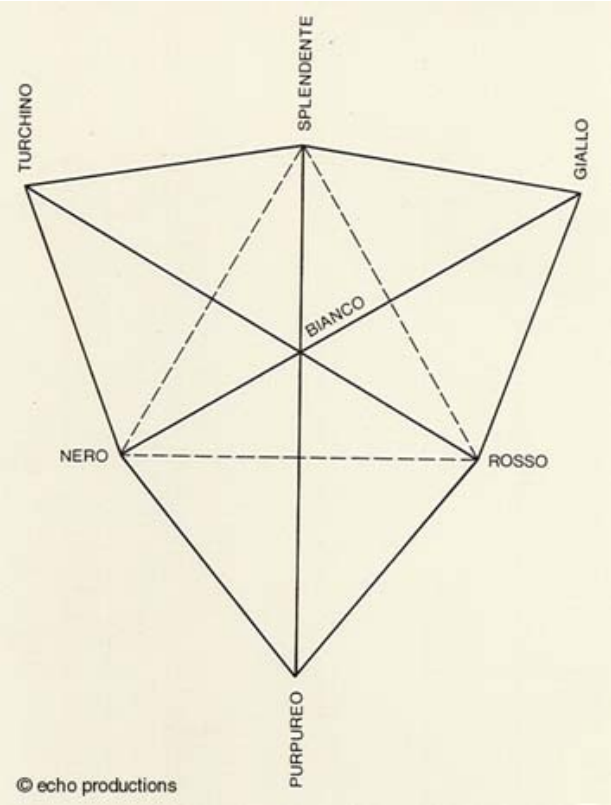
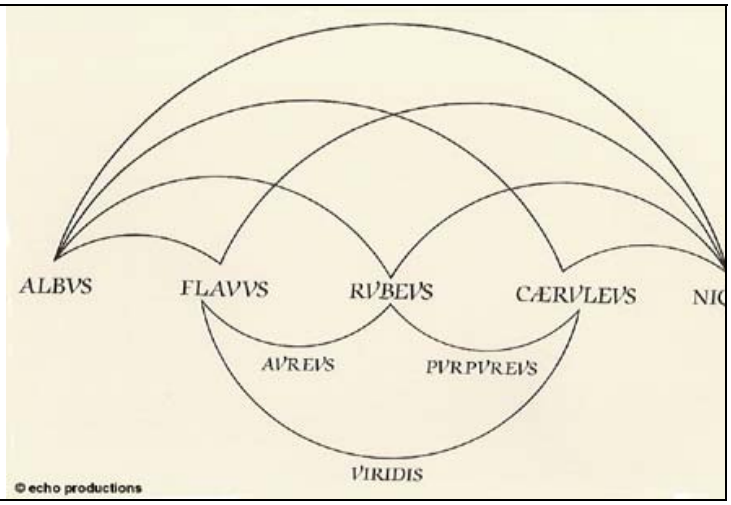
EARLIEST DESCRIPTORS OF COLOR



PLATO

TURCHINO = BLUE
SPLENDENTE = SHINY
GIALLO = YELLOW
BIANCO = WHITE
NERO = BLACK
ROSSO = RED
PURPUREO = PURPLE

In 1613, Aquilonius believed in the straight line of color from black to white, but added arcs as a way of mixing colors.

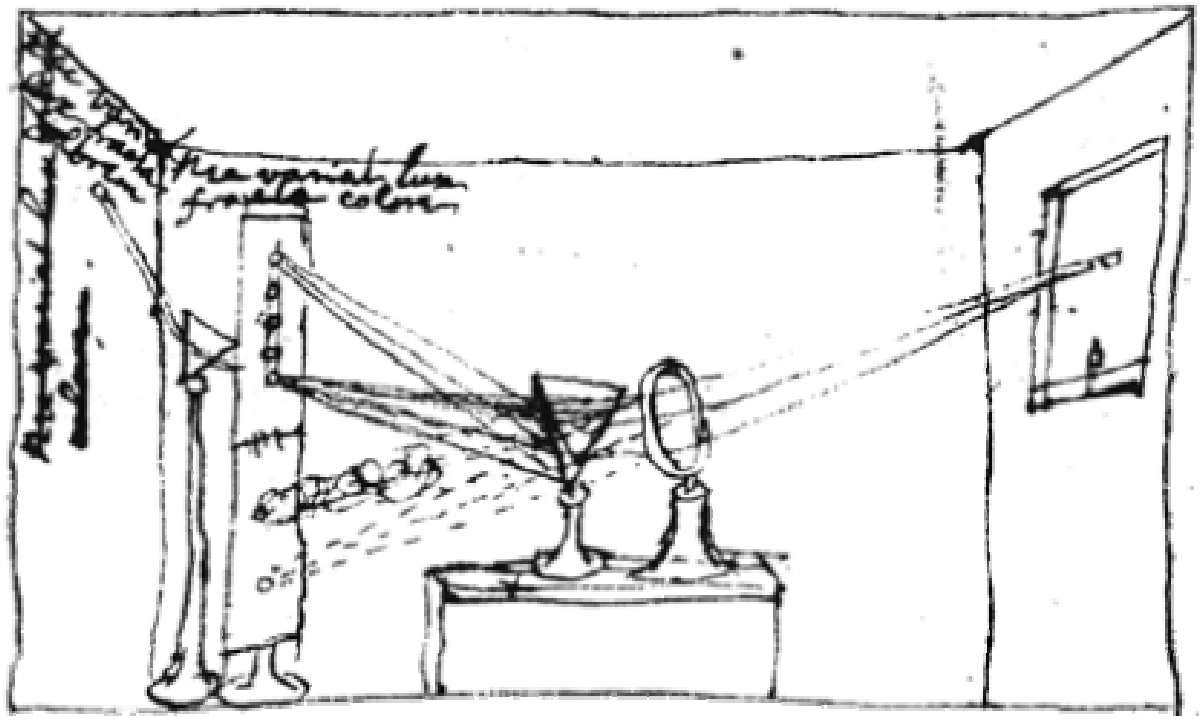
ALBUS = WHITE FLAVUS = AUREUS = RUBEUS = RED VIRIDIS = GREEN PURPUREUS = PURPLE CAERULEUS = BLUE NIGER = BLACK	

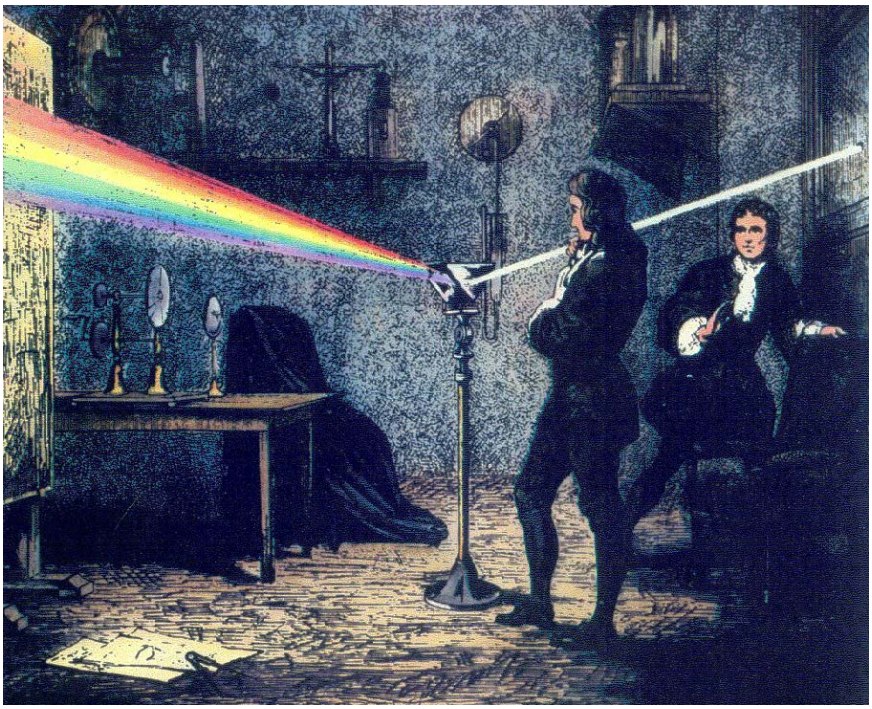
NEWTON AND HIS PRISM

Sir,

To perform my late promise to you, I shall without further ceremony acquaint you, that in the beginning of the year 1666 (at which time I applyed my self to the Grinding of Optick Glasses of other figures than spherical) I procured me a Triangular Glass Prism, to try therewith the celebrated Phaenomena of colours.

(from A Discourse of Mr Isaac Newton, containing his new theory about light and colours, sent by him from Cambridge to the Secretary of the Royal Society, 6 February 1671 /2. Original in possession of the Royal Society of London)



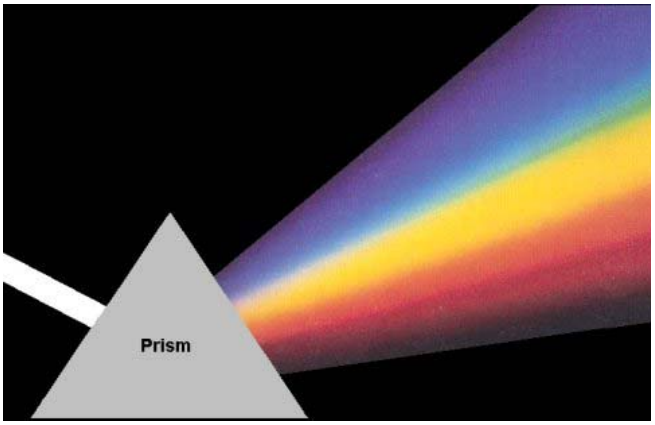


And in order thereto have darkened my Chamber, and made a small hole in my Windowshutts, to let in a convenient quantity of the Sun's light. I placed my prism at his Entrance, that it might so thereby be refracted to the opposite Wall. It was at first a very pleasing Divertisement, to view the Vivid and intense colours produced thereby, but after a while applying myself to consider them, more circumspectly, I became surprized to see them in an oblong form, which according to the received Laws of Refractions, I expected should have been circular

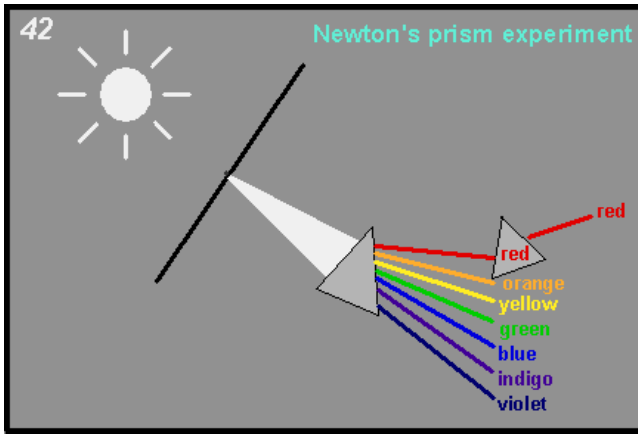
Comparing the length of the spectrum with its breadth. I found It above five times greater, a disproportion so extravagant, that it excited me to a more than ordinary curiosity of examining from wherever it might proceed.

(The Royal Society of London, R.B.C. 3, 215, 1671/2)

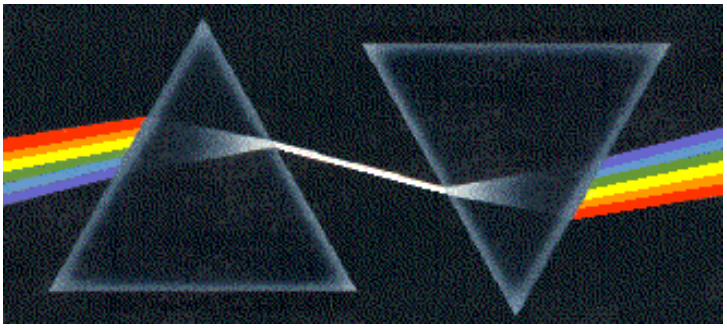
INTERESTING INTERPRETATIONS



from Purdue



from MIT



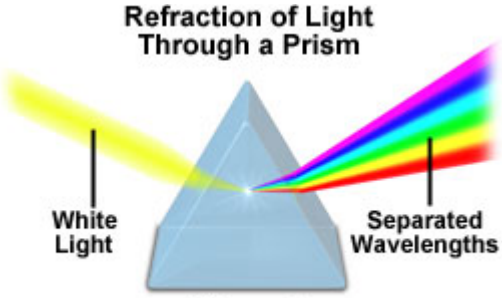
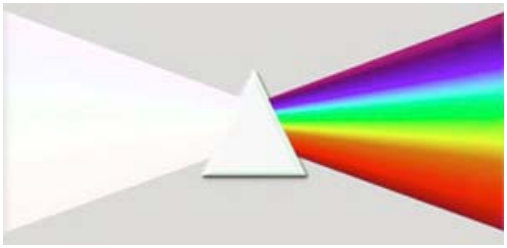
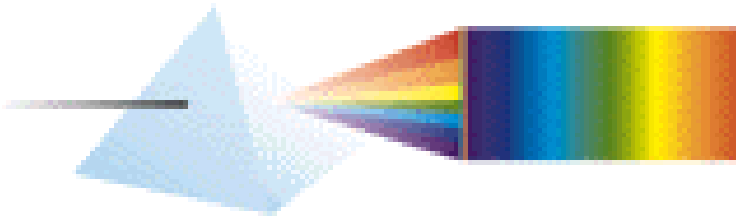


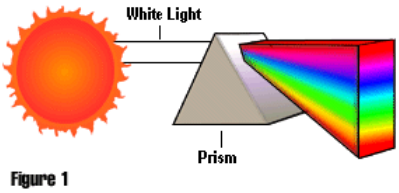
Figure 5

MORE INTERESTING PRISMS

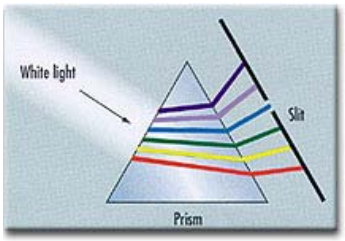




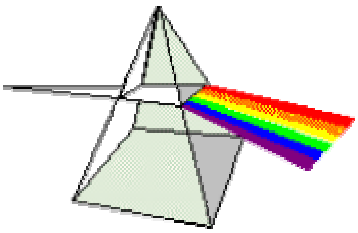
from Epson



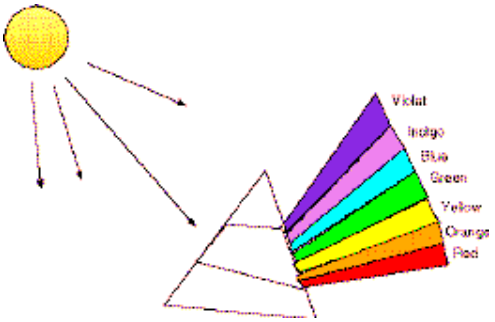
from US Ink



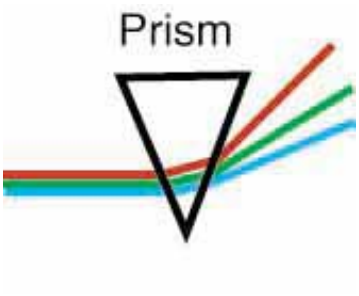
from Sensors Inc.



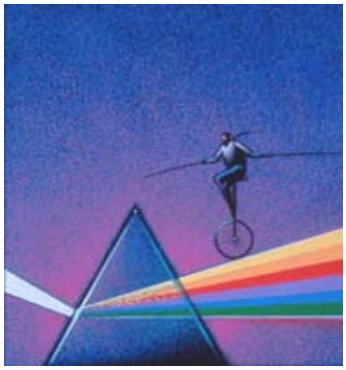
Dream analysis

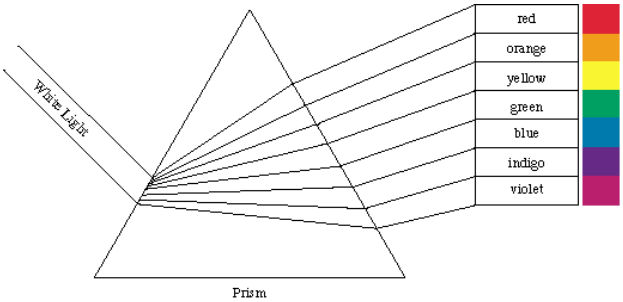


from UCSD



WDM tutorial

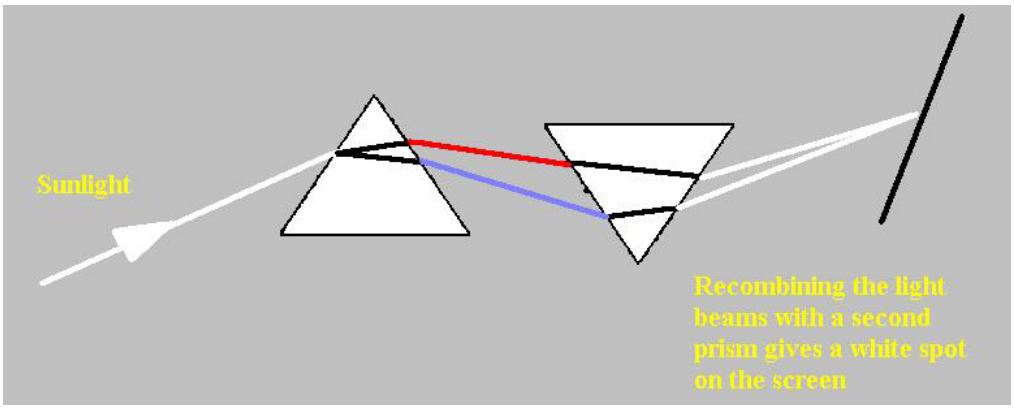


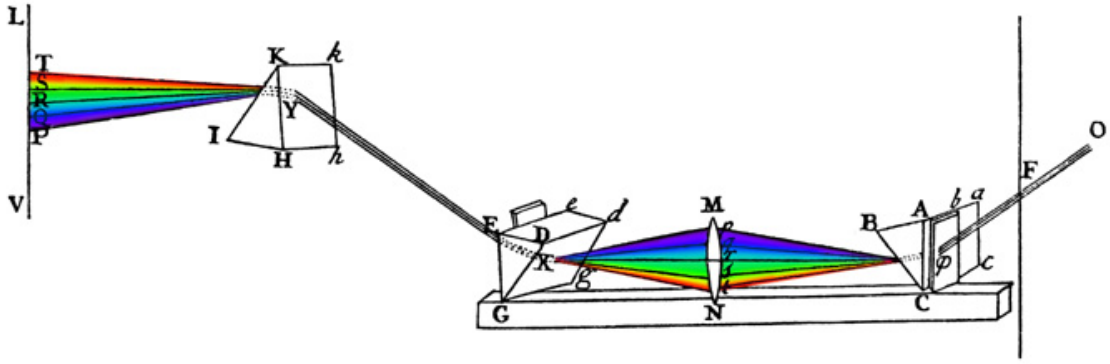


Quilters prism

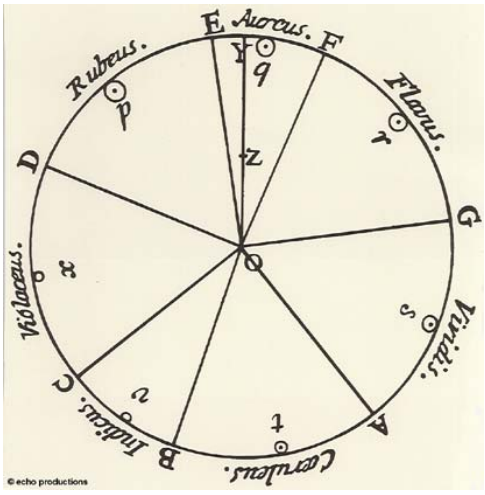
MORE NEWTON

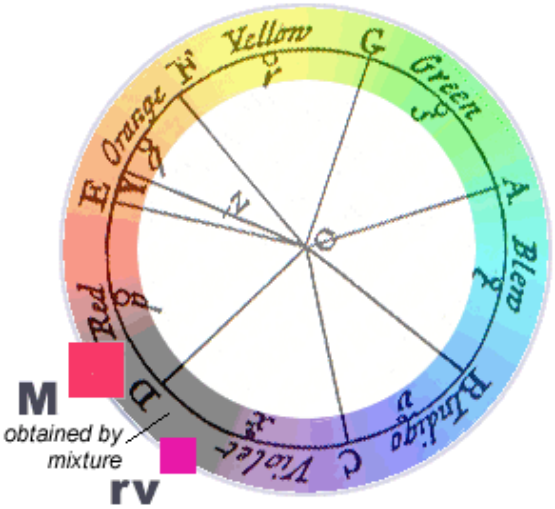
Newton demonstrated that you could disperse a spectrum, then put it back together to reconstruct white light.





He constructed what is probably the first color circle.

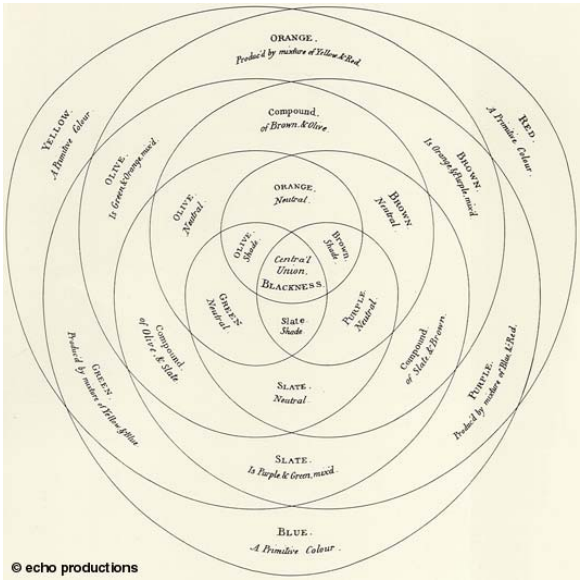




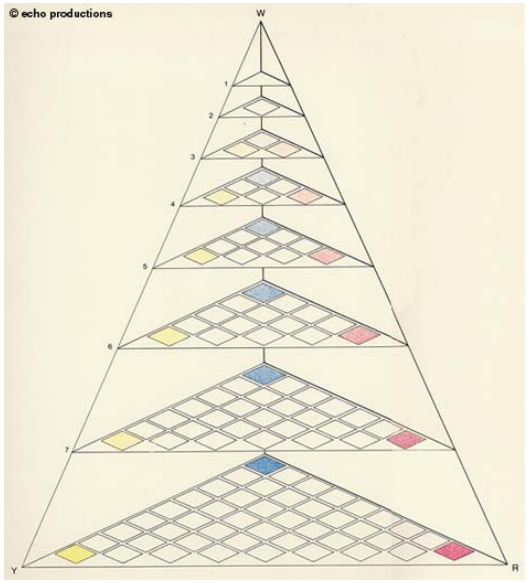
A FEW OTHER EARLY COLOR SPACE MAPS

CHEVREUL (1839)

GOETHE (1810)

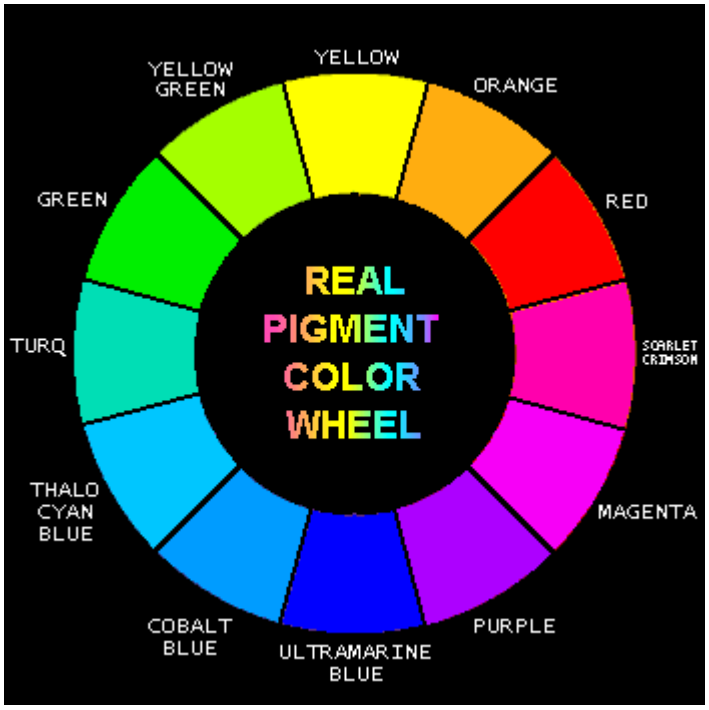


HAYTER (1826)



LAMBERT(1772)

THE "REAL" COLOR WHEREL



Each color opposition on the RCW mixes to a dark neutral that tints a neutral gray.

WHAT DO WE SEE?

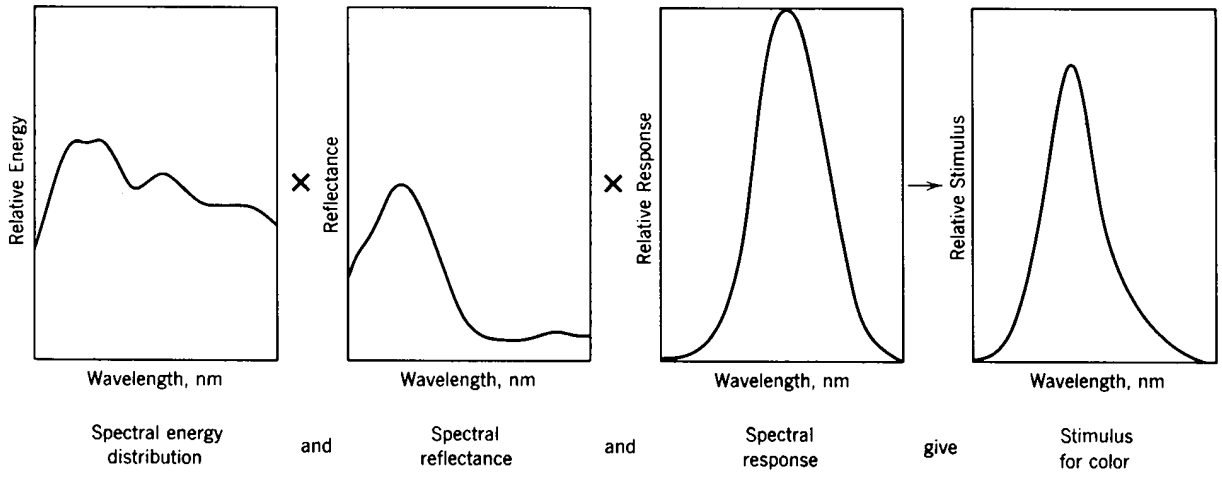
The stimulus presented to the brain is the product of several factors:

Source of light L_λ

Reflection/transmission coefficient $\rho(\lambda)$

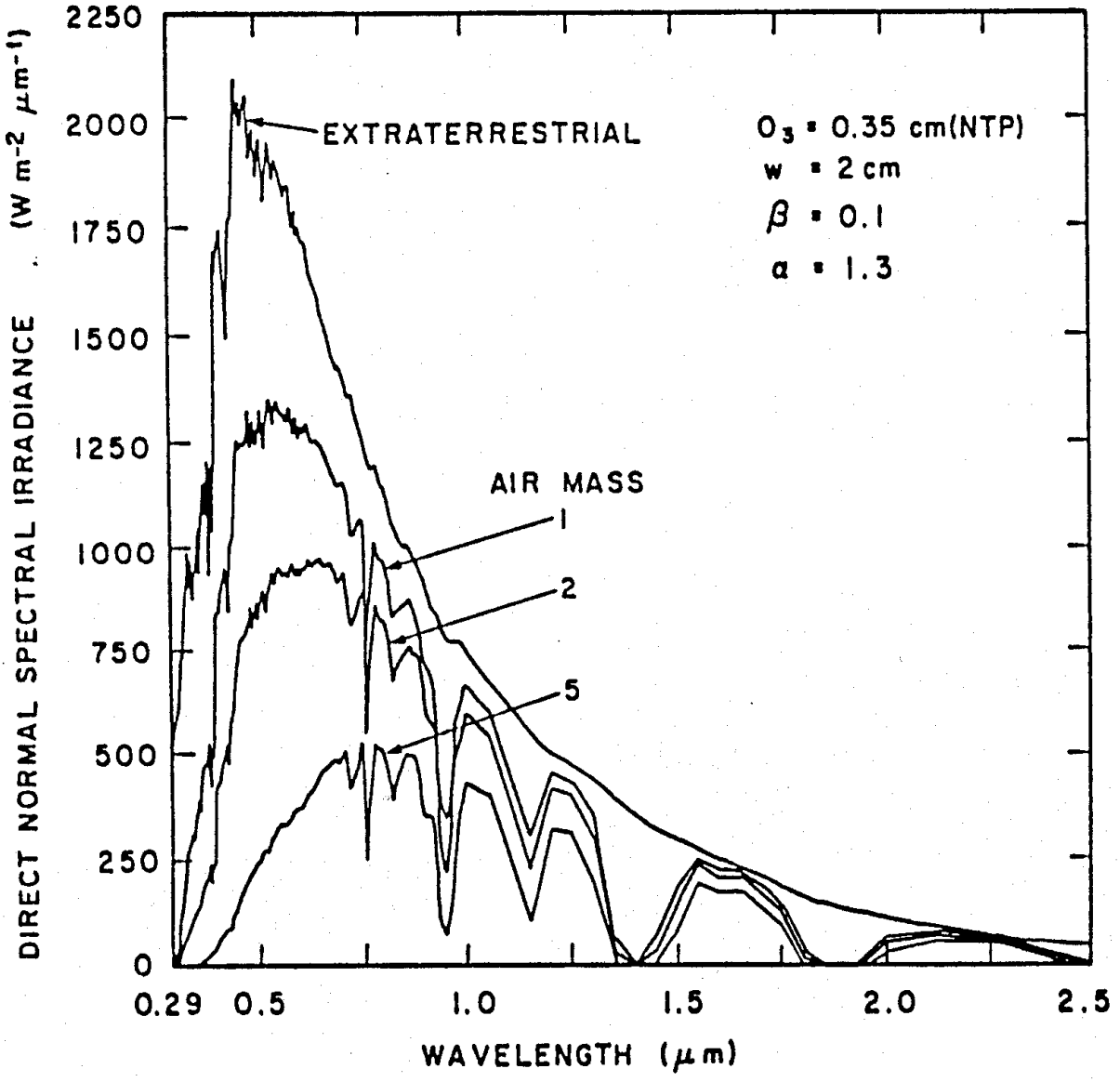
Spectral response of the eye itself $V(\lambda)$

$$STIMULUS = \int L_\lambda \cdot \rho(\lambda) \cdot V(\lambda) \cdot d\lambda$$



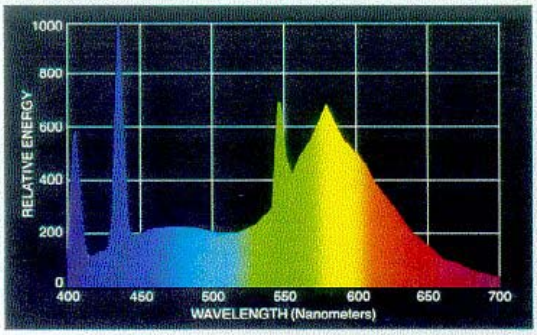
$$STIMULUS = \sum L_\lambda \cdot \rho(\lambda) \cdot V(\lambda) \cdot \Delta\lambda$$

THE MOTHER OF ALL LIGHT SOURCES

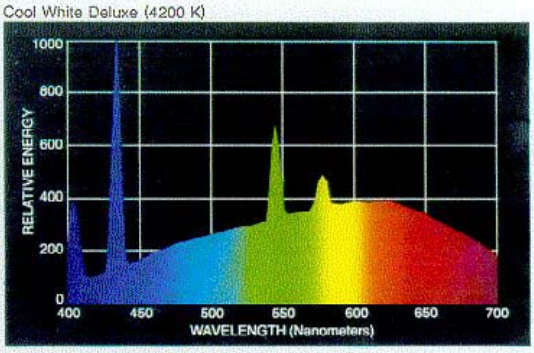


SOURCE SPECTRA

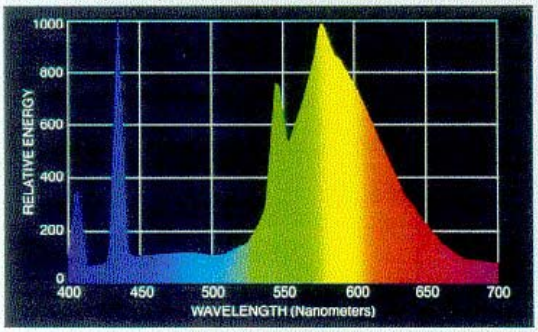
Cool White (4100 K)



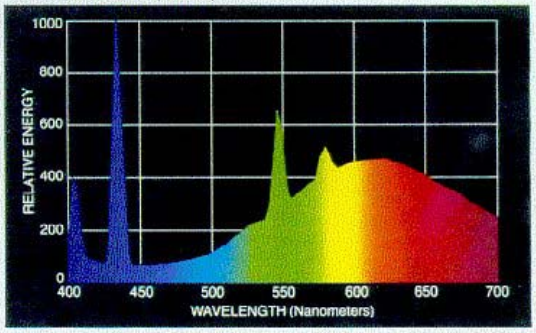
Cool White Deluxe (4200 K)



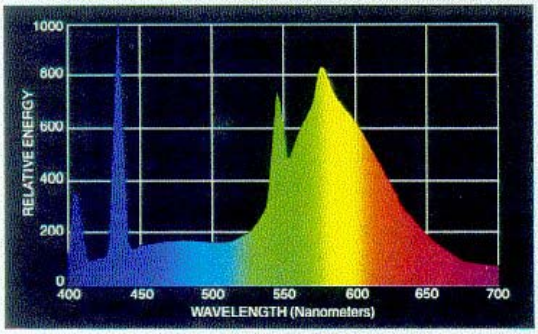
Warm White (3000 K)



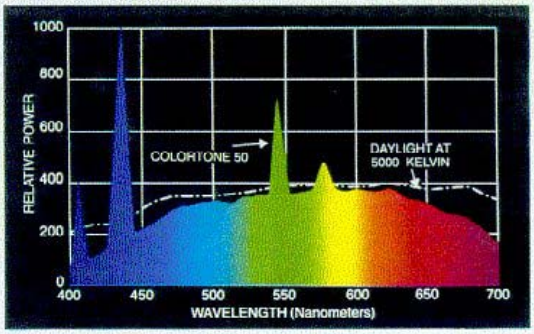
Warm White Deluxe (3000 K)



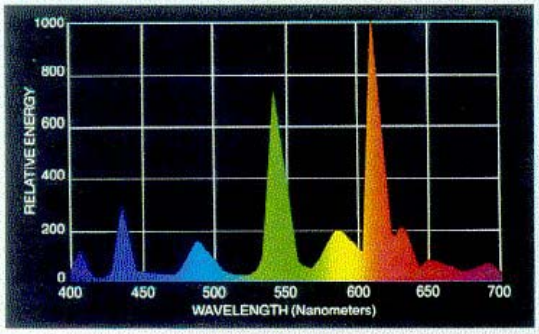
White (3500 K)



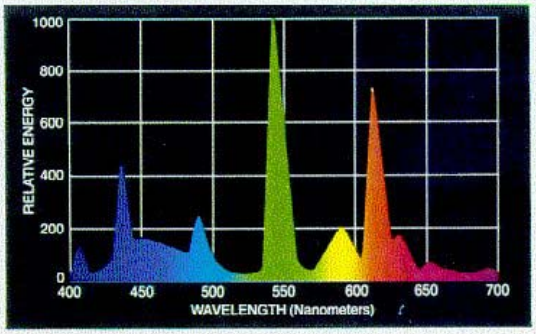
Color-matching (5000 K)



Rare-earth phosphor (3000 K)

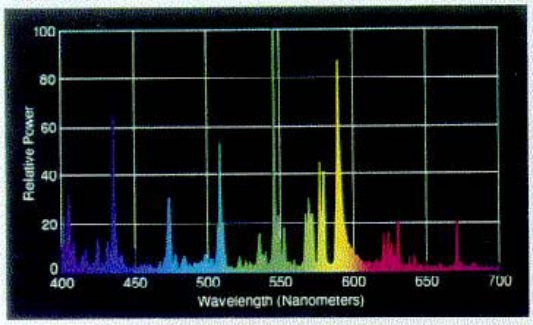


Rare-earth phosphor (5000 K)

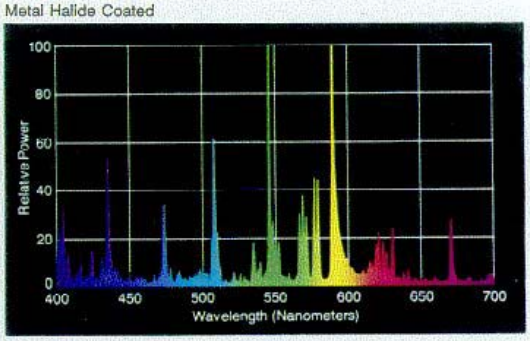


MORE SOURCE SPECTRA

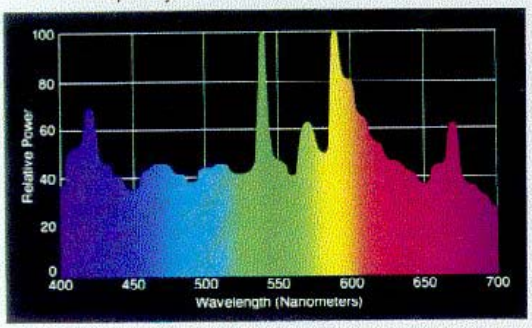
Metal Halide



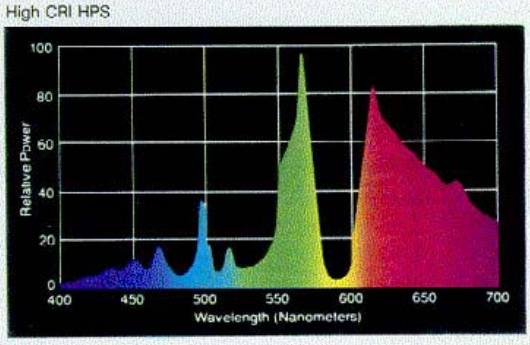
Metal Halide Coated



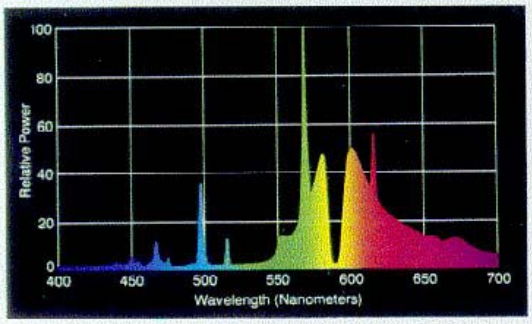
Metal Halide Specialty



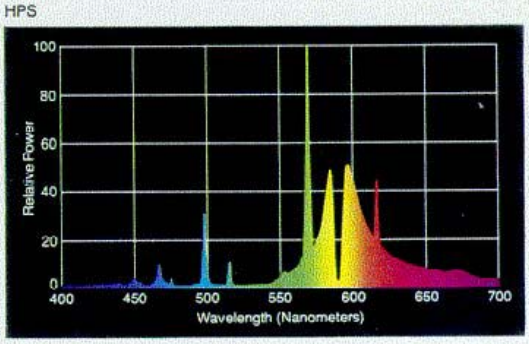
High CRI HPS



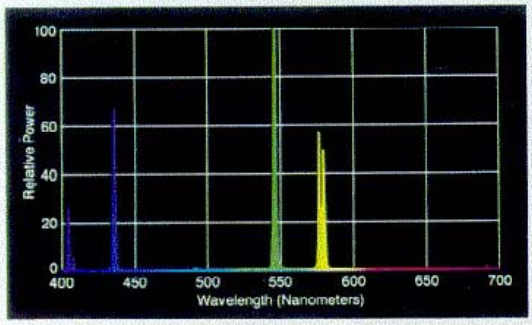
Color-improved HPS



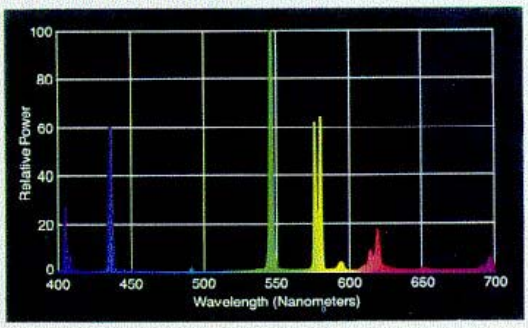
HPS



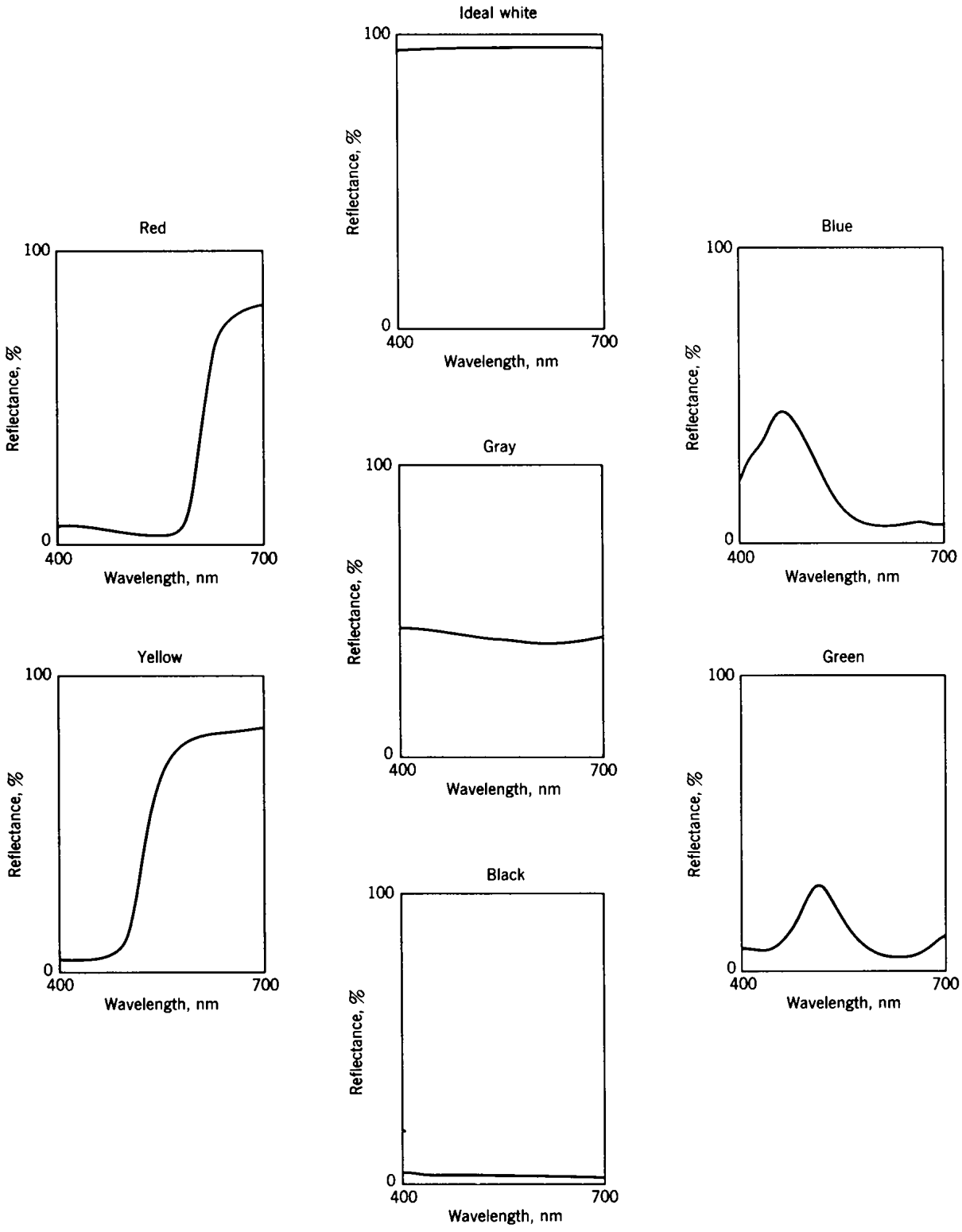
Clear Mercury Vapor



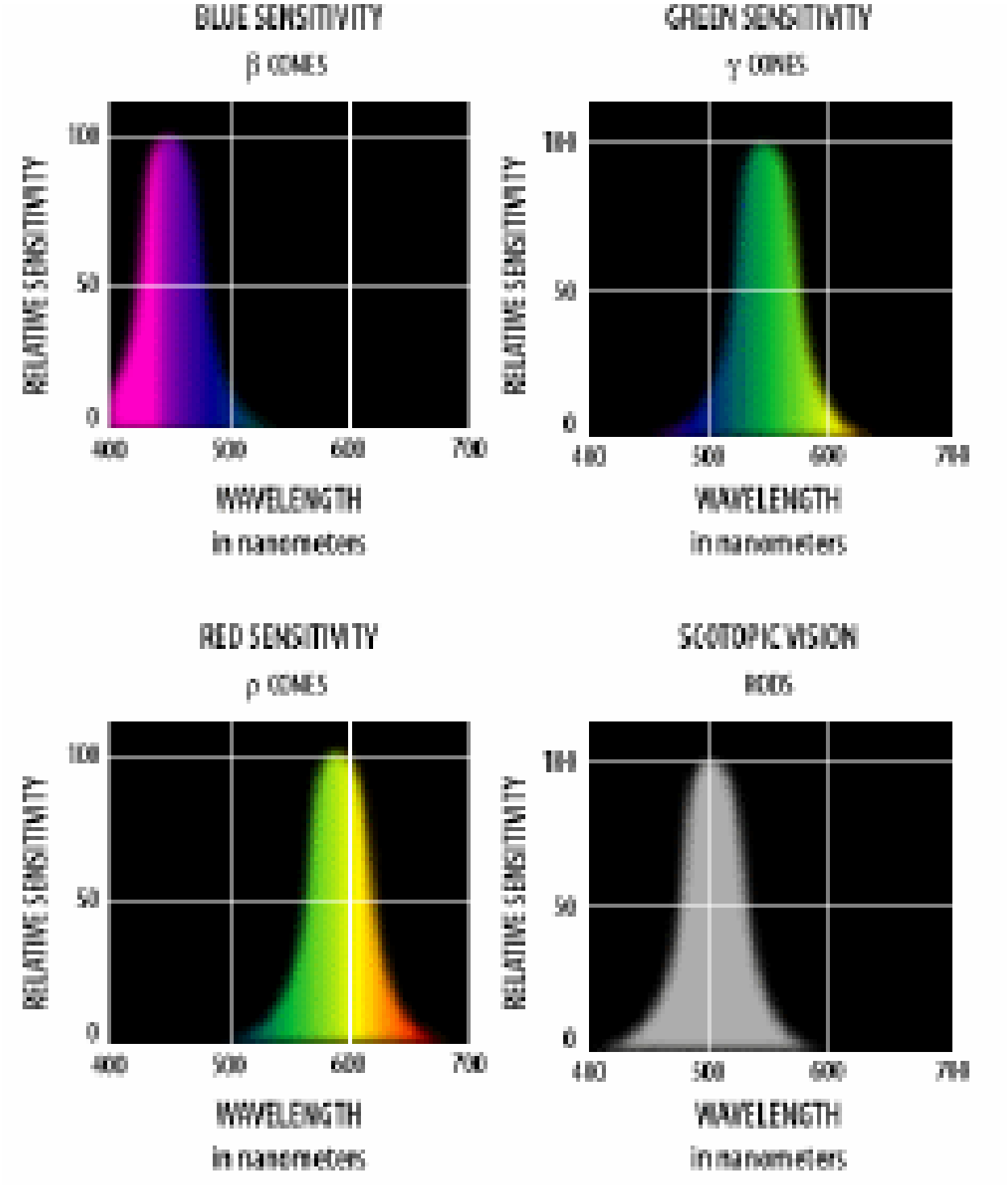
Phosphor-coated Mercury Vapor



COLOR VIA REFLECTANCE

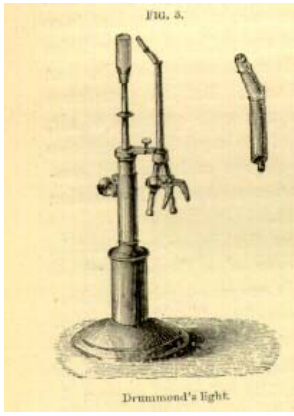


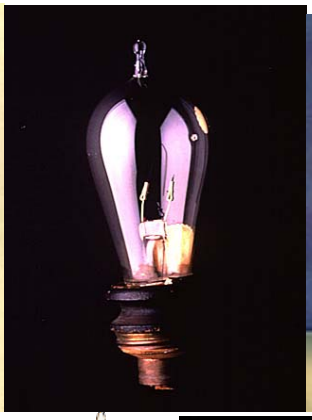
COLOR RECEPTORS IN THE EYE

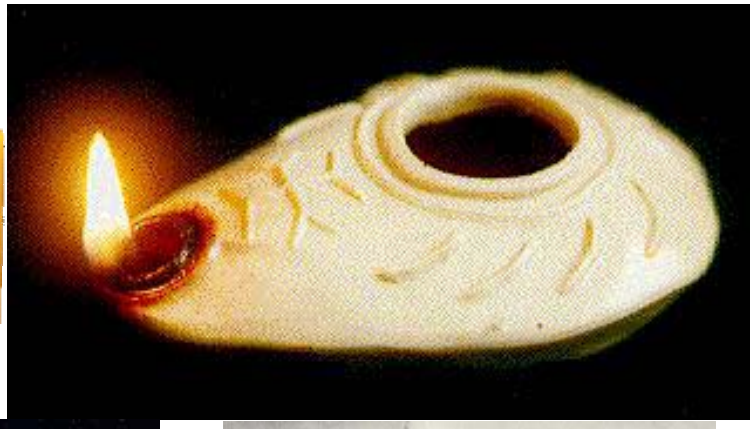


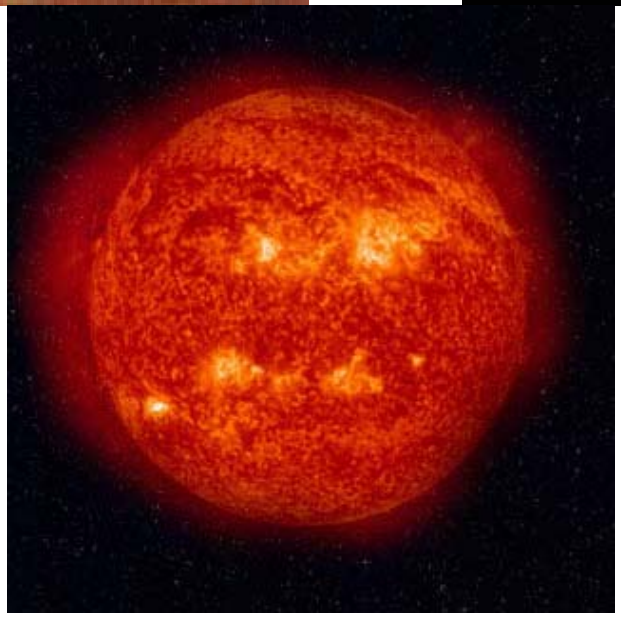
FIFTEEN MECHANISMS FOR COLOR (NASSAU)

1. INCANDESCENCE



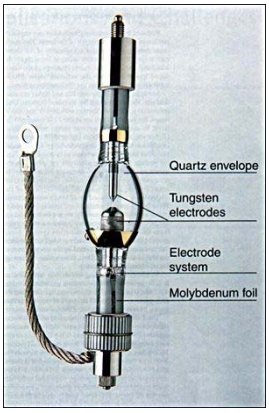






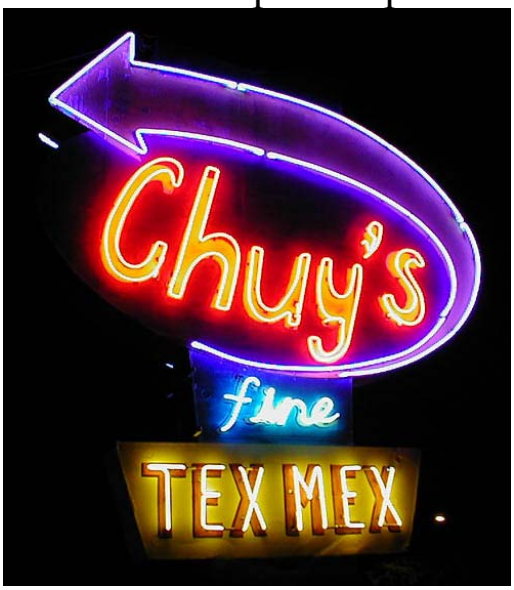
2. GAS EXCITATION

sodium vapor lamp



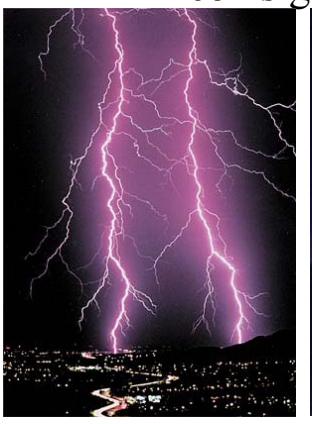
xenon arc

metal halide lamp



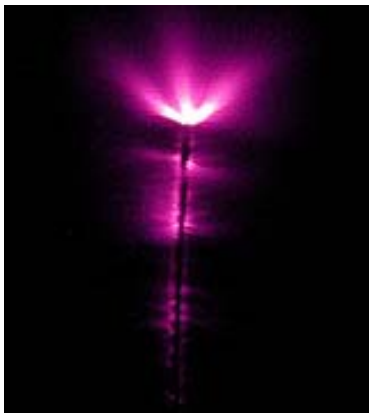
neon sign

neon sign



lightning

aurora



corona discharge

3. VIBRATION & ROTATION

CRATER LAKE

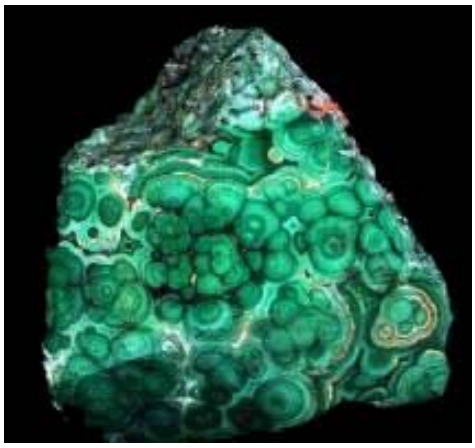
BLUE ICE

BLUE GAS FLAME

Also I, Br and Cl gas

4. TRANSITION METAL COMPOUNDS

turquoise



malachite

copper patina

rhodochrosite

Also fluorescence*, phosphorescence*, lasers*, phosphors*

5. TRANSITION METAL IMPURITIES

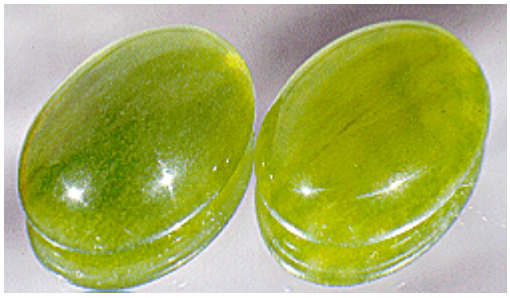
ruby

emerald

alexandrite

aquamarine

red iron ore



jade

Also glasses, dyes*, fluorescence*, phosphorescence*, lasers*

6. **ORGANIC COMPOUNDS** - dyes, biological colorants,

Also fluorescence*, phosphorescence*, lasers*

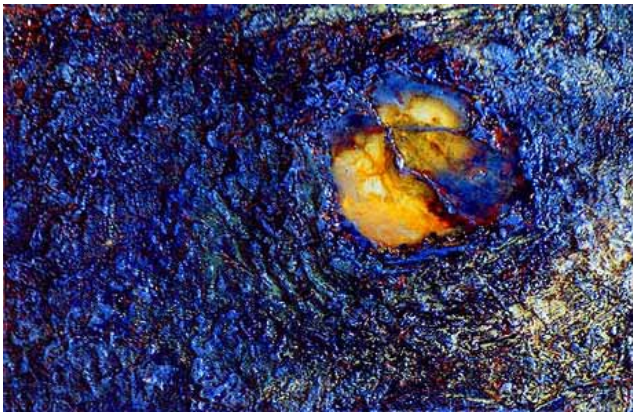
cochineal

7. **CHARGE TRANSFER**

blue sapphire

magnetite

Also lapis lazuli



ultramarine

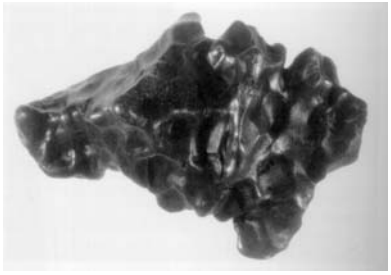
Also chromates

8. METALS

copper

silver

gold



iron

brass

9. PURE SEMICONDUCTORS

silicon

galena

cinnabar

vermilion

cadmium orange and yellow

diamond

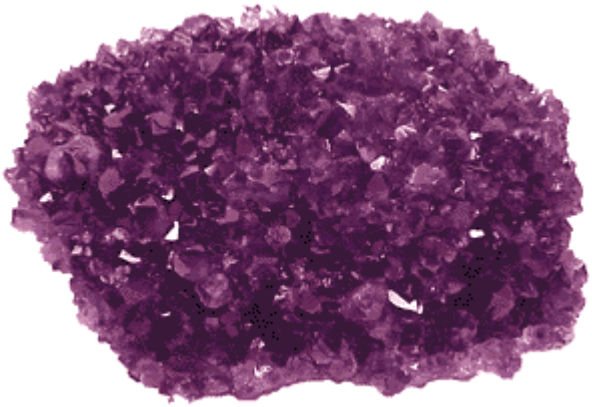
10. DOPED SEMICONDUCTORS

blue diamond

yellow diamond

Also lasers*, phosphors*

11. **COLOR CENTERS** -, *



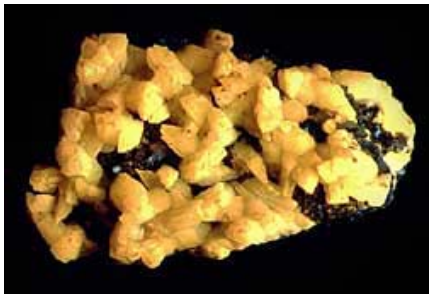
amethyst

smoky quartz

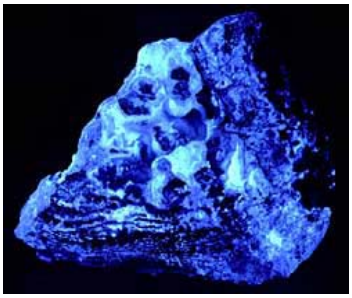
Also fluorescence*, phosphorescence

FLUORESCENCE FROM MINERALS

Substance absorbs optical radiation (typically ultraviolet) and re-emits at longer wavelength



CALCITE



HYDROZINCITE

ARAGONITE

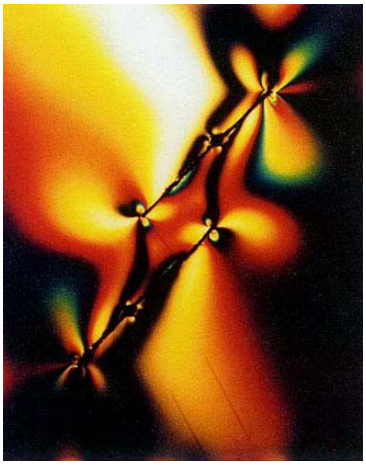
FLUORITE

CALCITE

ARAGONITE

12. DISPERSIVE REFRACTION, POLARIZATION, ETC

halos and sun dogs



photoelastic stress analysis

fire” in gemstones

13. SCATTERING

blue sky

blue moon

butterflies

red sunset

blue eyes

moonstone

14. INTERFERENCE WITHOUT DIFFRACTION

oil slick on water

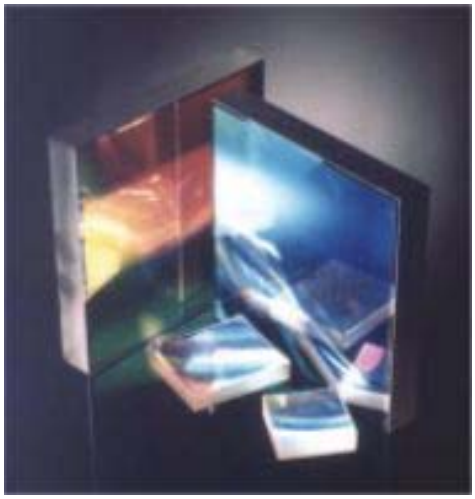
soap bubbles

coatings on camera lenses

15. DIFFRACTION

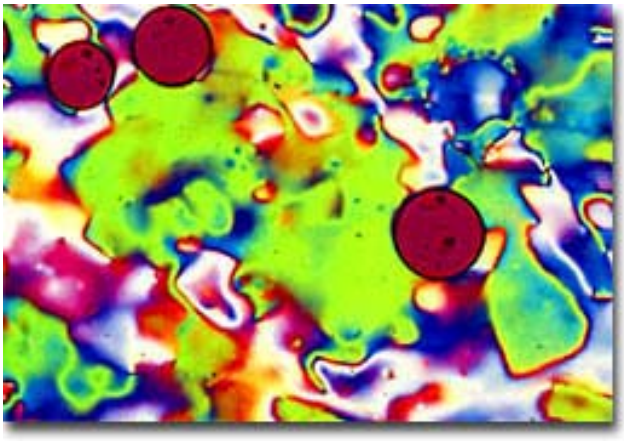
aureole

glory



diffraction grating spectrum

opal



liquid crystals

CD

WHAT IS COLOR?

CIE definition 845-02-18: *(perceived) color*

Attribute of a visual perception consisting of any combination of chromatic and achromatic content. This attribute can be described by chromatic color names such as yellow, orange, brown, red, pink, green, blue, purple, etc., or by achromatic color names such as white, gray, black, etc., and qualified by bright, dim, light, dark etc., or by combinations of such names.

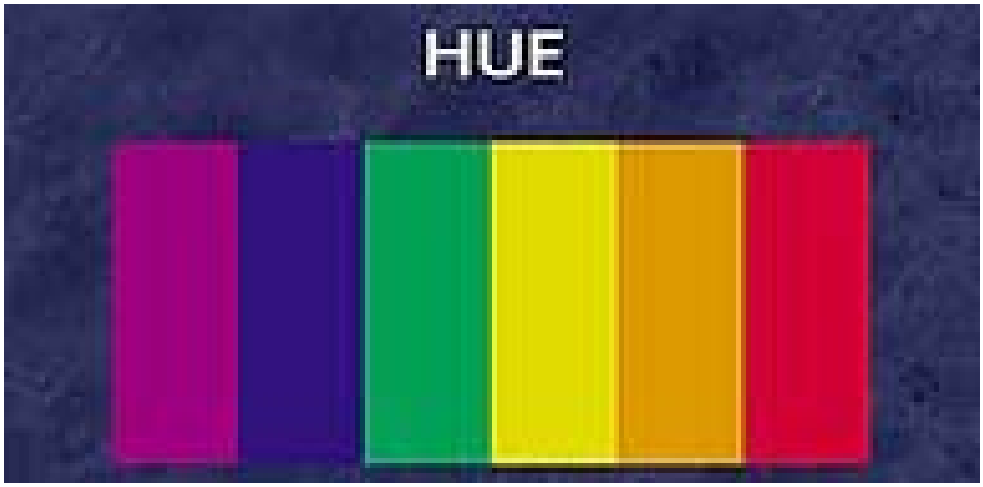
OBJECT: aspect of appearance distinct from form, shape, size, position, or gloss that depends upon the spectral composition of the incident light, the spectral reflectance of transmittance of the object, and the spectral response of the observer, as well as the illuminating and viewing geometry.

PERCEIVED: attribute of visual perception that can be described by color names such as white, gray, black, yellow, brown, vivid red, deep reddish purple, or by combinations of such names.

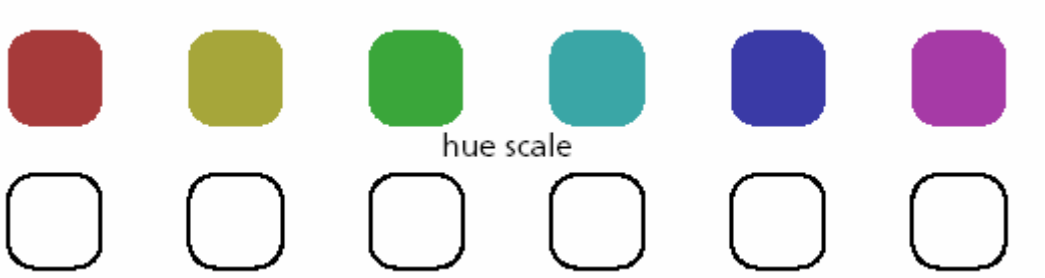
PSYCHOPHYSICAL: characteristics of a color stimulus denoted by a colorimetric specification.

ALTERNATE DEFINITION: That aspect of visible radiant energy by which an observer may distinguish differences between two structure-free fields of view of the same size and shape, caused by differences in spectral composition.

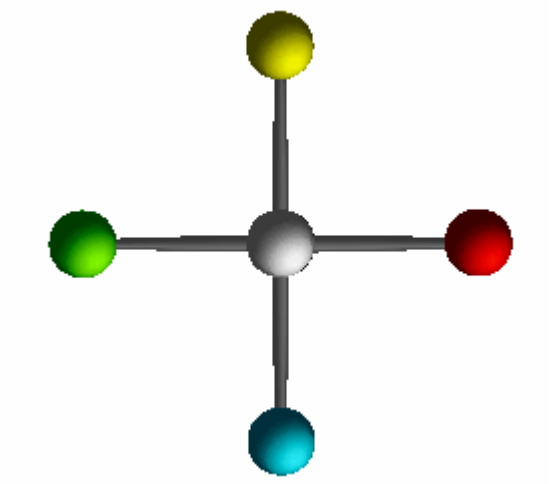
THREE PRIMARY ATTRIBUTES - HUE



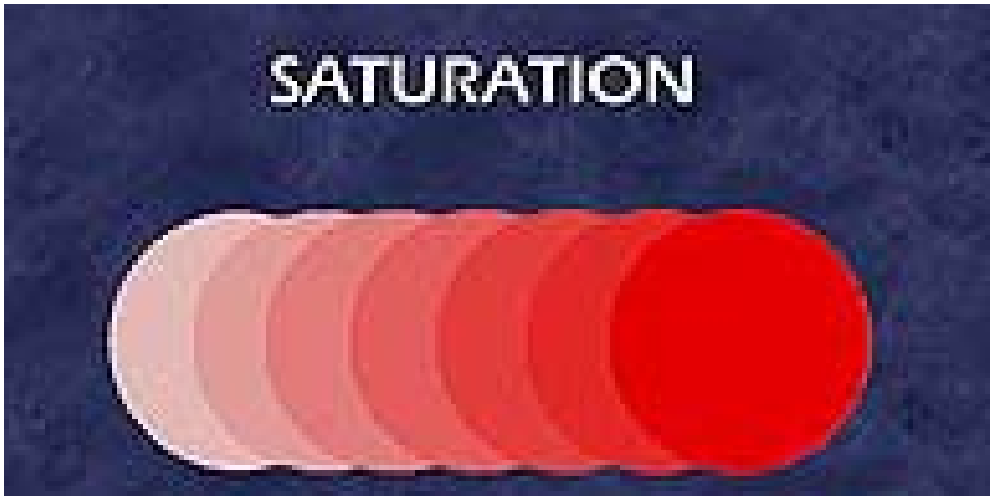
The attribute of color by means of which a color is perceived to be red, yellow, green, blue, purple, etc. Pure white, black, and grays possess no hue.



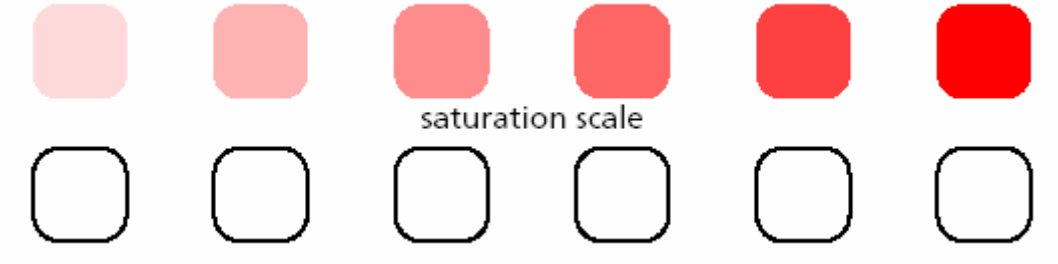
Unique hue: One that cannot be further described by use of the hue names other than its own. There are four unique hues, each of which shows no perceptual similarity to any of the others: *red, green, yellow,* and *blue*



THREE PRIMARY ATTRIBUTES - SATURATION

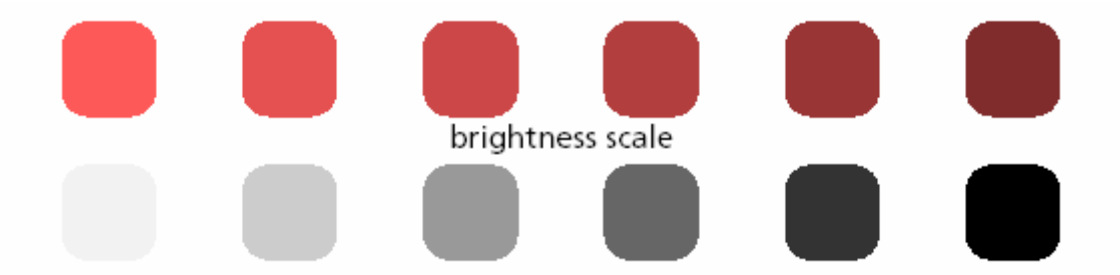


Saturation: the attribute of color perception that expresses the degree of departure from the gray of the same lightness. All grays have zero saturation. Commonly used as a synonym for **chroma** especially in graphic arts.



THREE PRIMARY ATTRIBUTES - LIGHTNESS

Lightness: (1) the attribute of color perception by which a non-self-luminous body is judged to reflect more or less light. (2) the attribute by which a perceived color is judged to be equivalent to one of a series of grays ranging from black to white. Alternatu term is **value**.



BRIGHTNESS

Similar to lightness.

Alternate term is value, as in HSV.

Brightness: (1) aspect of visual perception whereby an area appears to emit more or less light;

(2) of an object color, combination of lightness and saturation;

(3) in the textile industry, perceived as saturated, vivid, deep, or clean. (color);

(4) of paper, reflectance of an infinitely thick specimen (reflectivity) measured for blue light with a centroid wavelength of 457 nm under specified spectral and geometric conditions of measurement.

(5) the color quality, combining lightness and saturation that would be decreased by adding black, gray, or a complementary color to a chromatic dye.

Objective term: luminance (L)

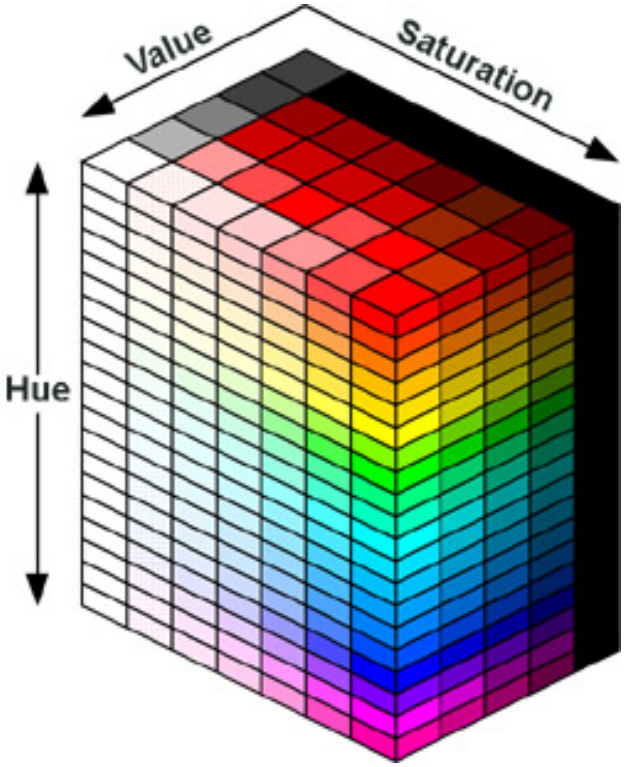
THE THREE ATTRIBUTES COMBINED

The three attributes can be simultaneously represented in three orthogonal dimensions by an HSV cube.

HUE - attribute denoted by blue, green, red, etc.

SATURATION (chroma) - degree of difference from achromatic

VALUE (lightness) - comparison with achromatic gray scale



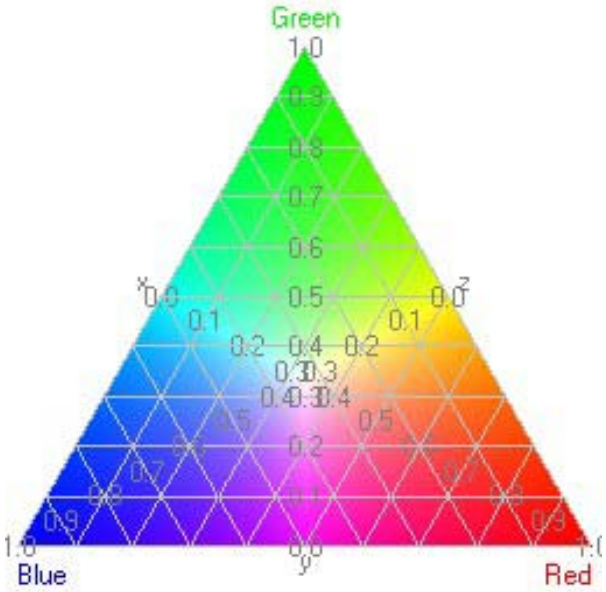
OTHER DESCRIPTORS

DOMINANT WAVELENGTH - wavelength of monochromatic spectrum color that when added to an achromatic (white or gray), yields a color match.

COMPLEMENTARY WAVELENGTH - wavelength of monochromatic spectrum color that when added color under consideration, yields achromatic.

PURITY - Fraction of monochromatic color added to gray to yield a match (related to saturation).

Can obtain almost any color between red and blue by mixing a dominant wavelength with white. The other colors (magentas) obtained by using complementary wavelength.



OTHER DEFINITIONS

achromatic: (1) for primary light sources, the computed chromaticity of the equal-energy spectrum. (2) for surface colors, the color of a whitish light, serving as the illuminant, to which adaptation has taken place in the visual system of the observer. (3) perceived as having no hue, that is, as white, gray, or black. SYN. neutral

black: ideally, the complete absorption of incident light; the absence of any reflection. In the practical sense, any color that is close to this ideal in a relative viewing situation, i.e., a color of very low saturation and of low luminance.

chromatic : perceived as having a hue; not white, gray, or black. (opposite of achromatic)

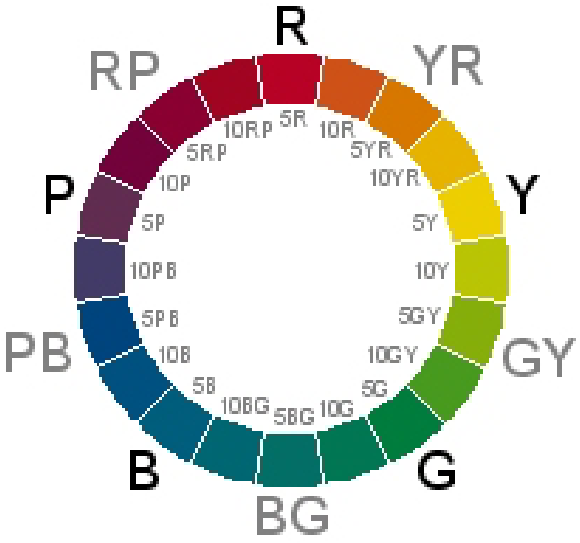
contrast : objective, the degree of dissimilarity of a measured quantity such as luminance of two areas, expressed as a number computed by a specified formula.

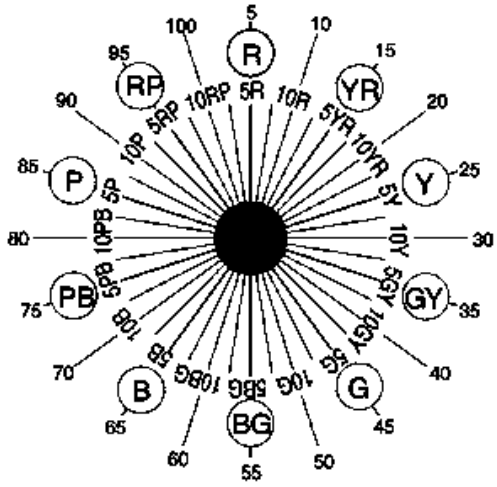
shade: (1) a color produced by a dye or pigment mixture including black dye or pigment. (2) an expression of color difference from a reference dyeing such that another dye must be added to produce a match. (3) a color slightly different from a reference color.

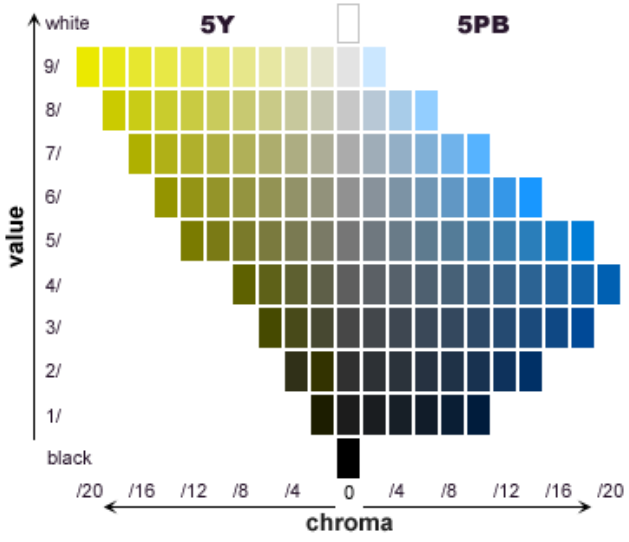
tint : the color produced by the mixture of white pigment with absorbing (generally chromatic) colorants. The color of the resulting mixture is lighter and less saturated than the color without the addition of the white.

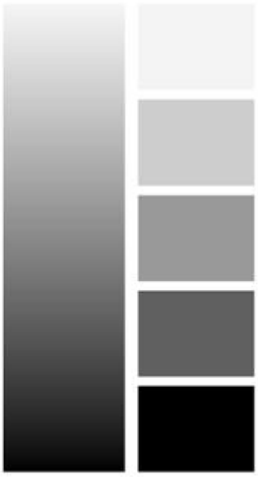
MUNSELL COLOR SYSTEM

Early system based on hue, saturation and value. Still in common use.

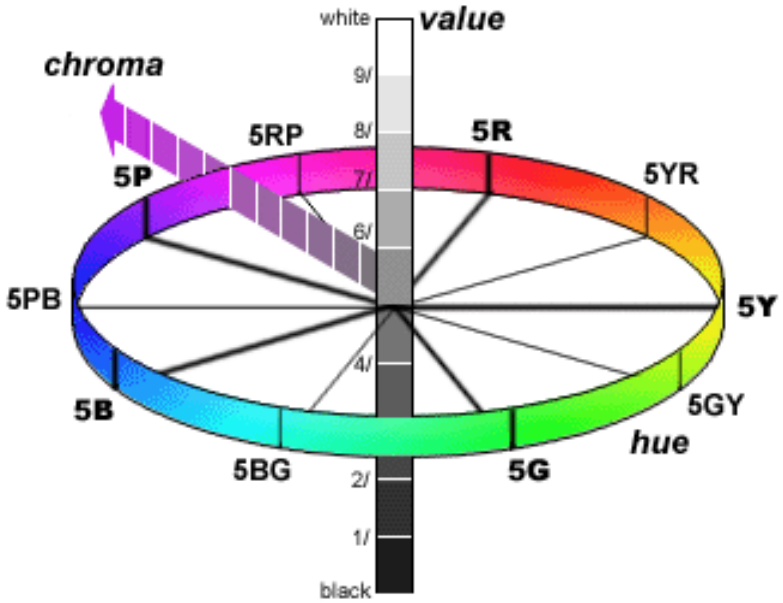


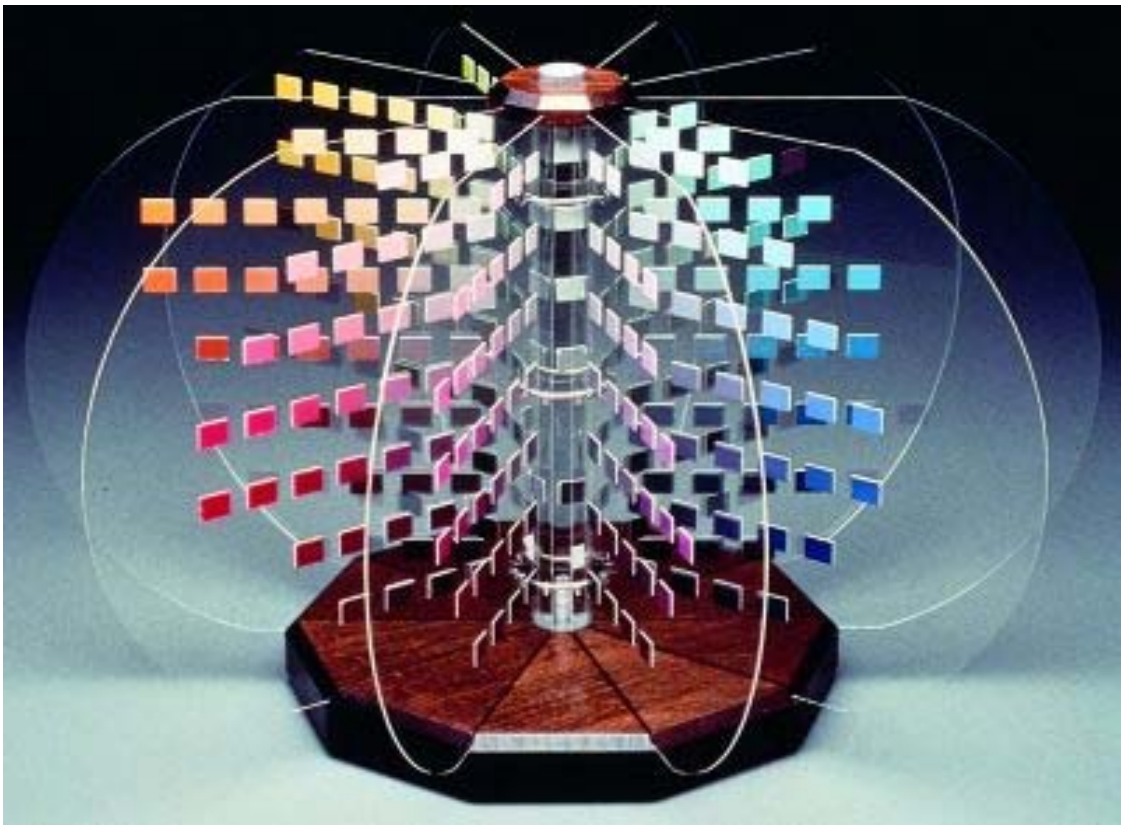






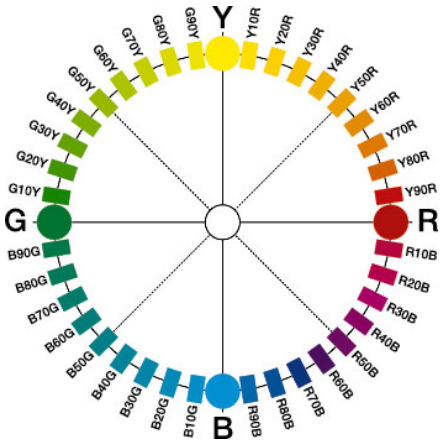
MUNSELL COLOR TREE

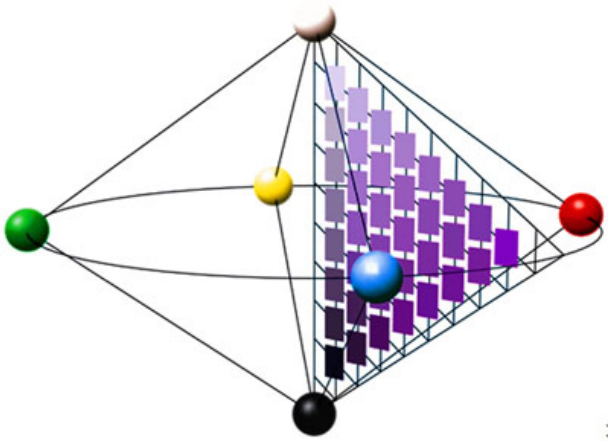


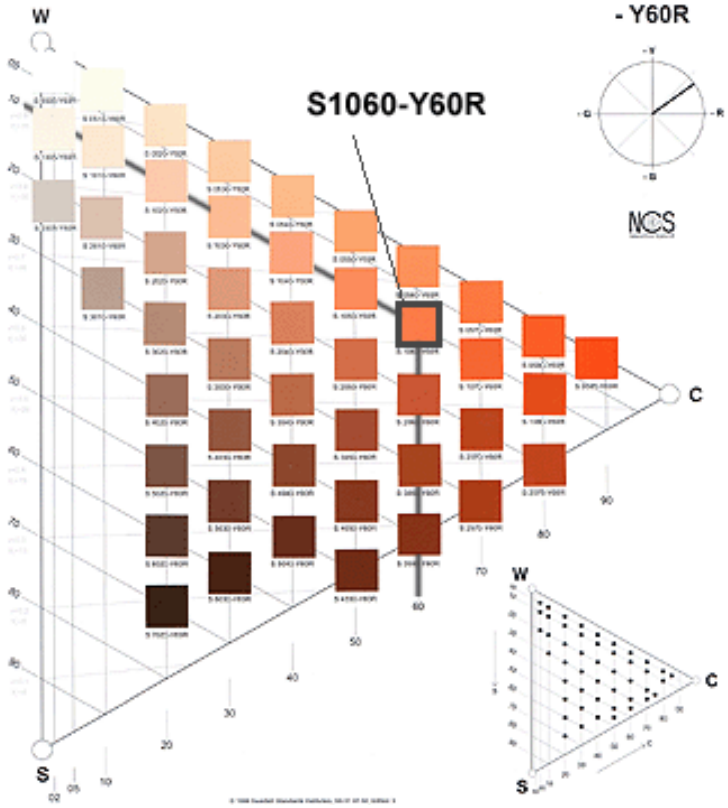


NATURAL COLOR SYSTEM

International standard initiated in Sweden. Has 1750 distinct colors. Based on opponent (complementary) colors.

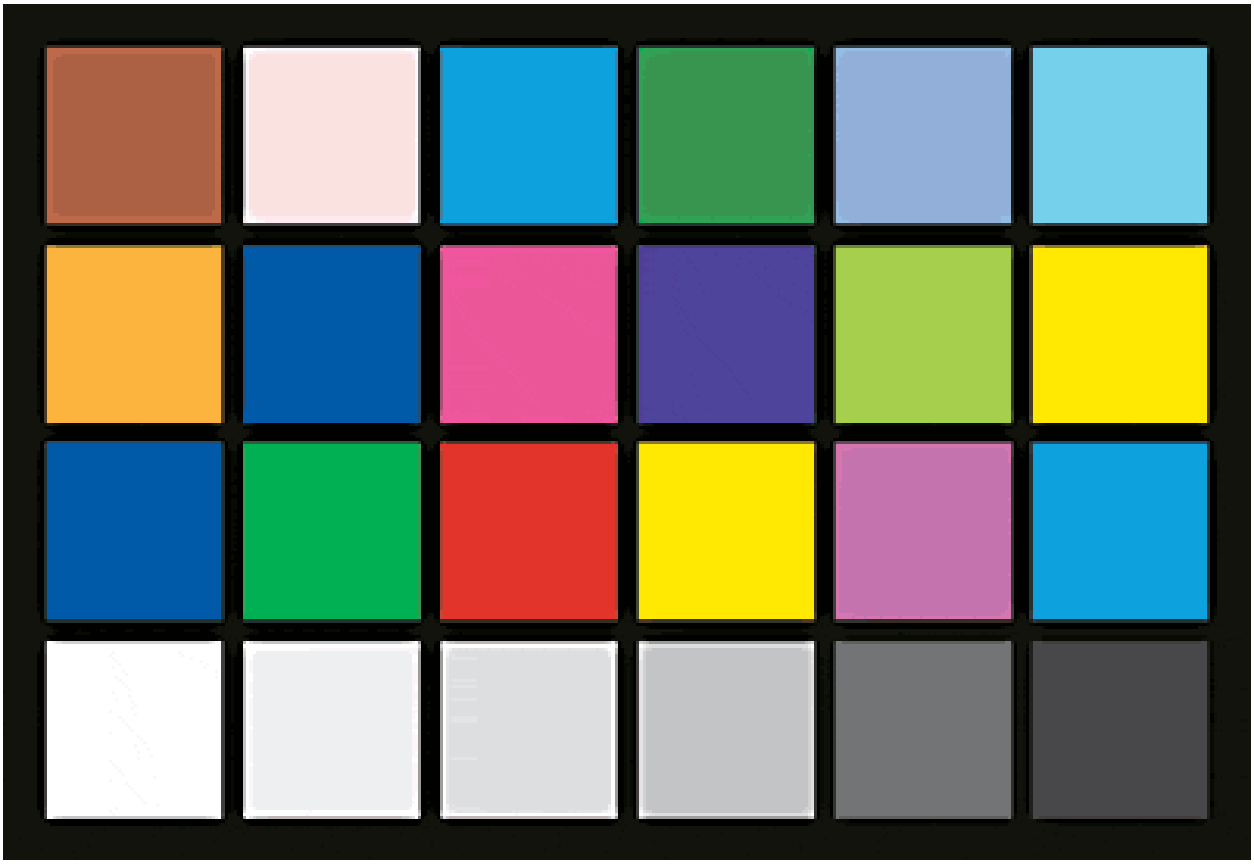






MACBETH COLOR CHECKER

Used for color photography (place it in the scene and crop it out later), monitor adjustment, and general-purpose color control.

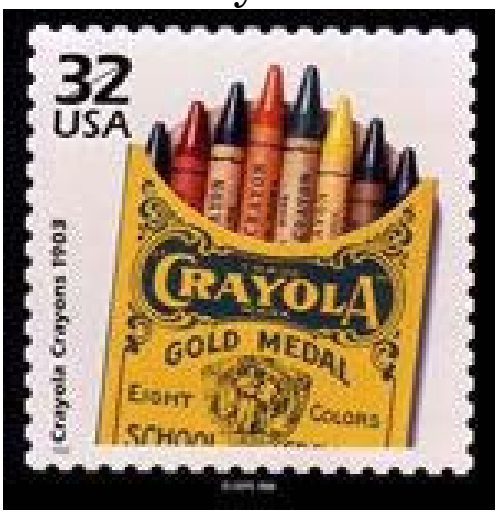


WHAT ARE THE PRIMARY COLORS?

Your second grade teacher told you they were:

RED YELLOW BLUE.

Crayolas

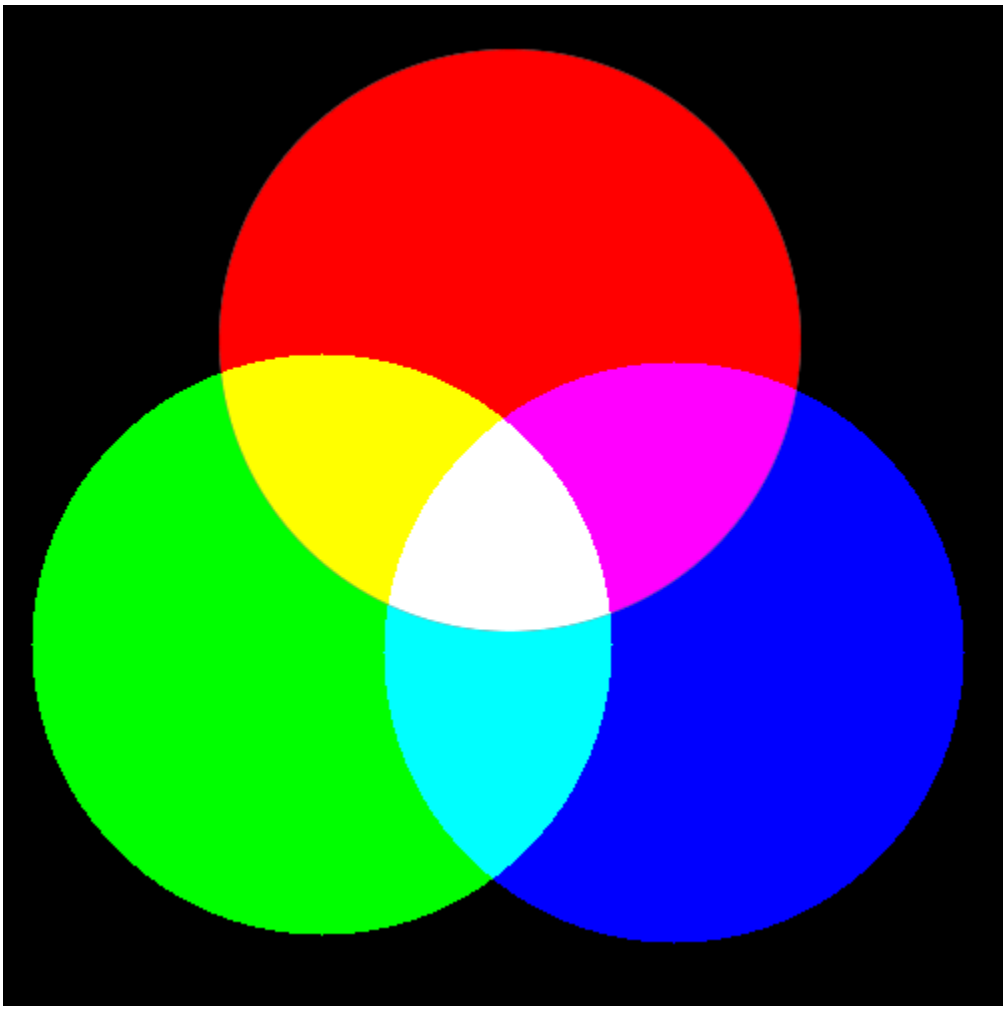


Finger Paints

RGB COLOR MIXING

Your second grade teacher had it wrong. It's RGB.

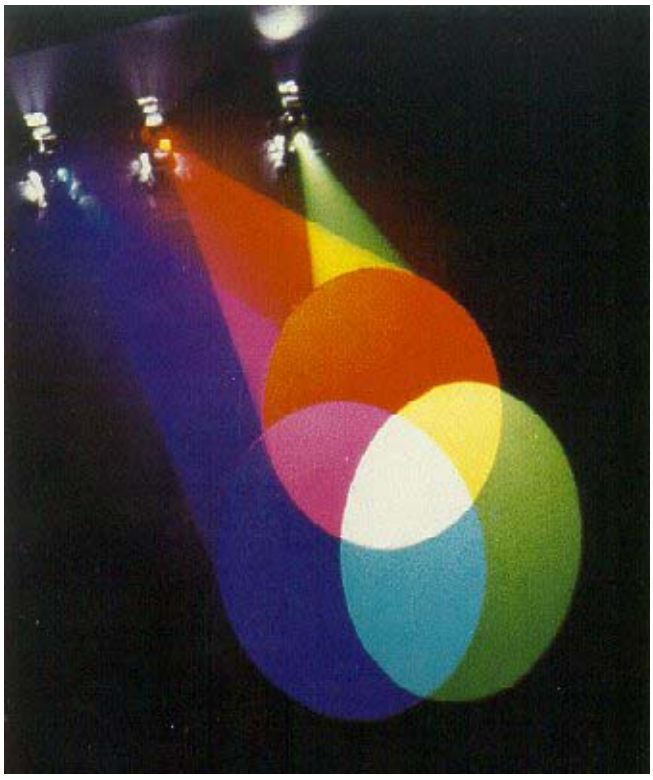
RED GREEN BLUE.



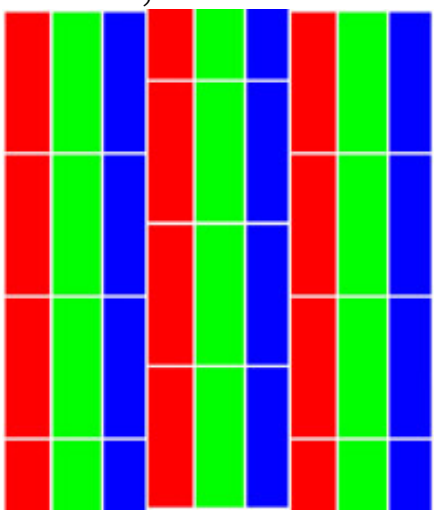
These are the "additive" colors, produced by adding light from different sources. This is the way your computer and television work.

ADDITIVE COLOR MIXING

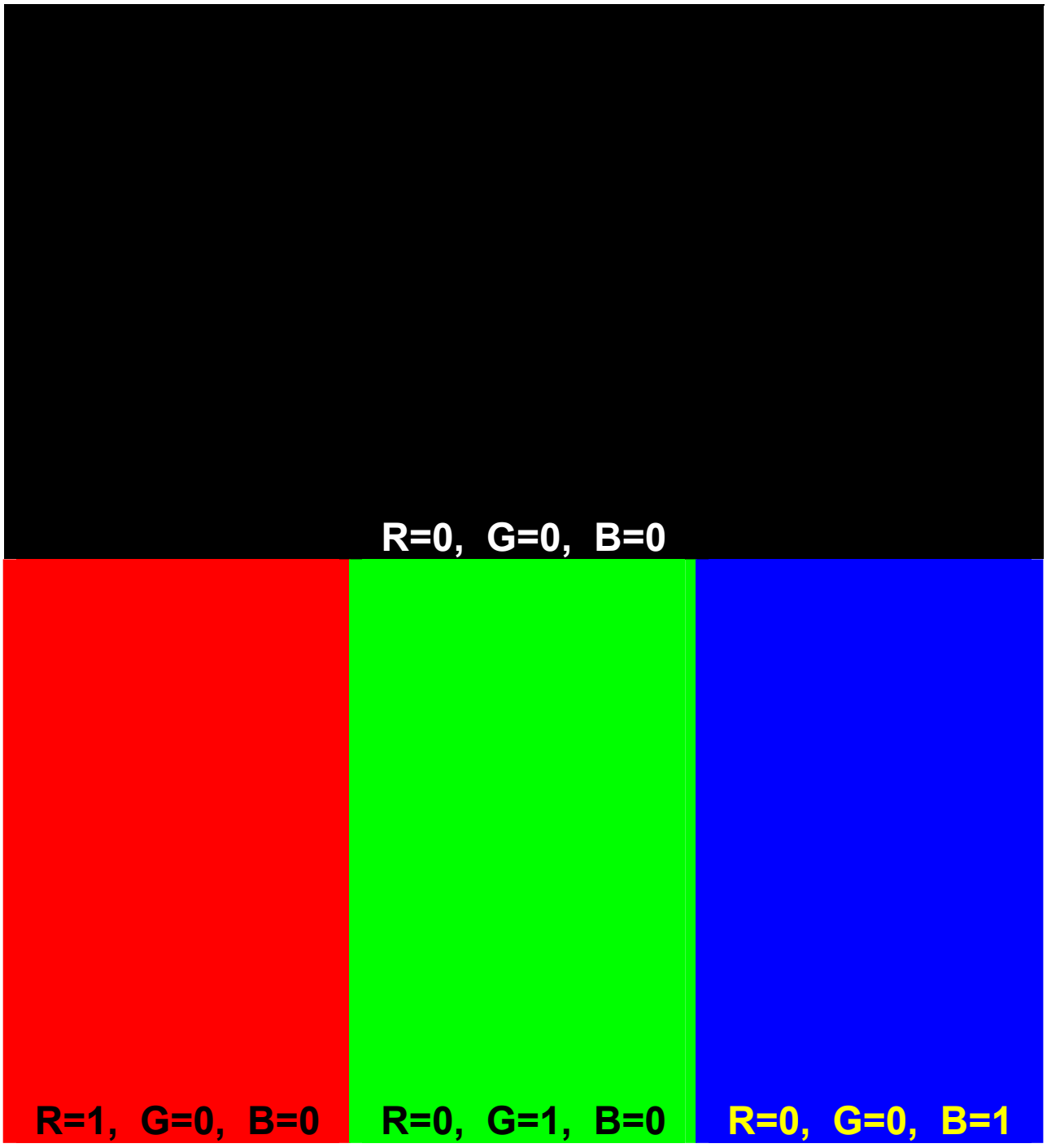
Colored lights



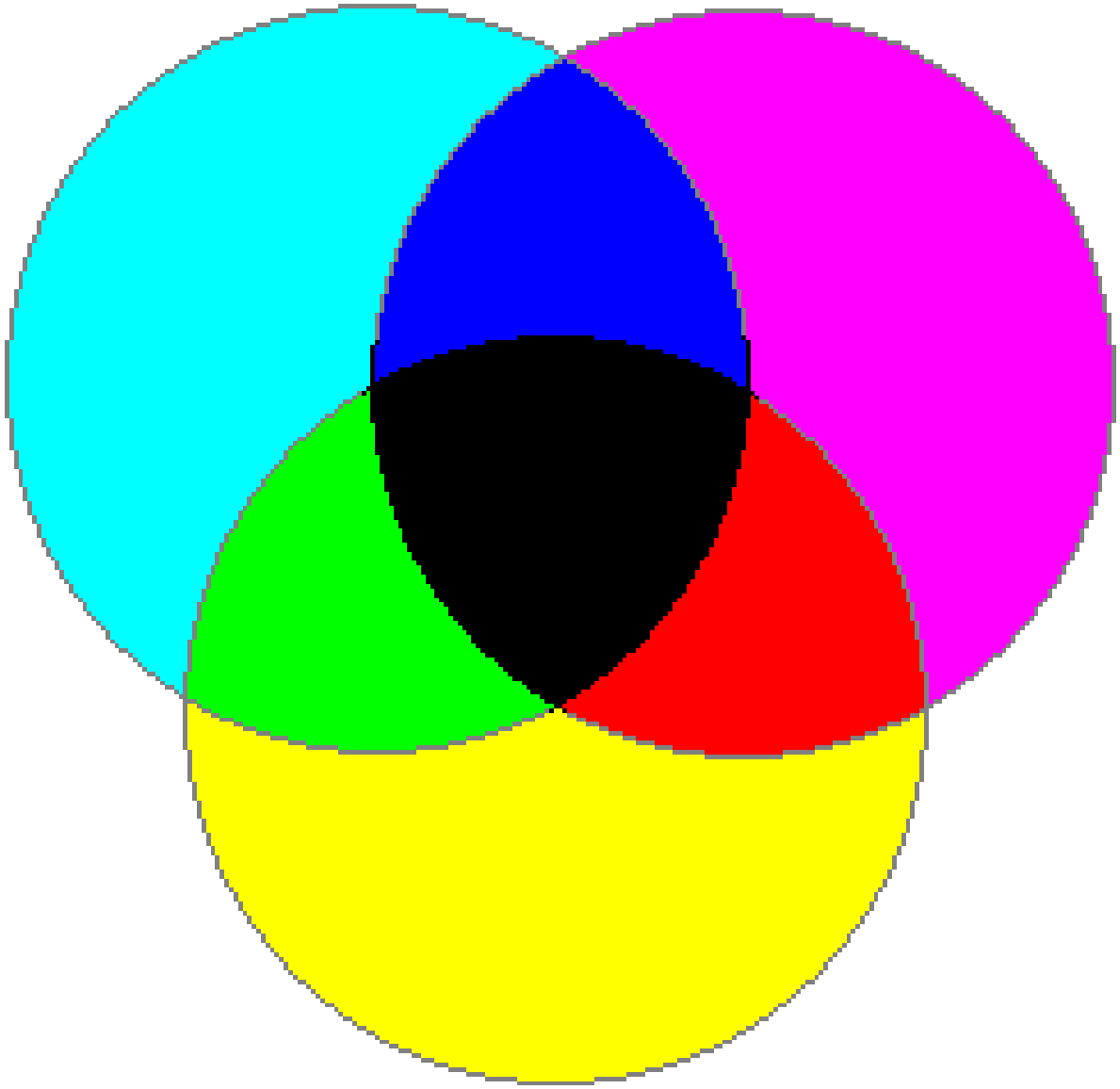
Used in stage and general lighting, television, computer monitors & screens (use a magnifier to see individual pixels). Start with black, add all three to create white.



BLACK and COLORS (RGB)



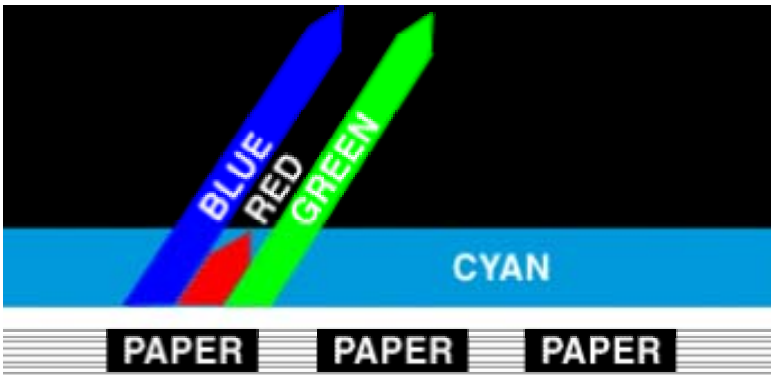
SUBTRACTIVE COLOR MIXING

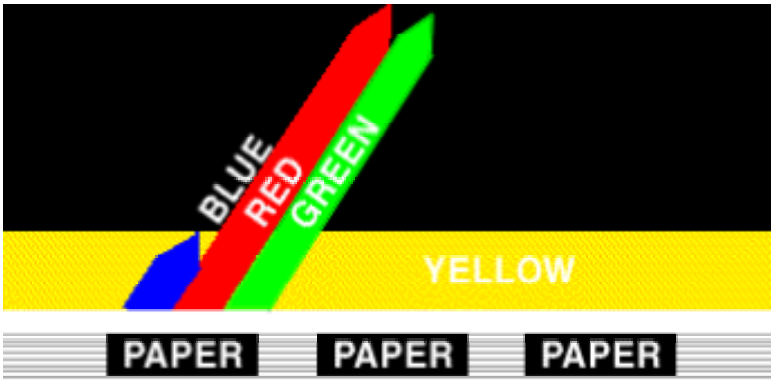


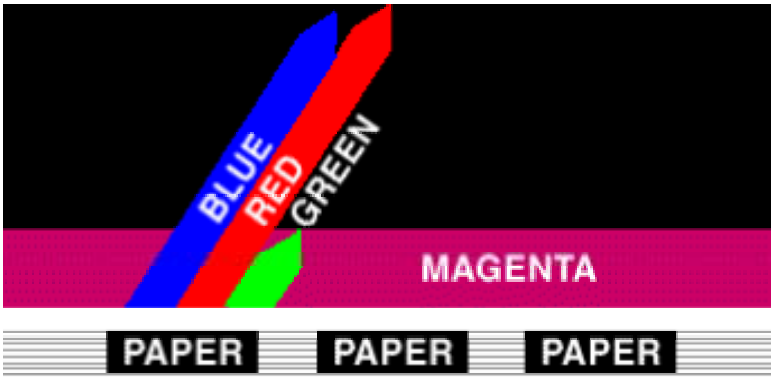
Primary colors are cyan, yellow and magenta. Start with white; remove colors. Used in photography, textiles, printing, dyes, paints and crayons. Subtraction of all three from white yields black.

WHITE and COLORS (CYM)

COLORANTS ON PAPER



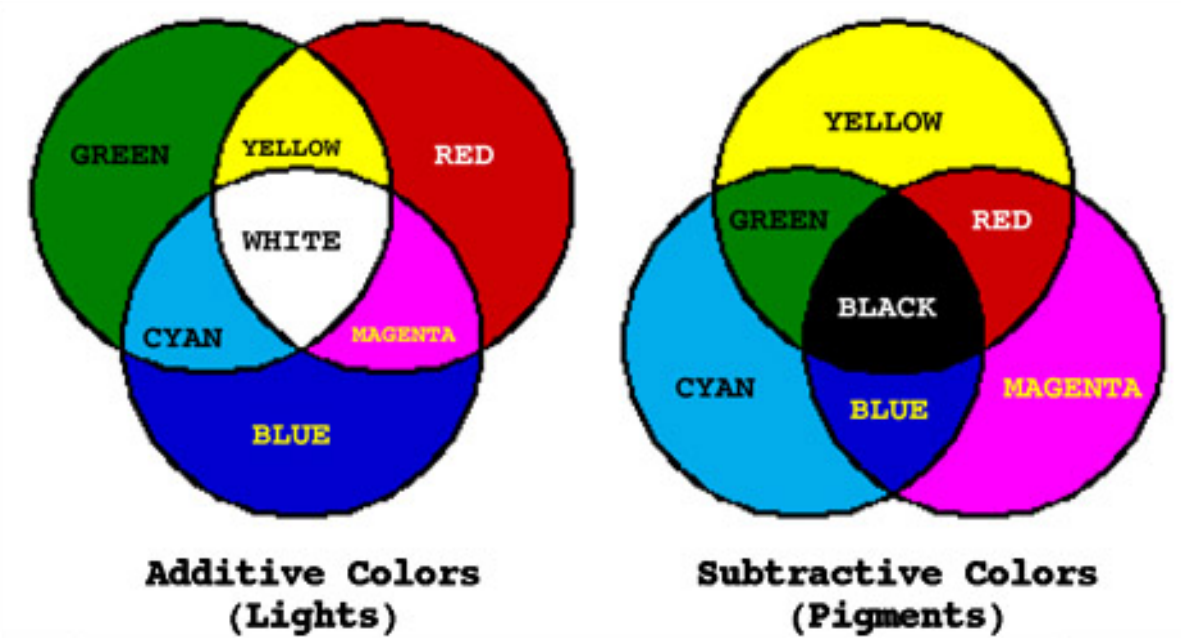




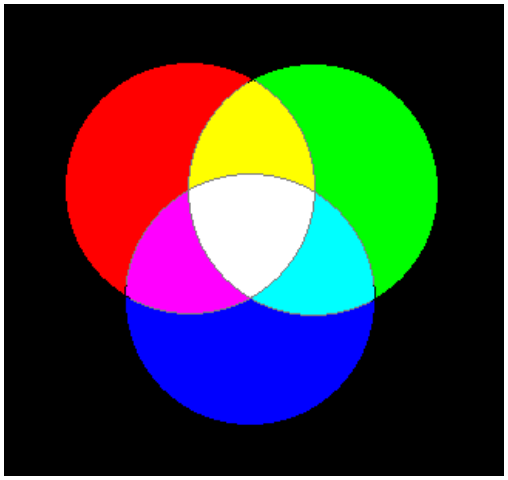
So your teacher was sorta correct, she just didn't know the right names for the subtractive primaries.

COMPLEMENTARY COLORS

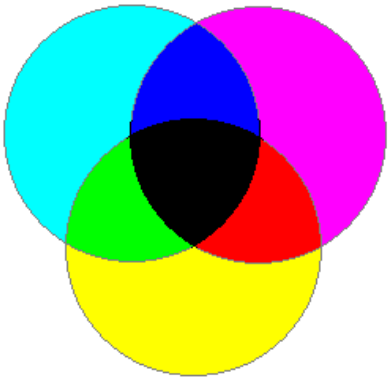
Notice that these choices for additive and subtractive primaries are complementary



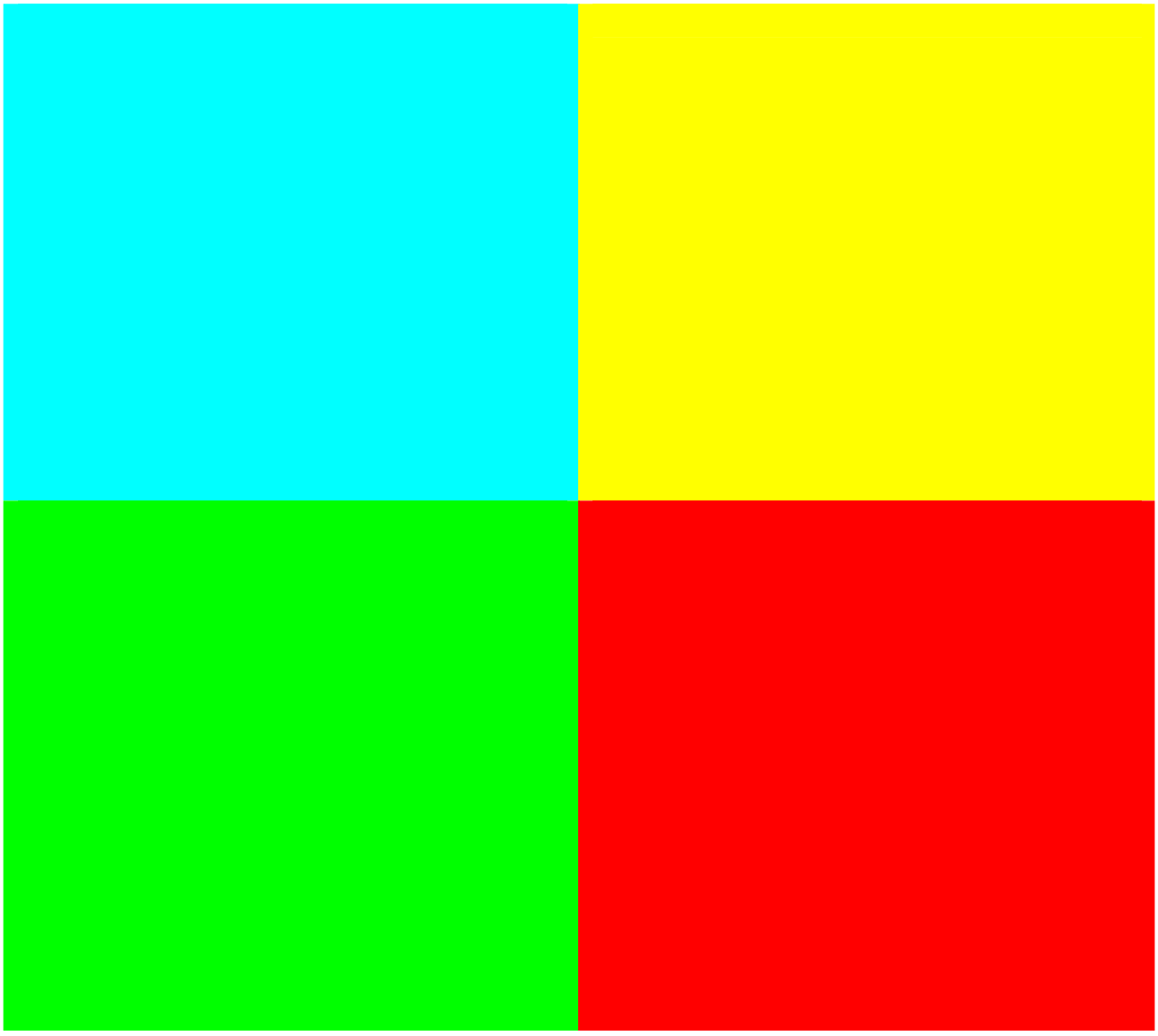
ADDITIVE



SUBTRACTIVE

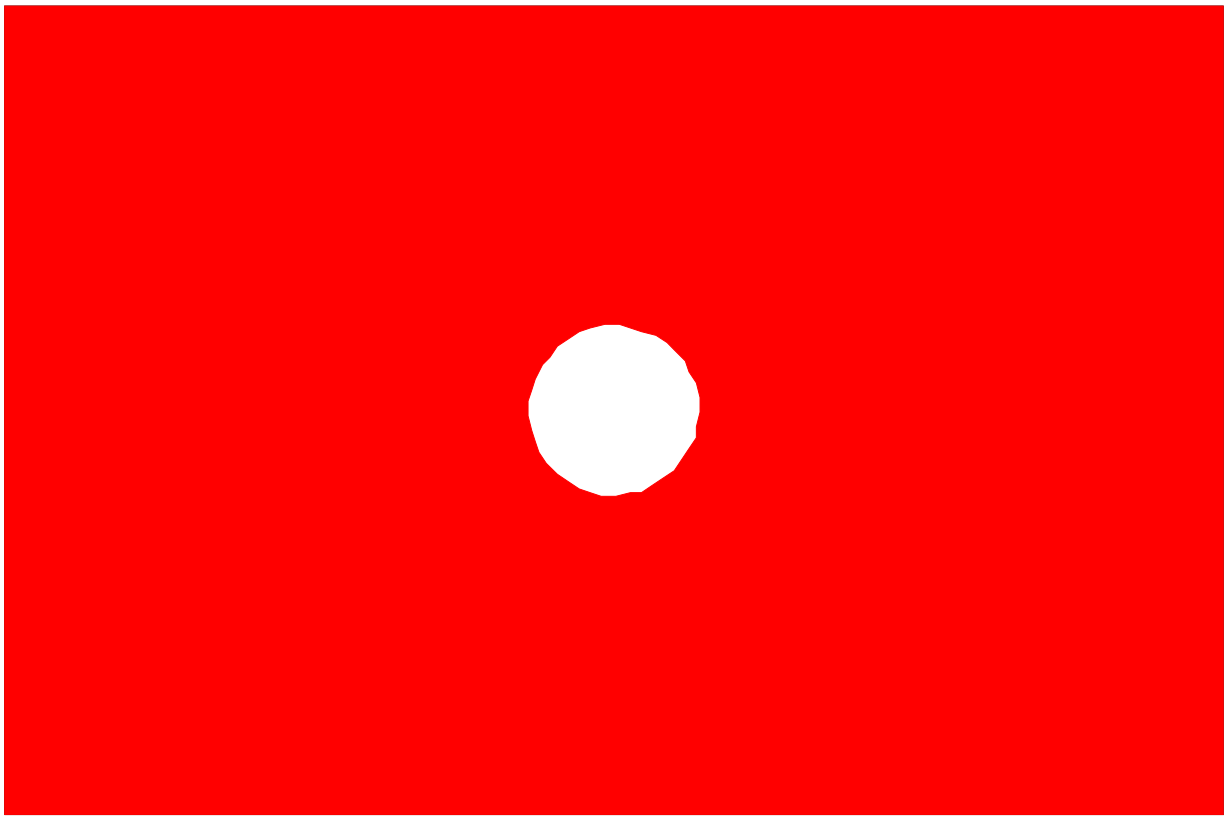


STARE AT THE CENTER OF THIS PATTERN FOR 20-30 SECONDS



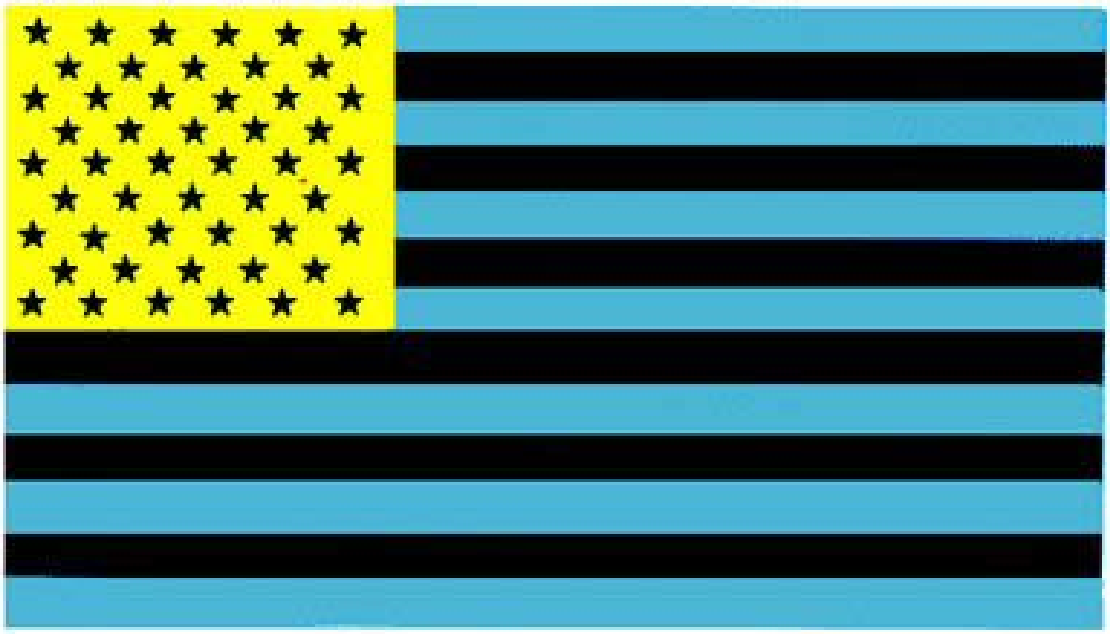
WHAT DO YOU SEE HERE?

STARE AT THE CENTER OF THIS PICTURE



NOW WHAT DO YOU SEE?

A FINAL EXAMPLE



WHAT DO YOU SEE NOW?