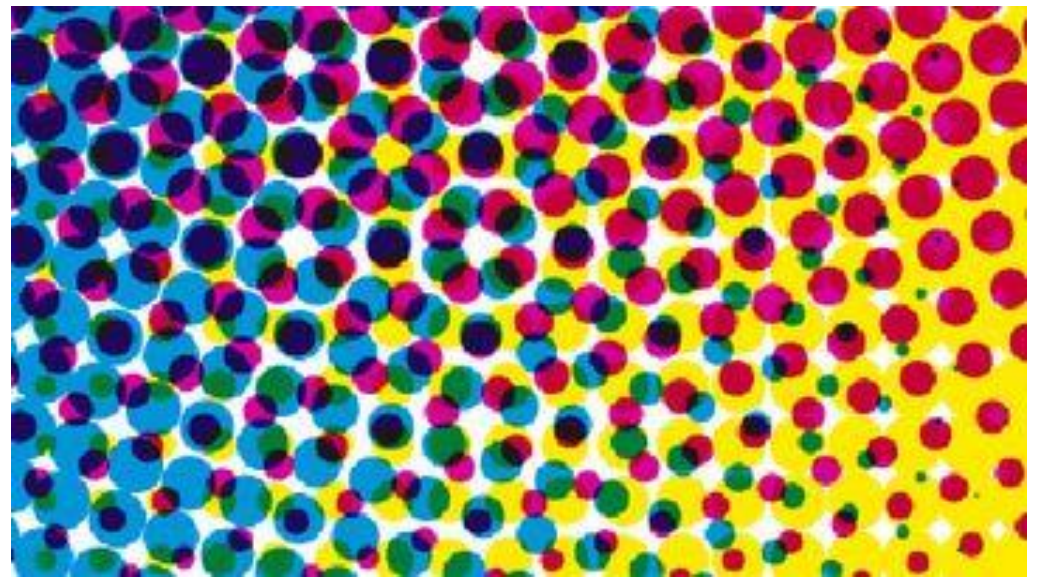


Mixing paints or pigments is subtractive.

**...computer screen IN DETAIL**



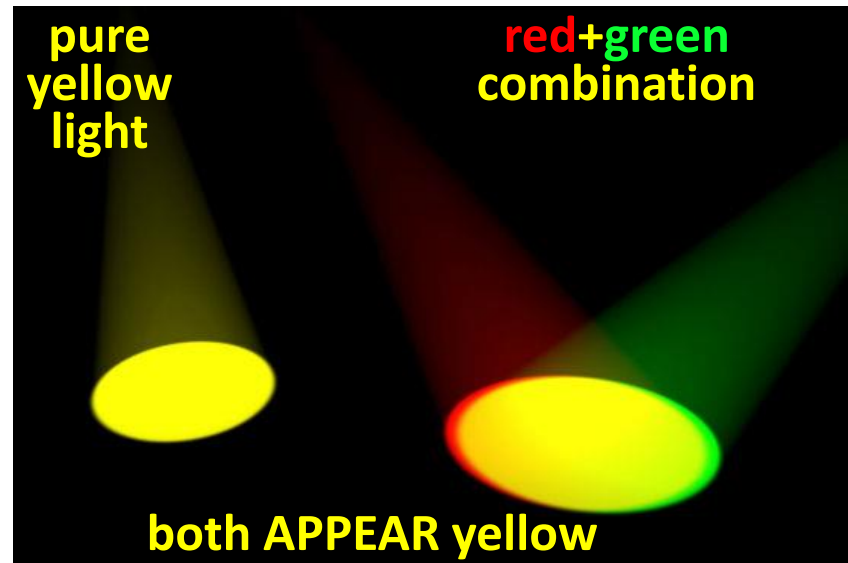
**...something printed**



# Is Color *Real*?

Additive color mixing is **subjective** – it provides only the **sensation of color**.

- Actual wavelength may not be present within the combined spectra of the incoming light.
- For the eye-brain system, there is no difference between *pure yellow* light and *red-green combination*.



- What about **PINK?** **MAGENTA?** **PURPLE?**
- Combination colors – do not exist within the spectrum of white light, but are recognized as distinct colors by human visual system.

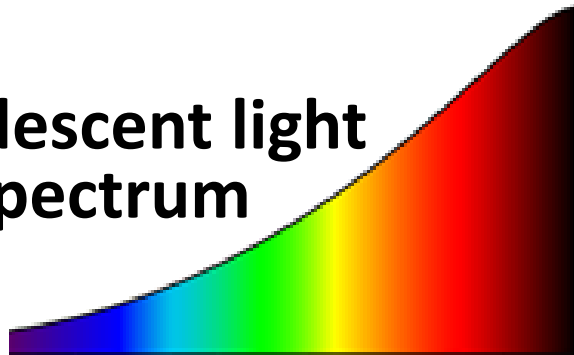
...actually, all “colors” we see could be considered **a trick of the mind** 😊

# What color is this tulip? And why?



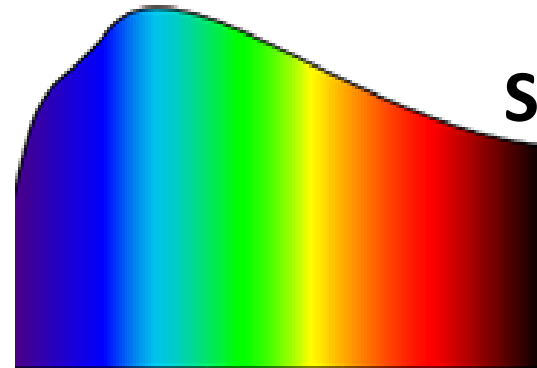
Indoor and outdoor *lighting* can be quite different!

Incandescent light  
bulb spectrum



much more red+yellow  
than blue

Sunlight  
spectrum



red and blue components  
are similar



😊another trick😊

# What is Image?

- Generally, an image is a reproduction of the likeness of a subject.
- An **optical image** may be regarded as the **apparent reproduction of an object by means of light**.

A **real image** occurs where light rays coming from an object converge.



Examples: the image on a cinema screen (the source = projector), and the image produced in the eye on an eyeball retina.

A **virtual image** occurs where light rays only appear to converge.



A mirror image appears positioned behind the mirror, although *light from the source only exists in front of the mirror*: the image exists in a space that is not real in a sense...