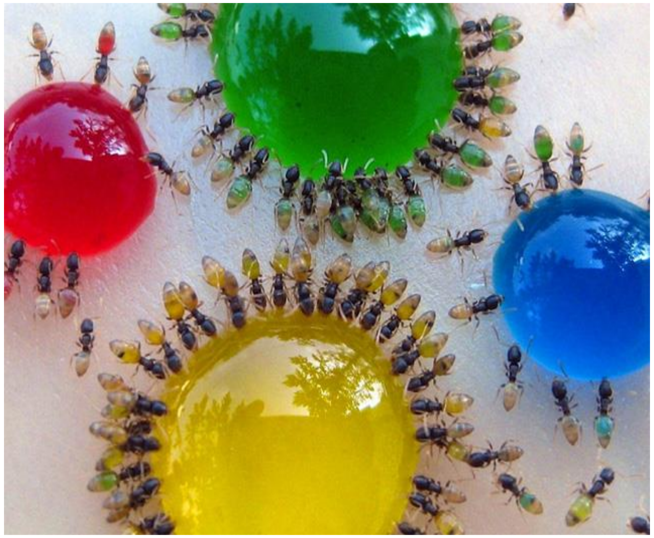
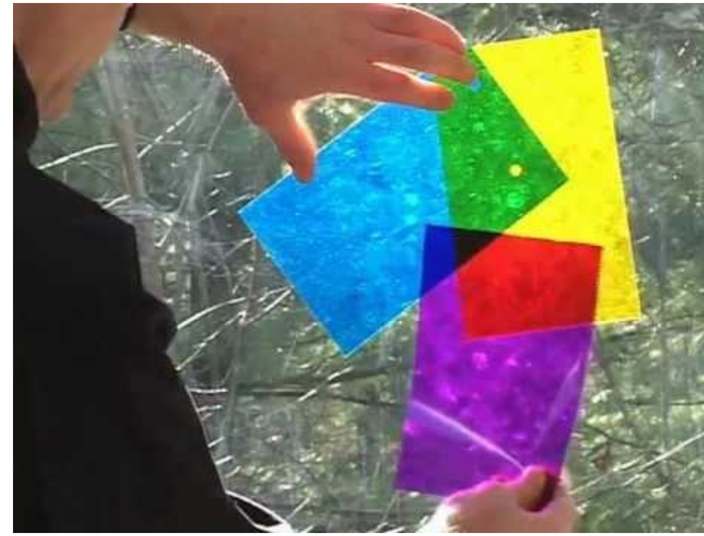
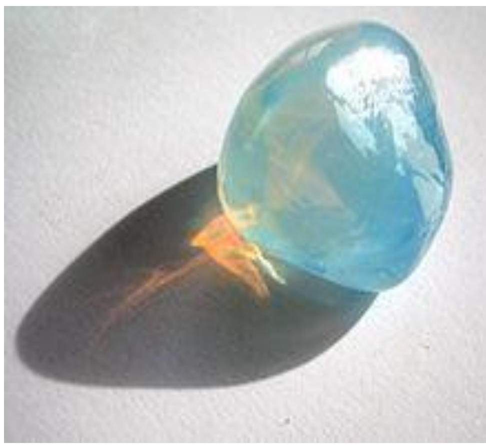
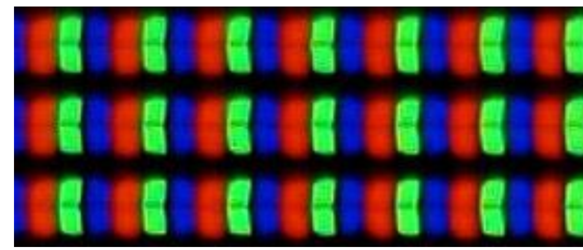
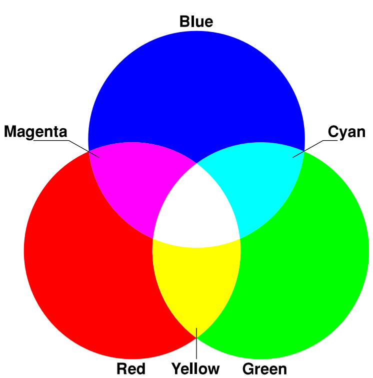




It's a Colorful World

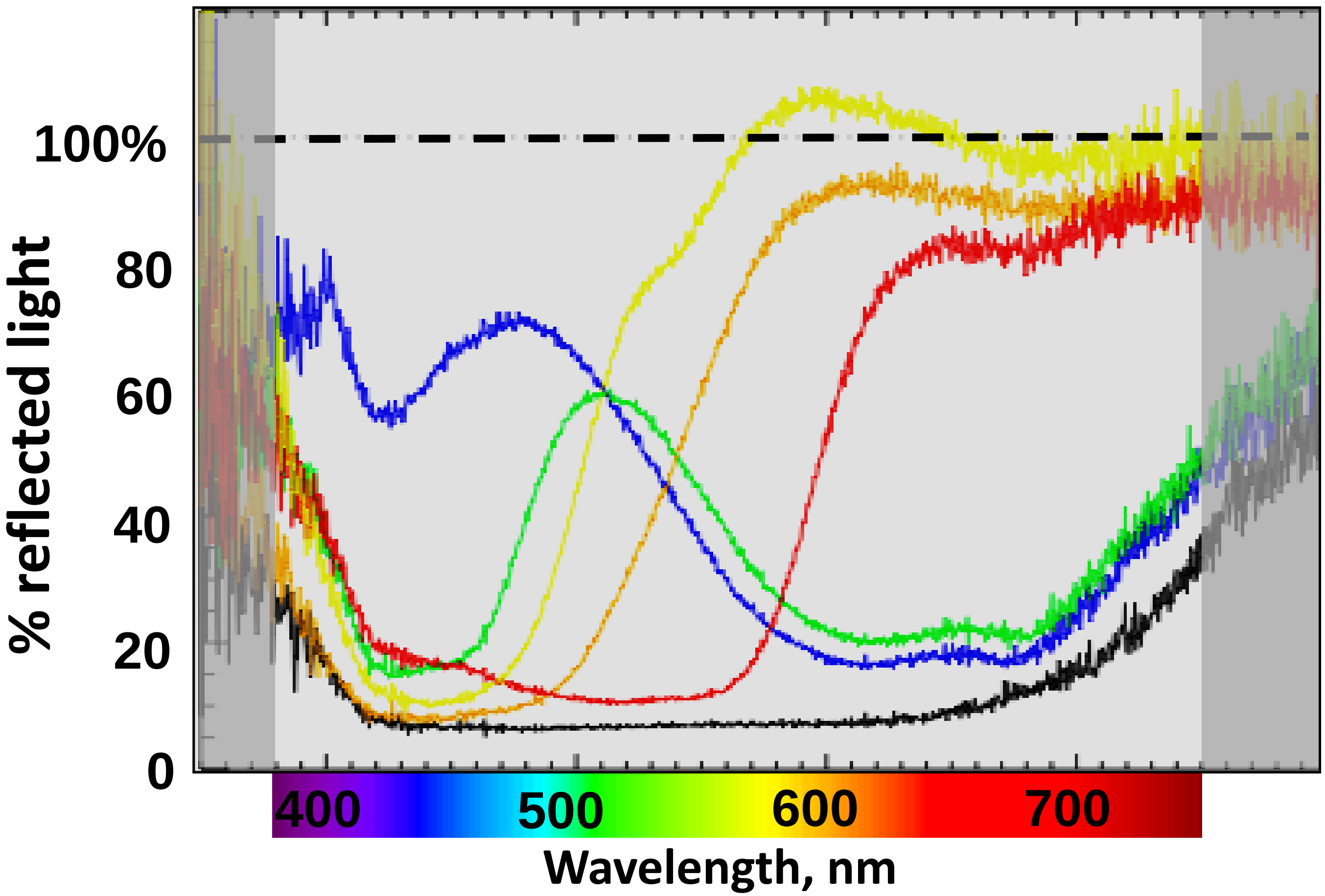






The color of an object depends on which wavelengths of light the object reflects. Each of these flowers is illuminated by *white* sunlight and reflects the color that you see.

Can we measure it?



Selective reflection **of sunlight off colored paper,**

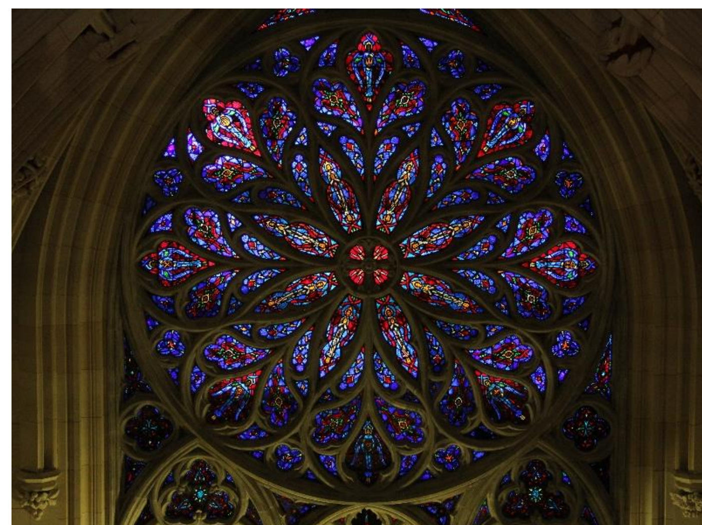
blue
green
yellow
orange
red
black.

Question: what would a white paper curve look like?

Light Filters *(selective transmission)*

Rashad Alakbarov, Azerbaijan

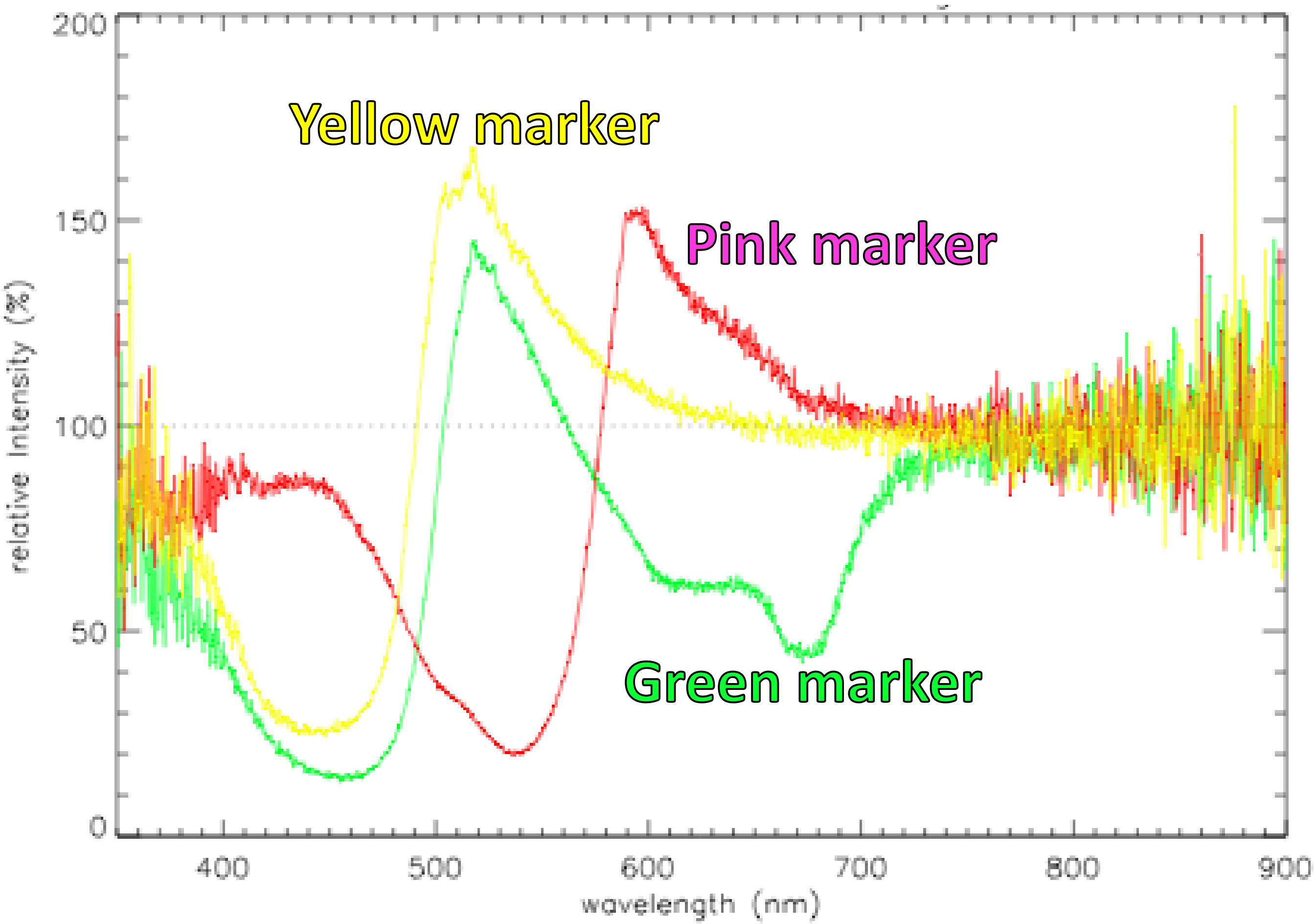
Tom Fruin, USA



Rose Window
St. Patrick's Cathedral, New York

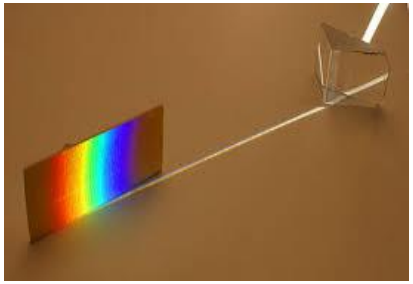
Fluorescent Markers (Highlighters)

Light response under white light illumination



Fluorescent markers absorb white and re-emit colored light.

(note *signal above 100%* in certain spectral ranges)



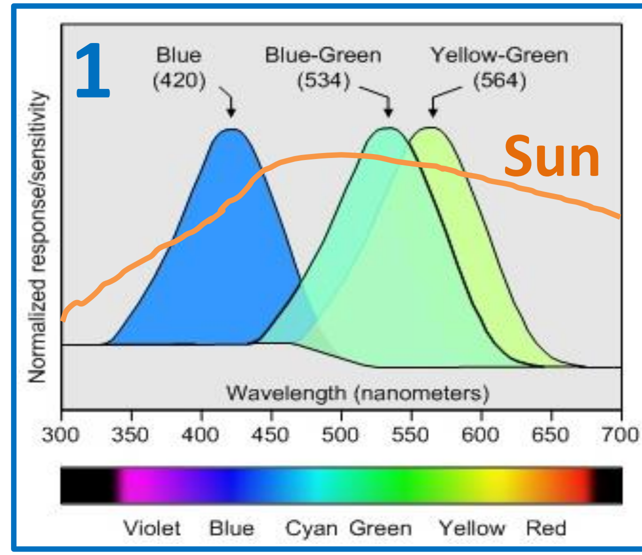
Note: there is no pink wavelength of light…

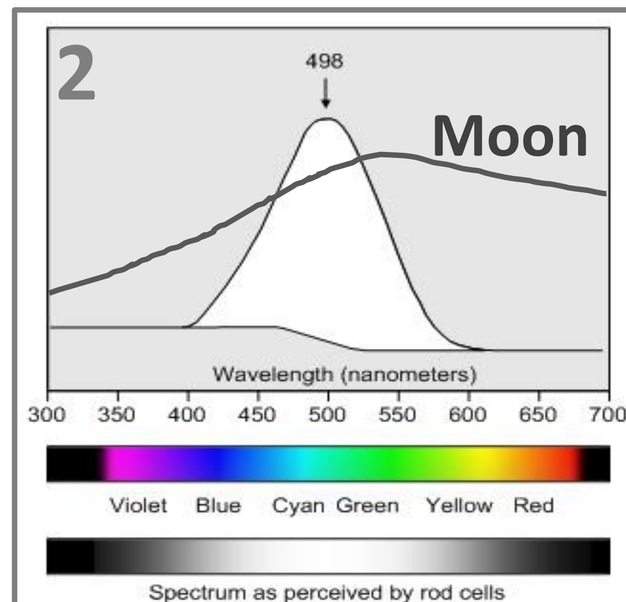
... so how do we see color?

The brain perceives color based on two major light detectors in the eye:

1. **Cone cells detect color**
   - each type of cone cell absorbs specific colors (wavelengths) of light
   - the number of cone cell types creates the range and detail of color an eye can see (distinguish).

2. **Rod cells detect intensity**
   - shades of a color (either light or dark)
   - ~1000x more sensitive than cone cells
   - maximum sensitivity at ~500 nm
   - retina contains about 20 times more rods than cones.





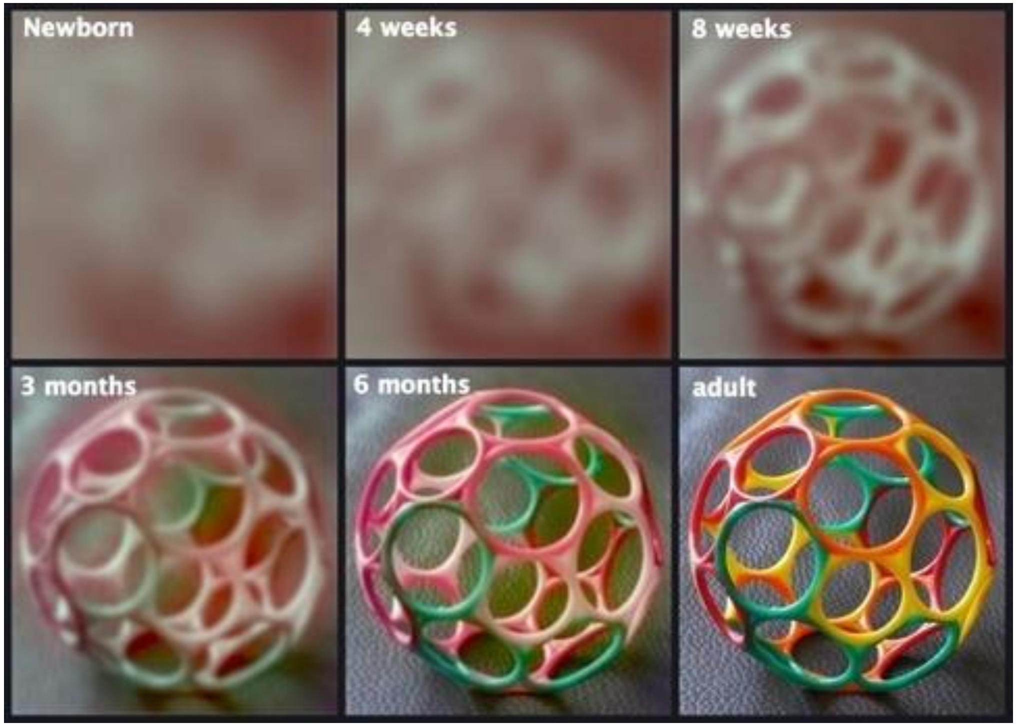
Photopic vision – bright light, cones.

Scotopic vision - in the dark, rods.

Learning Process

Our visual abilities such as focusing (accommodation), moving the eyes accurately (eye tracking), using the eyes together (eye teaming), and the brain processing what it sees (visual processing including <u>color recognition</u>) are learned skills.

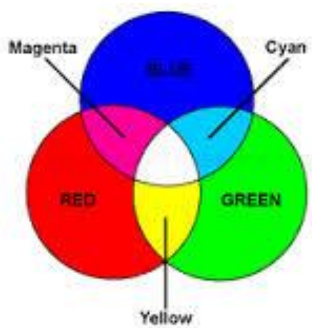
- <u>At birth</u>, we can only see as far as 7-10 inches away and in two dimensions only.
- <u>By 1 month</u>, the useful sight distance grows to about 3 feet, depth perception and 3D vision begin to appear.
- <u>By 6 month</u>, vision is almost fully developed, clarity and sharpness close to an adult.



By ~3 years of age complete development of color vision is achieved.

Color Formation

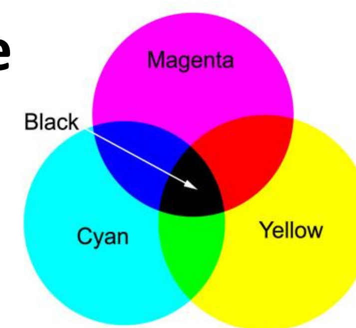
- The three color receptors in the human eye allow us to see millions of different colors.
- Color formation mechanism in the eye is **additive**.
- The additive primary colors are red, green, and blue (RGB).



- 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.

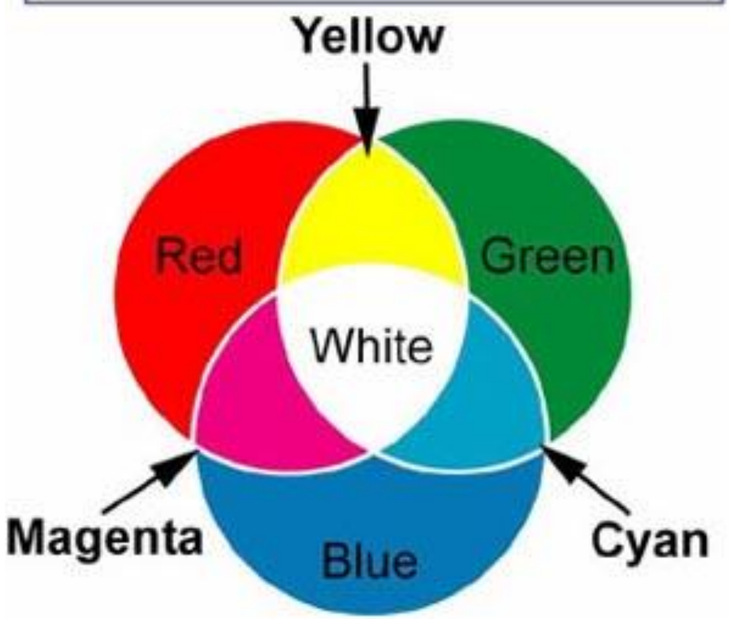
- Inks, dyes, and paints get their color from a **subtractive process**.
- Chemicals, known as pigments, absorb some colors (that is, *subtract from white light*) and allow the rest to be reflected – this reflected light makes the color you actually see.
- The subtractive primary colors are cyan, magenta,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



Mixing paints or pigments is subtractive.

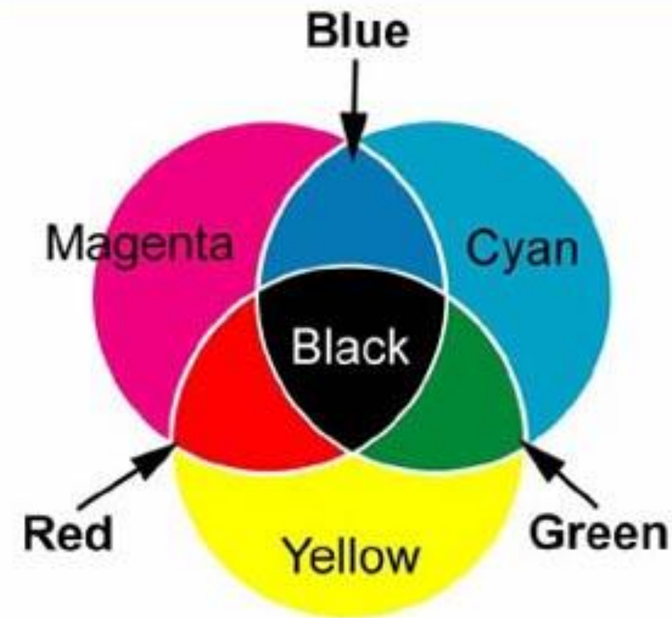
Color Formation Diagrams

The additive primary colors



White = red + green + blue
Yellow = red + green
Magenta = red + blue
Cyan = blue + green

The subtractive primary colors



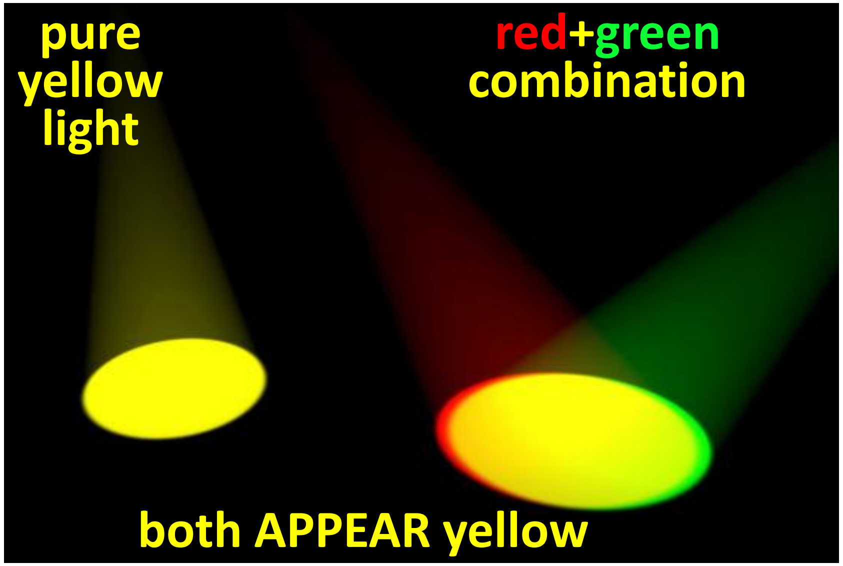
Black = magenta + yellow + cyan
Red = magenta + yellow
Green = cyan + yellow
Blue = magenta + cyan

Let’s look at this computer screen IN DETAIL…

Let’s look at this page printed IN DETAIL…

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 ☺