Ch.6: Color and Color Vision.
Ch.7: Additive Color Mixing

1. Physical Color.

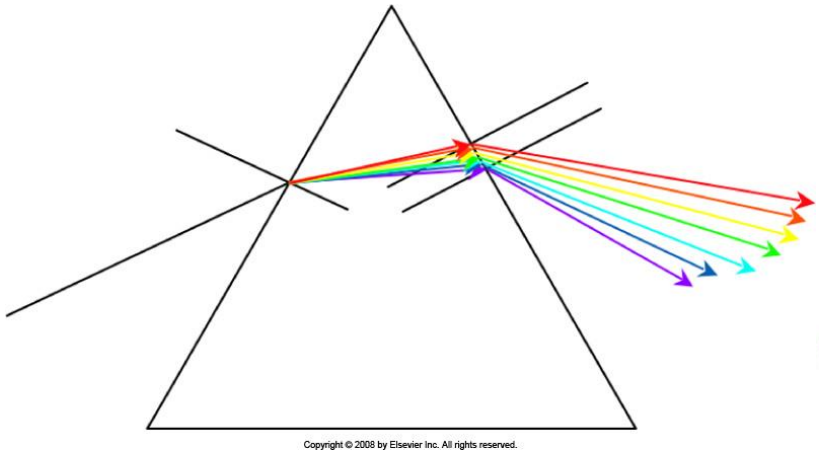
2. Color Perception – psychophysical parameters.

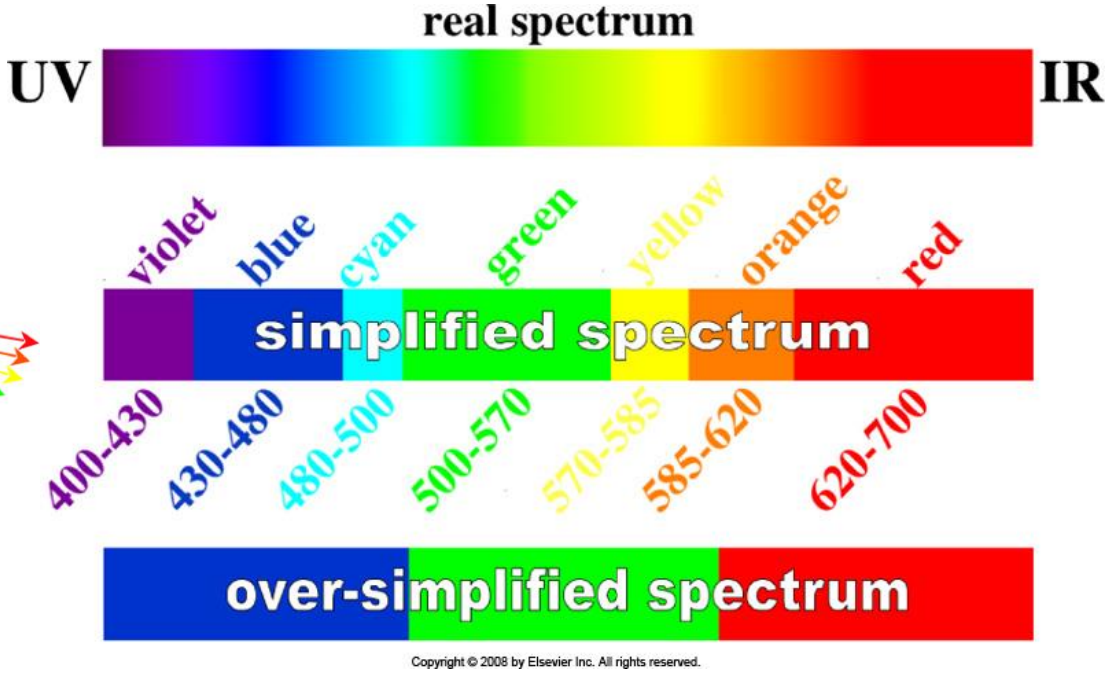
3. Color due to Scattering.

4. Primary Colors. Additive Color Mixing.

5. Examples of Additive Color Mixing in Paintings.

1. Physical (Spectral) Color.





Figs.6-1, 6-2

It is monochromatic – corresponds to one wavelength (or frequency).

Q: Are there any colors that are missing from the physical spectrum?

The emitted light spectrum can be continuous or discrete:

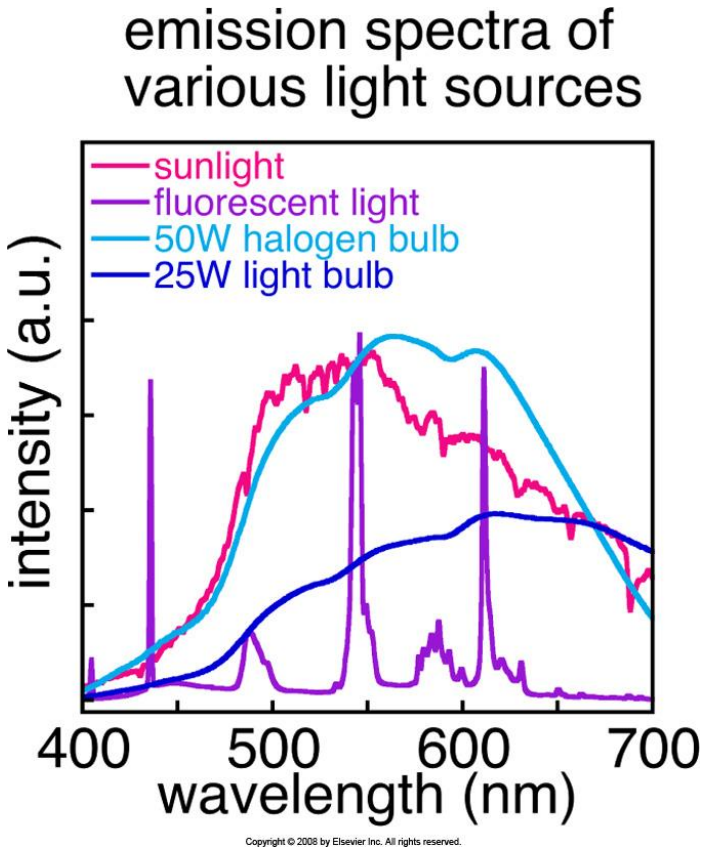


Fig.6-3

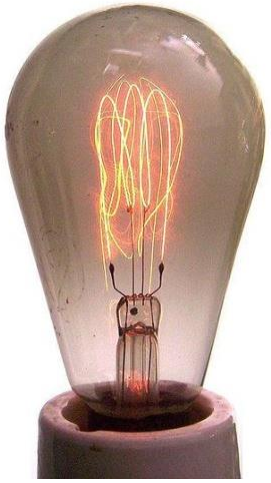
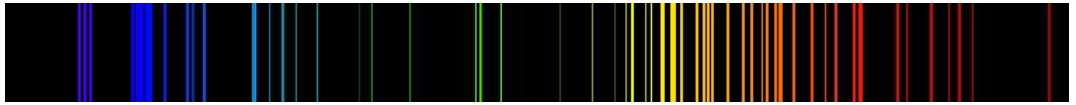


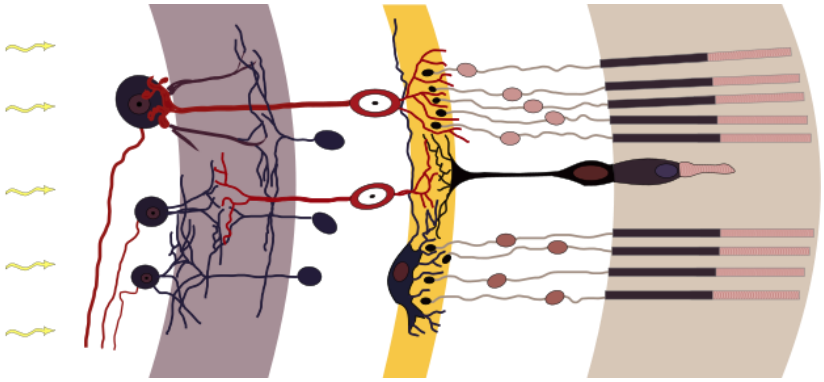
Photo by Ulfbastel
in the public domain

Public domain fig.

In public domain by User:Pslawinski



2. Color Perception



Cones and rods in the retina.

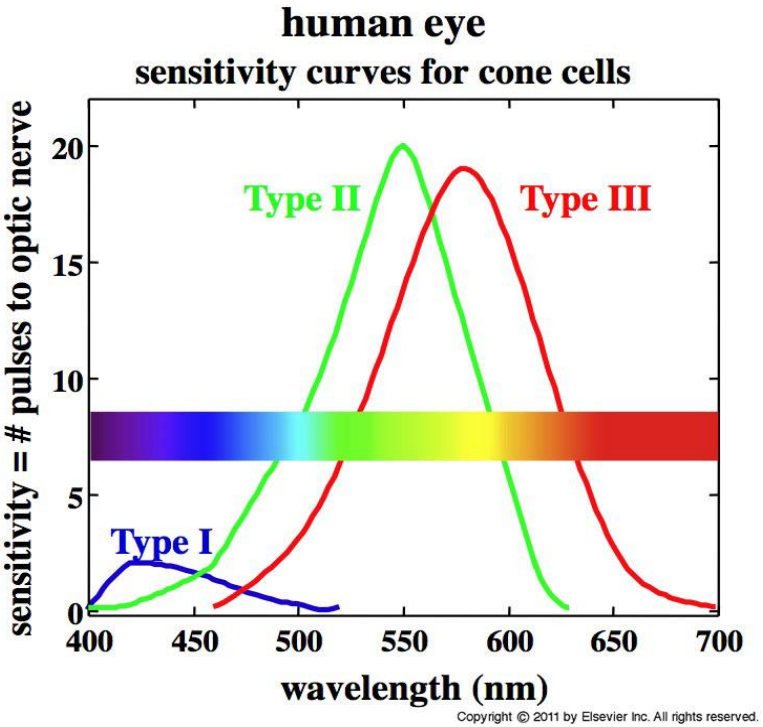


Fig. 6-4 The 3 types of cones in the human eye

The retina of the human eye contains
two types of photoreceptor cells: cones and rods.

The cones are used in bright light for detecting color and high-resolution central vision.

The rods are used in dim light, low-resolution peripheral vision.

Every type of cone is sensitive to a range of wavelengths.

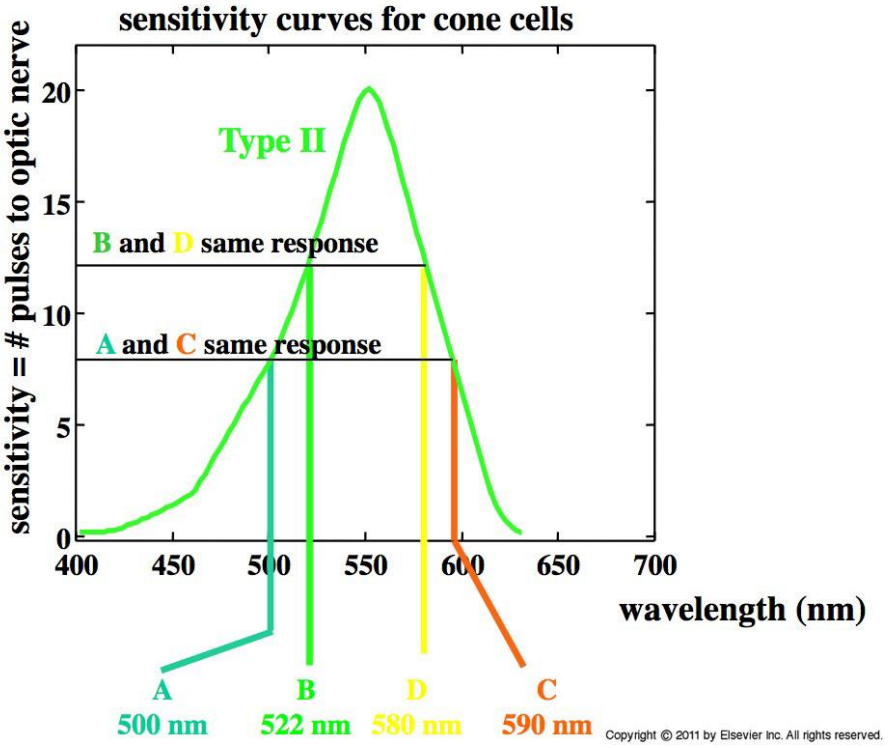


Fig.6-5

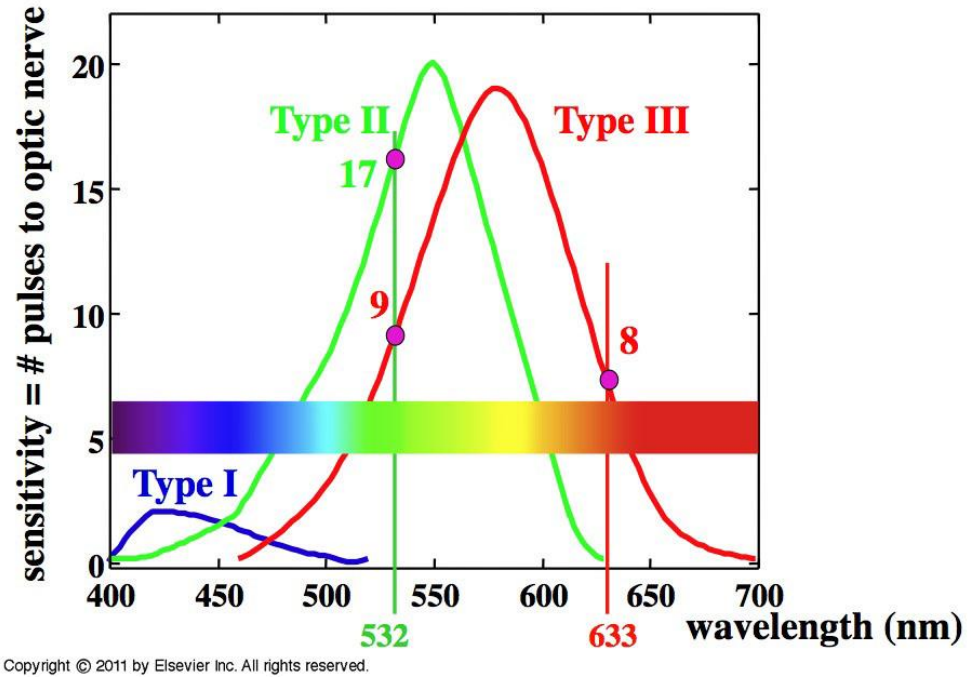
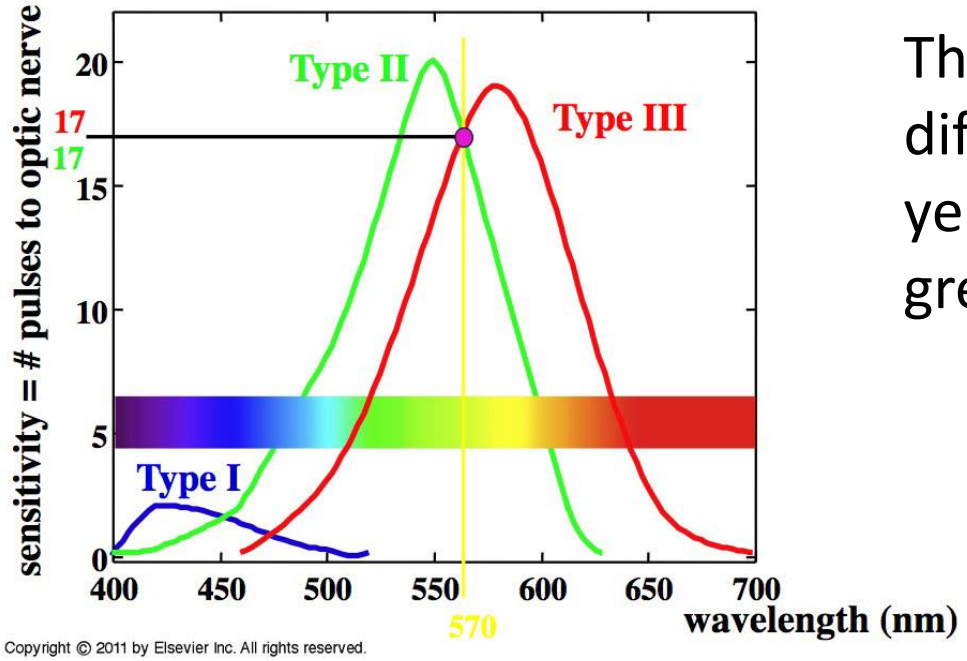


Fig.6-7. The brain interprets the sum of the responses of each type of cones to light of 2 laser pointers.

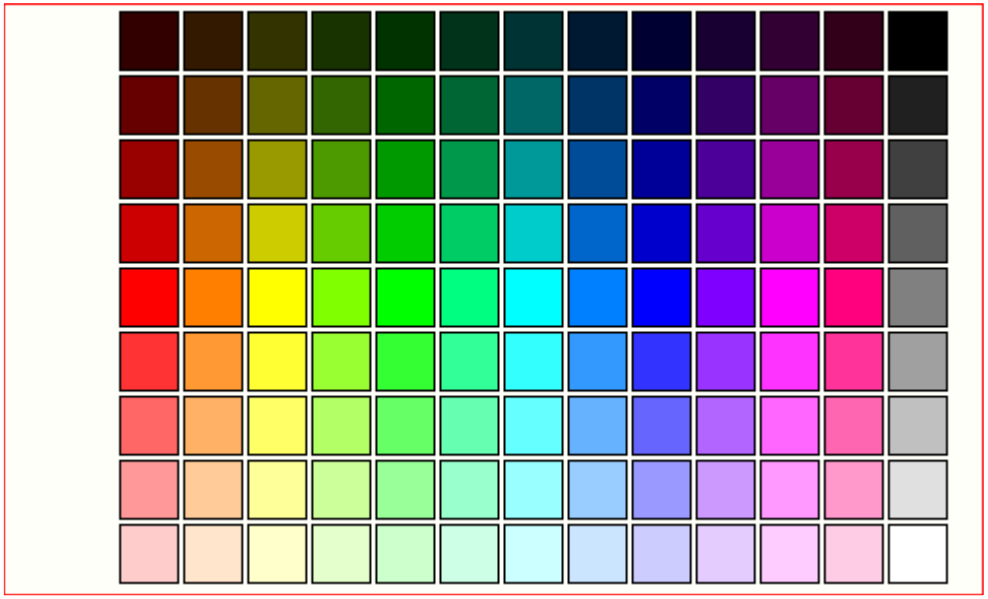
Green + Red = ?



The eye cannot tell the difference between a spectral yellow and the sum of spectral green and red!

Fig.6-8. Yellow light induces the same response in each of Type II and Type III cones.

Our eyes can distinguish many colors:



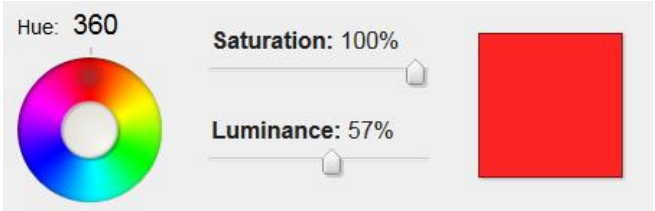
Hue – the psychological sensation of color

Explore the RGB-coordinates of colors:
https://www.rapidtables.com/web/color/RGB_Color.html

Hue, saturation and brightness are psychophysical parameters

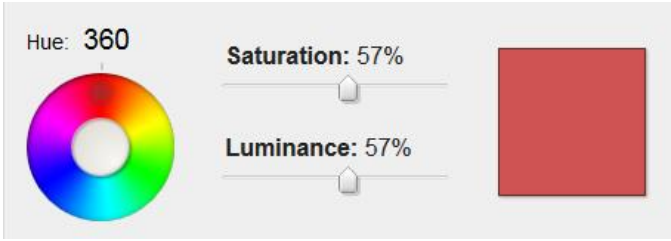
Hue, Saturation and Brightness:
https://www.rapidtables.com/web/color/color-scheme.html

Saturation = 100% – % of white light



100% saturation is pure color.

Low-saturation colors are pastels
(ex. pale yellow, beige, sky blue, etc.)



Perceived brightness depends on the adaptation of the eye, and on the surrounding illumination.

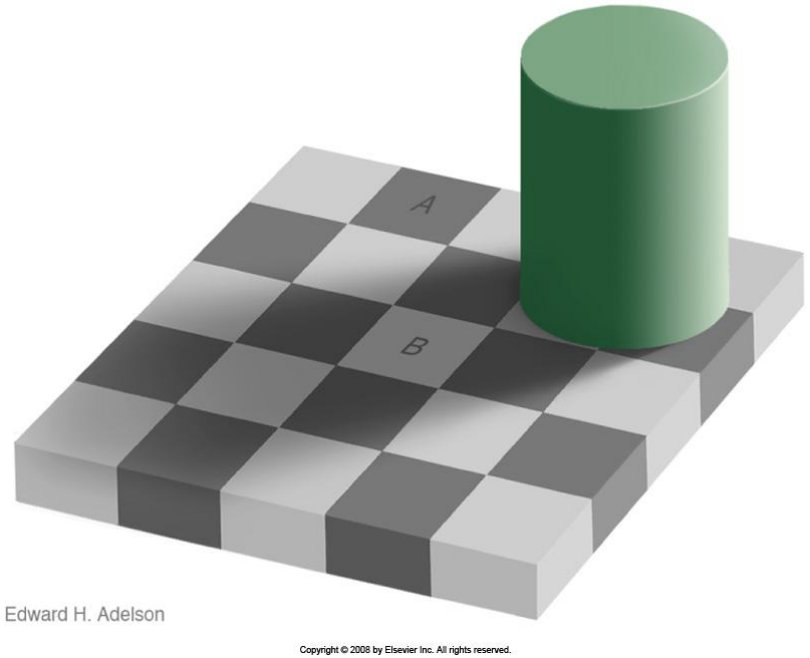
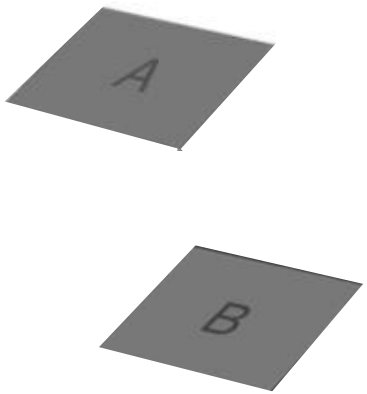


Fig.6.11 Which square is brighter – A or B?



The same squares cropped.

3. Color due to Scattering (Diffuse Reflection)

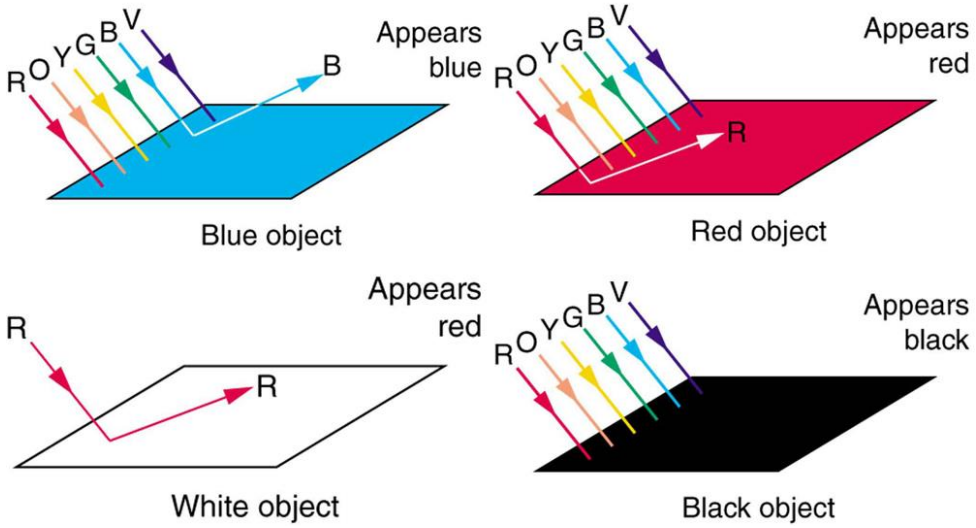
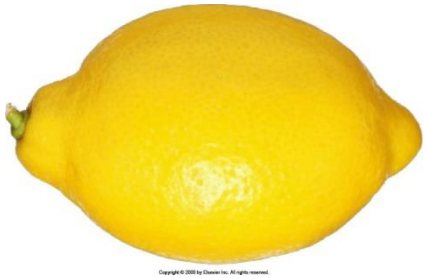


Fig.2 in Ch.26.3 OpenStax Physics
https://cnx.org/contents/Ax2o07Ul@9.99:1CyAfan6@4/Color-and-Color-Vision



Q: How do you explain the colors of these fruits?

We see the reflected color
(the rest of the spectrum is absorbed).

The color of the sky, and of water with various depths

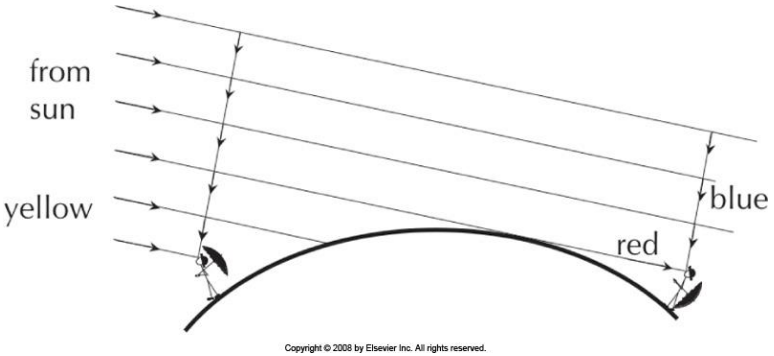



Photo: M. Nenkova

Figs.6.15 – 6.17

To summarize:

What does the color of an object depend on?

4. Primary Colors

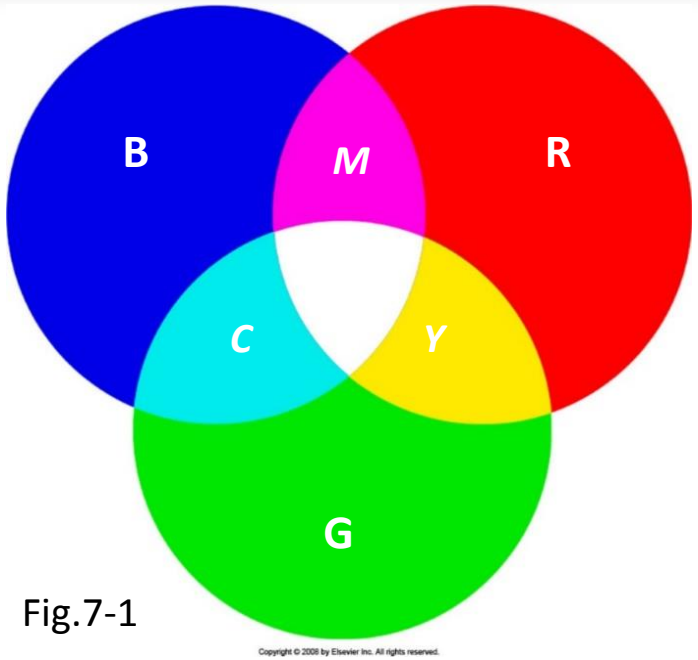


Fig.7-1

1) One primary color cannot be produced by any mix of the other two

2) When added in proper proportions they produce white

Examples of primary colors:

R + B + G = White

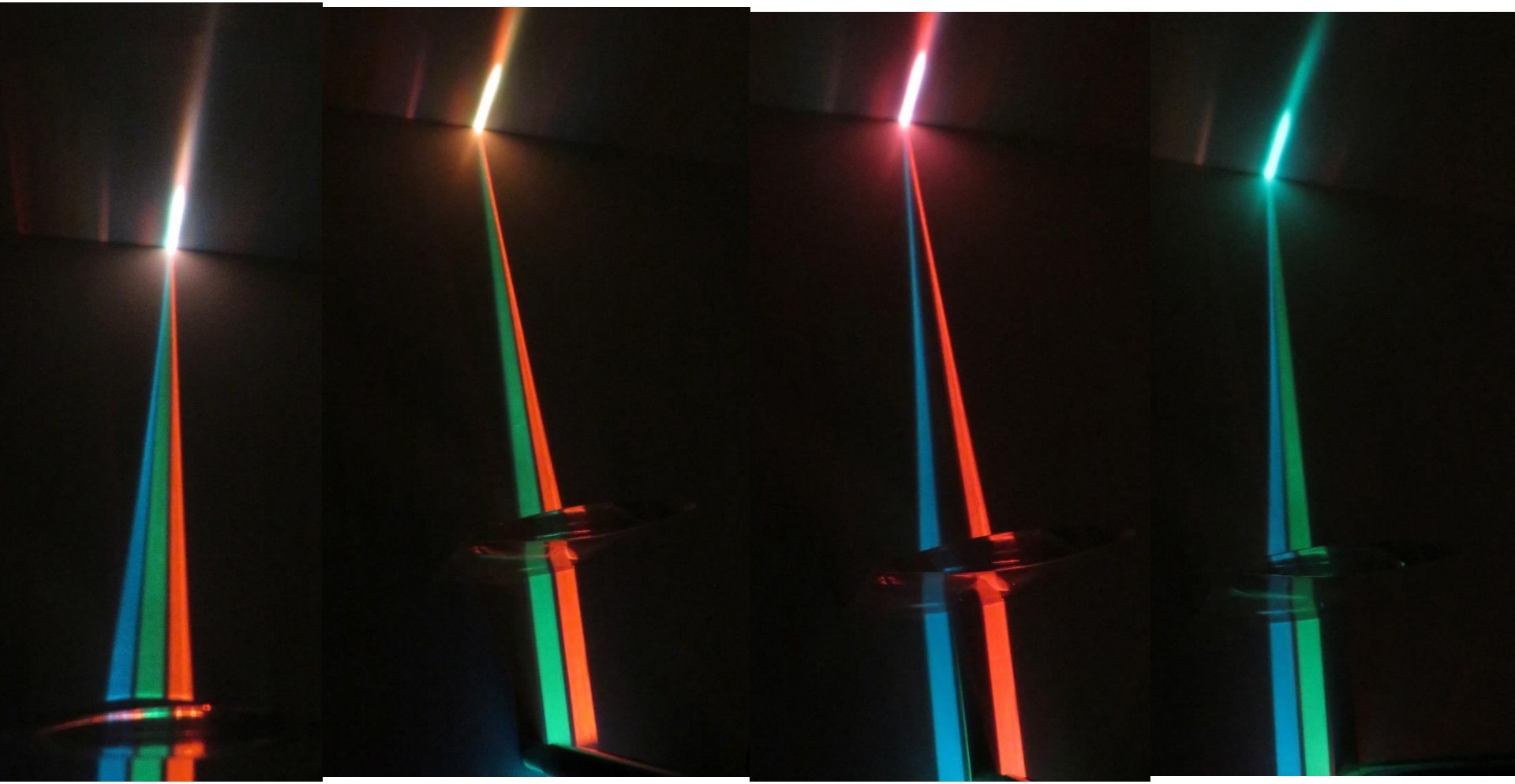
C + M + Y = White

Any color can be obtained as a combination of the primary colors:
S = aR + bG + cB, where a+b+c=1

The fractions of primary colors are: $r = \frac{a}{a+b+c}$ $g = \frac{b}{a+b+c}$

(Note, that we only need two fractions. *Why?*).

Adding primary colors with the optical setup



Ex. How to obtain brown and pink?

https://www.rapidtables.com/web/color/RGB_Color.html

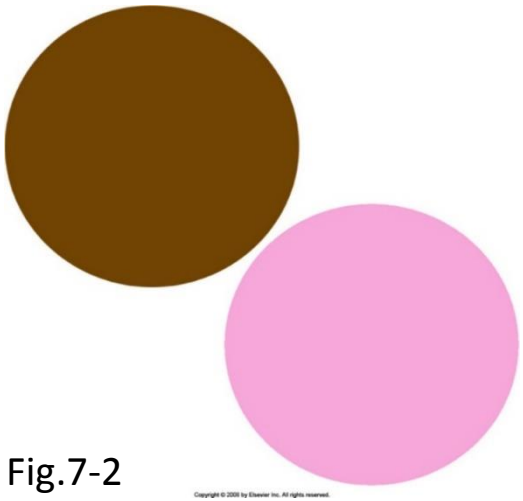
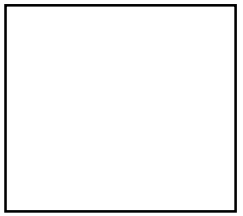


Fig.7-2

Cyclamen pink on the computer:

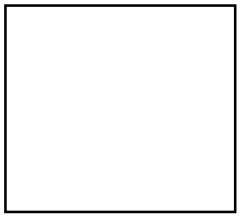
250R + 170G + 200B

or else?



Normalize by the sum of weights:

250+170+200 = 620



Result:

0.4r + 0.28g + 0.32b

Fractions of r and g are always between 0 and 1, and b = 1 – r – g. Therefore we can represent them as the sides of a color triangle.

The fractions (relative weights) always add to 1: r + g + b = 1

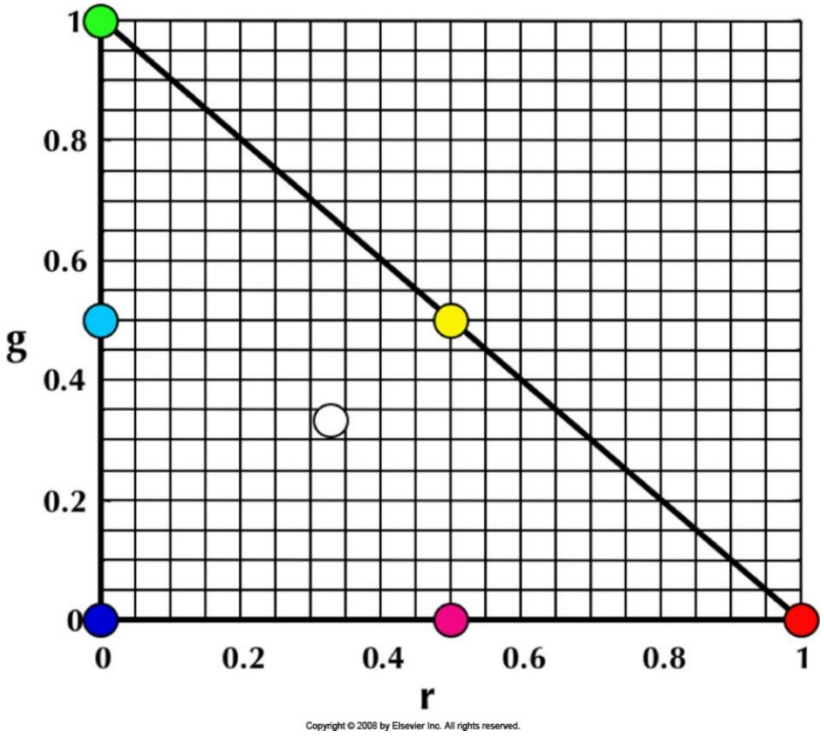


Fig.7-3 The color triangle with primary colors

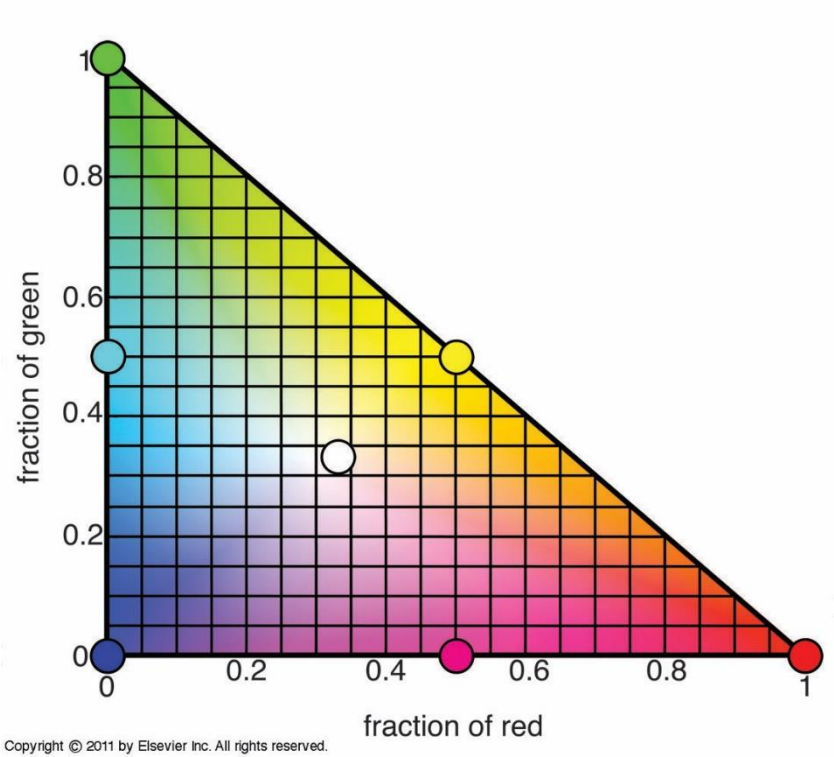


Fig.7-4 The color triangle filled-in

When adding 2 colors, the resulting color is always on the line joining the 2 colors.

Saturated colors are near the edges of the triangle; low-saturation colors are near the center.

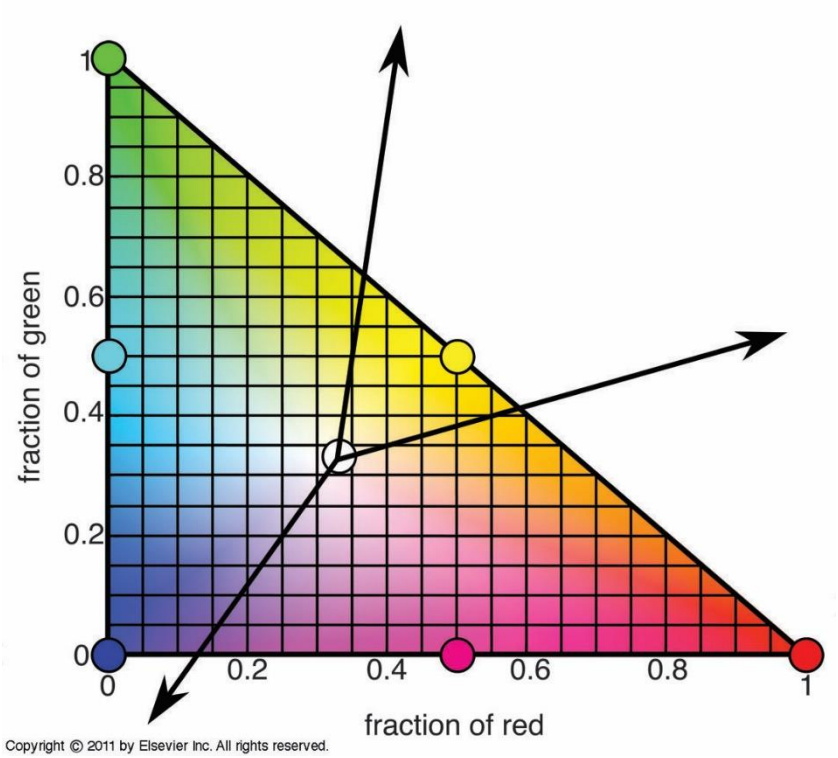


Fig.7-5

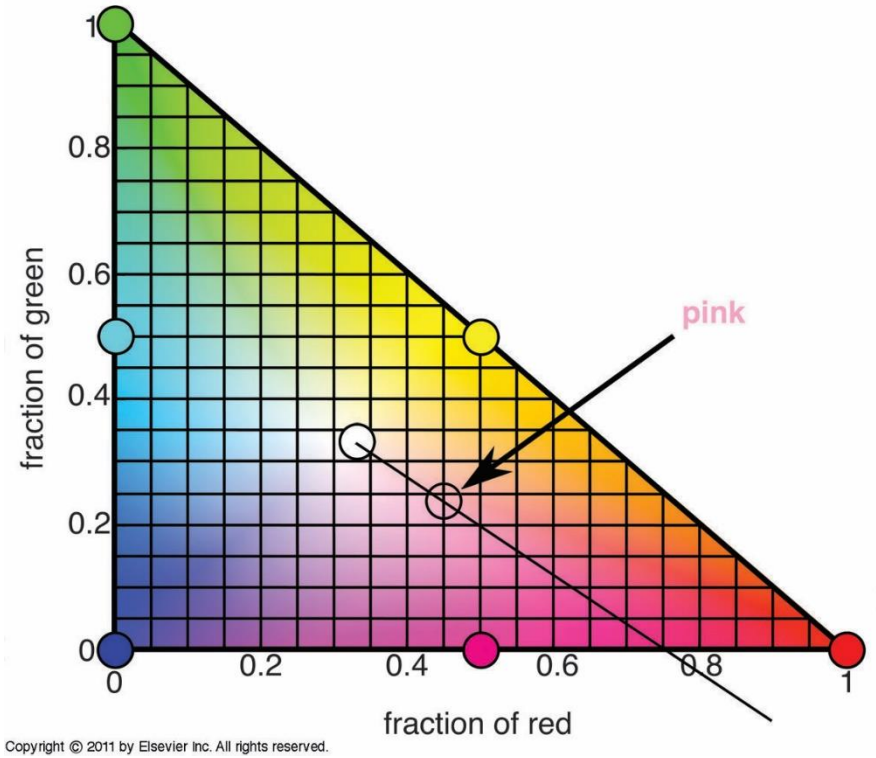
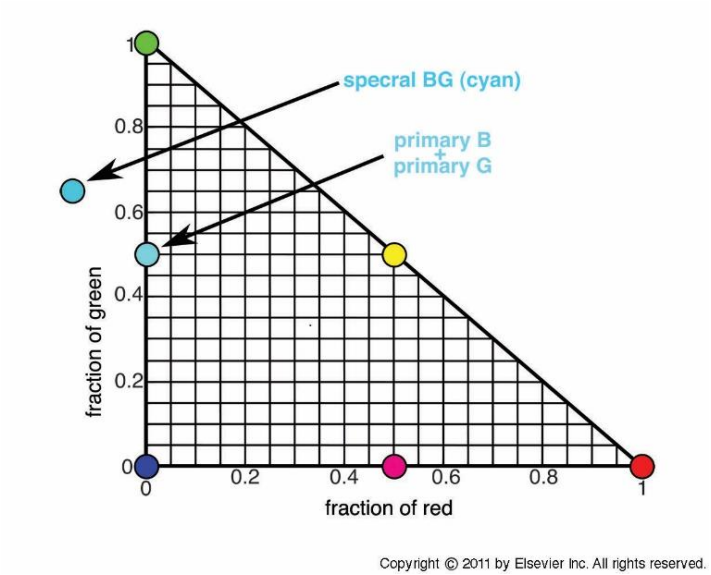


Fig.7-6 pink = r=0.45, g =0.24

The spectral colors are outside the color triangle



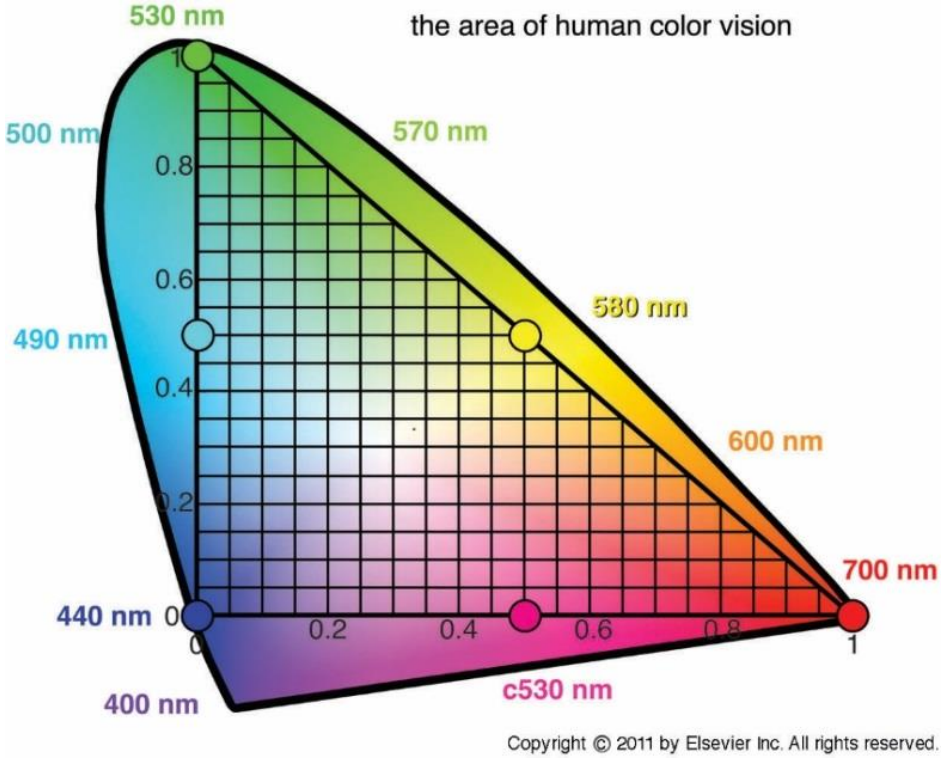
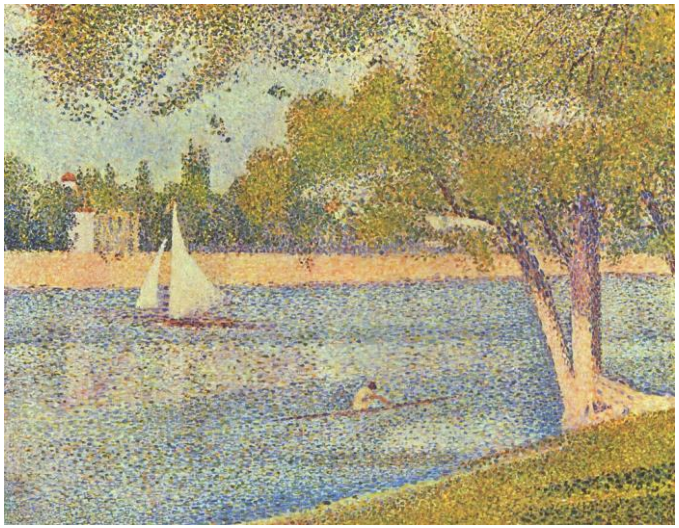
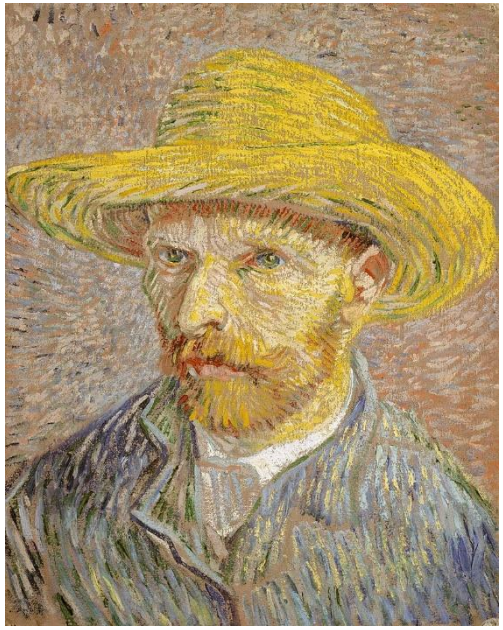


Fig.7.15 The color triangle only contains colors obtained by mixing primary R,G,B colors.
We can see more than this.
Magenta is non-spectral color.

5. Examples of Additive Color Mixing in Art



George Seurat, The Seine at La Grande Jatte (1888)



Van Gogh, Self-portrait with Straw Hat (1887)

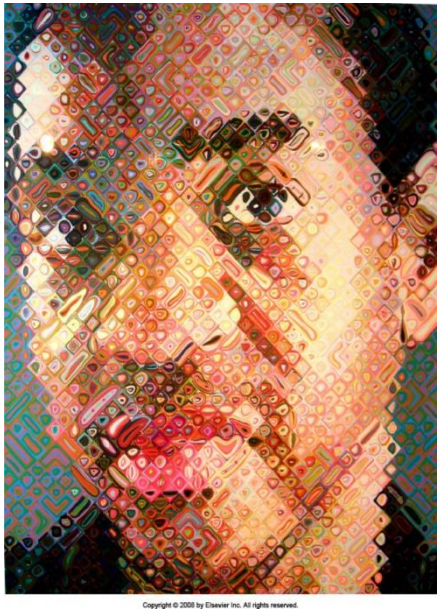


Fig.7.18

Different adjacent colors are mixed in our eyes creating a third, vivid, color.