

# Additive Color

## Part 2



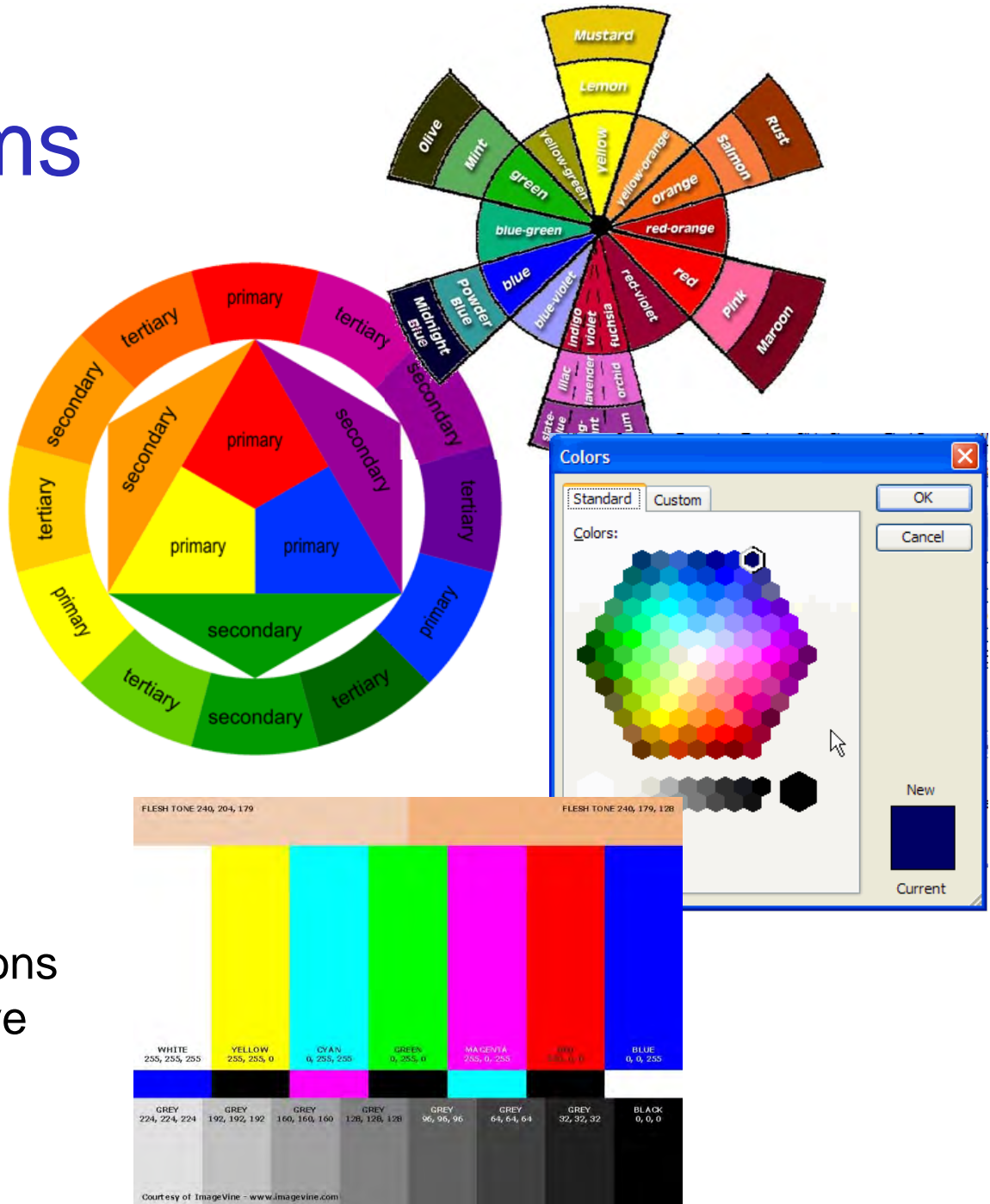
National Science Foundation  
WHERE DISCOVERIES BEGIN

# Color Systems

Lots of ways  
to organize  
colors

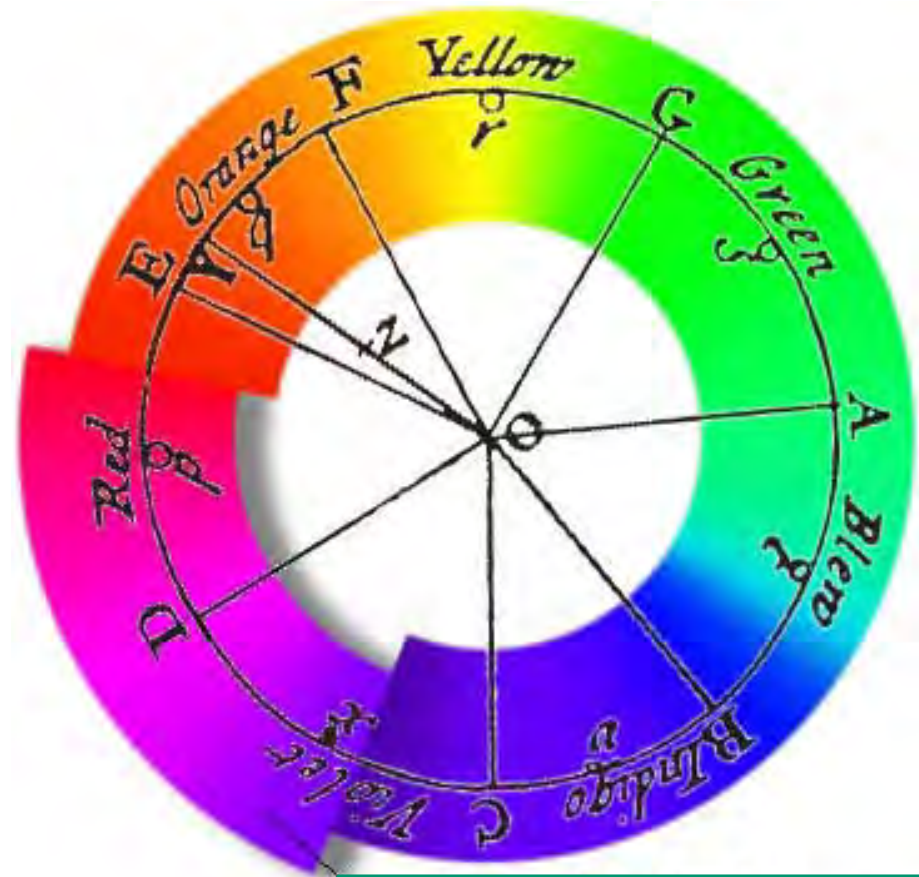
All these color systems are  
useful in their own way.

To answer scientific questions  
we need a more quantitative  
and complete system.



# Newton's Color Wheel

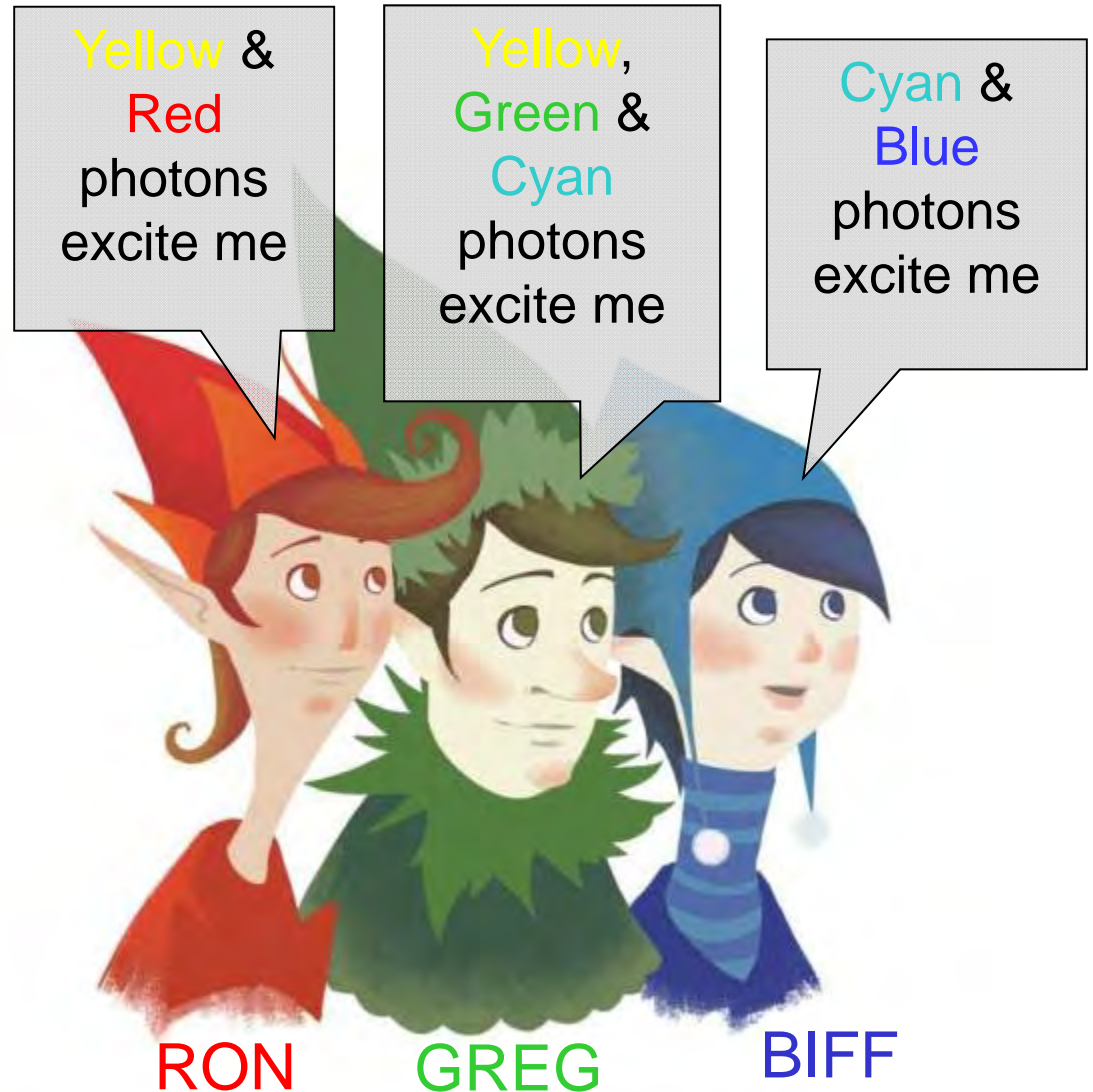
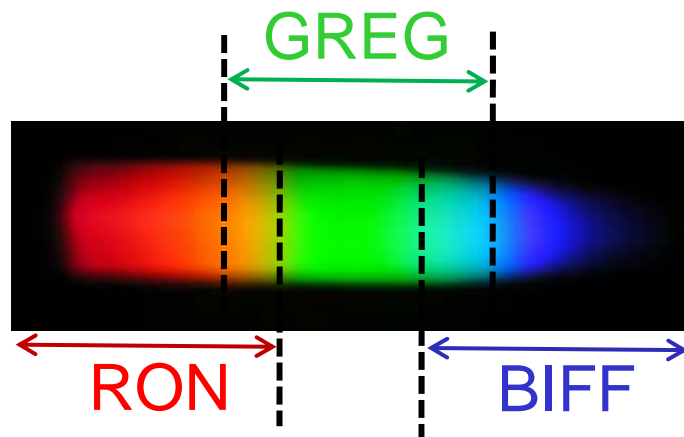
Visible spectrum is a straight line, yet Newton used a circular color wheel.



This segment is added to join the two ends of the spectrum

# Simple Trichromatic Theory

Imagine that inside your eye are these three guys, who send messages to your brain.

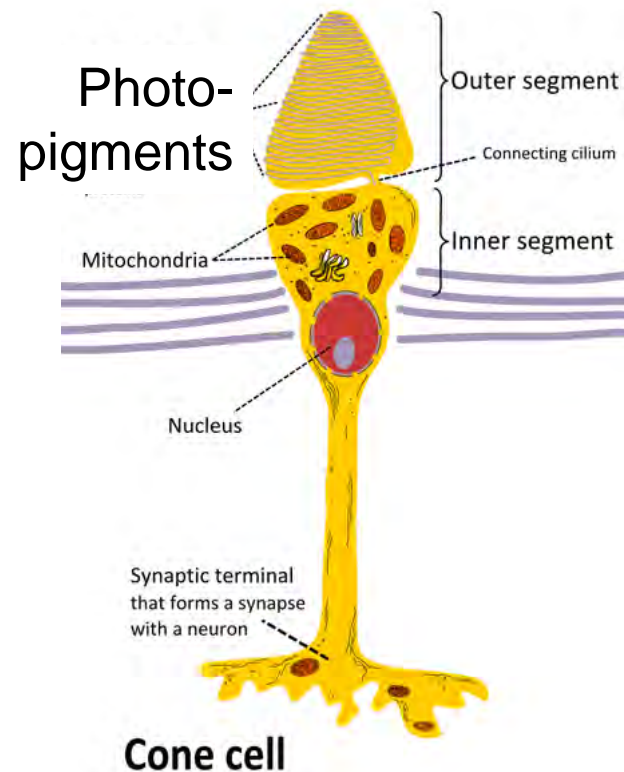
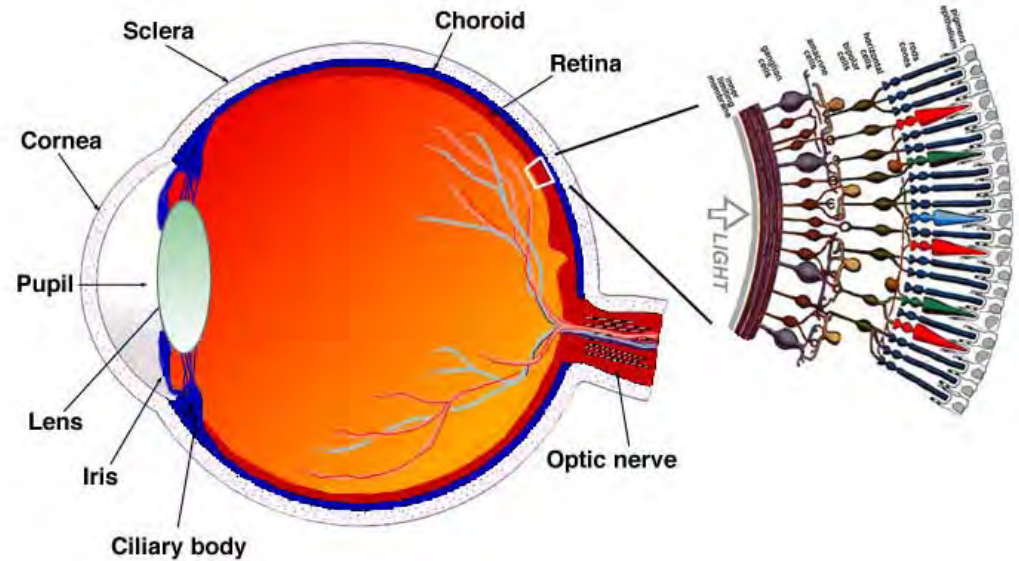




# Color Vision

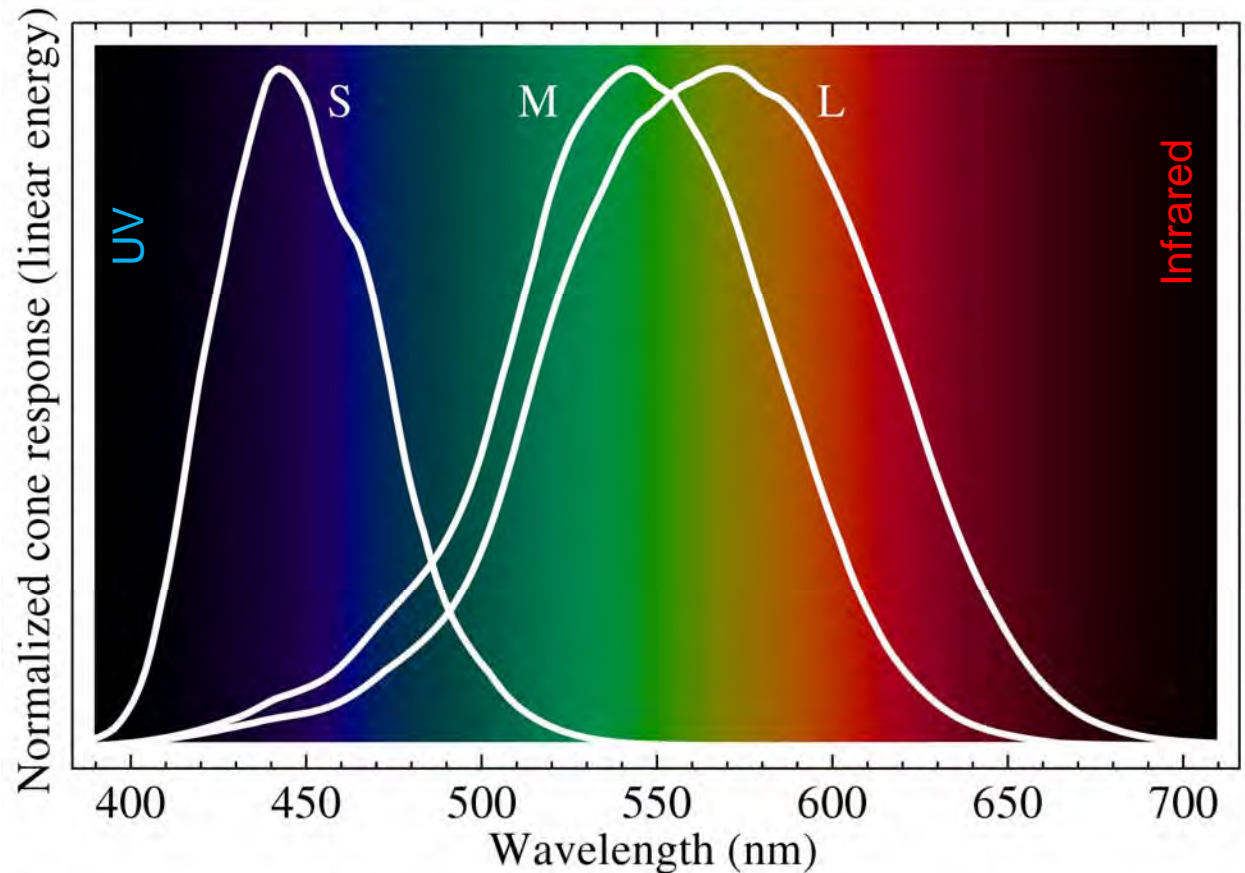
Light sensitive cells in your eye send a visual signal to your brain.

The color-sensitive cells are called *cones* and there are three types of cones.



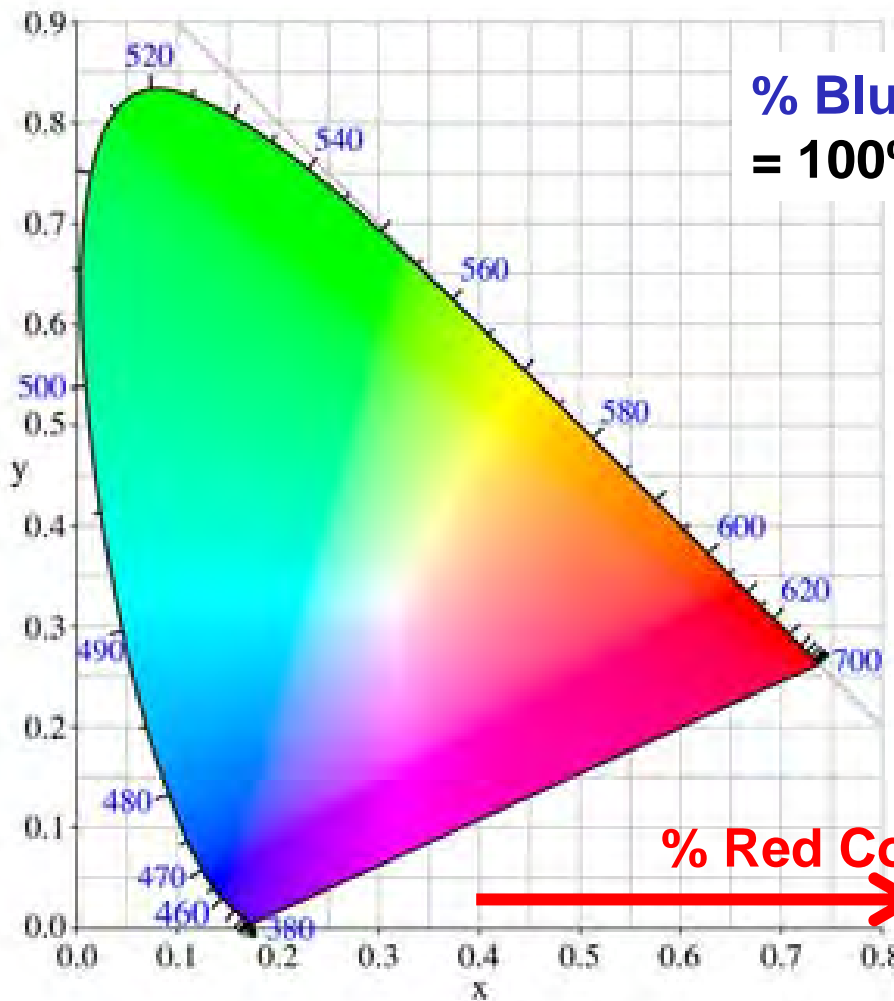
# Cone Response Curves

Three cones in the human eye are labeled:  
S (short), M (medium), and L (long).



# CIE Color Diagram

% Green Cone (M)



$$\% \text{ Blue Cone (S)} = 100\% - (\% \text{ Red} + \% \text{ Green})$$



Colors in this CIE diagram are only approximate.

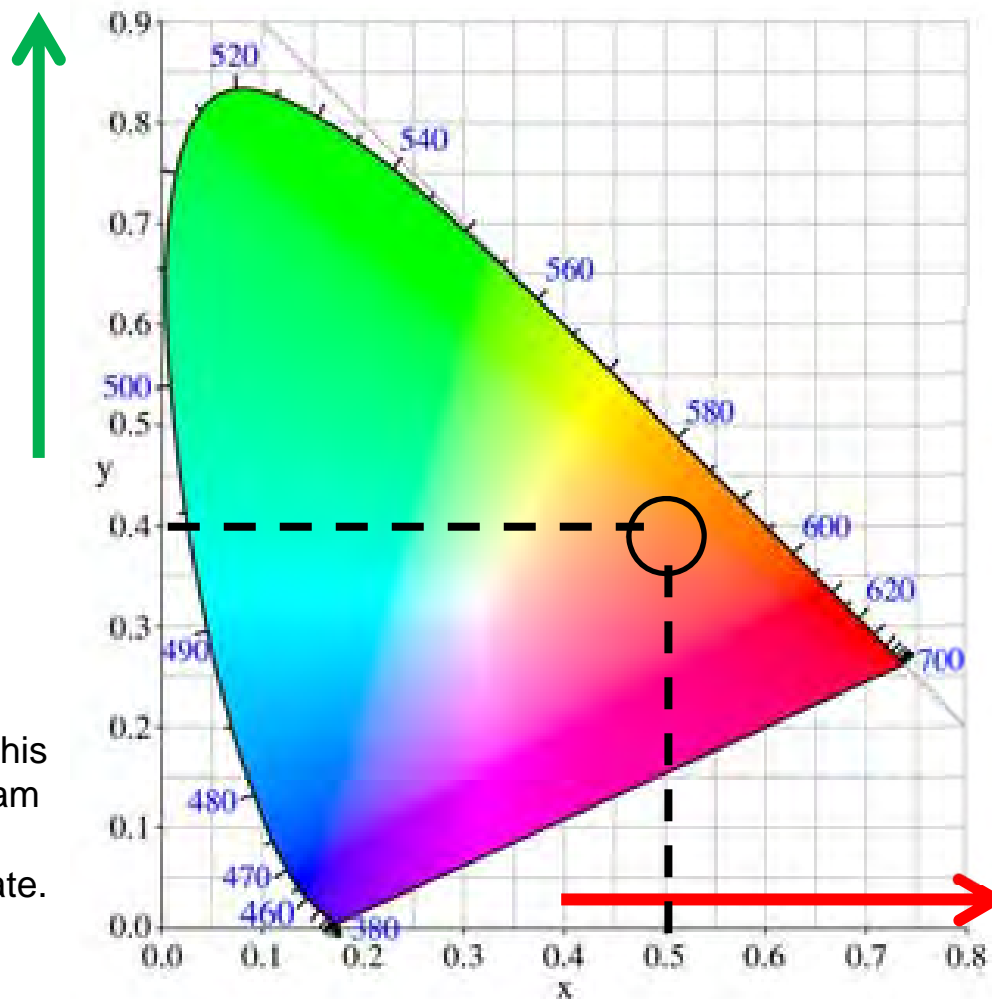
% Red Cone (L)

# Tristimulus Values

Tristimulus values  
**x = 0.50**, **y = 0.40**  
is an orange color.

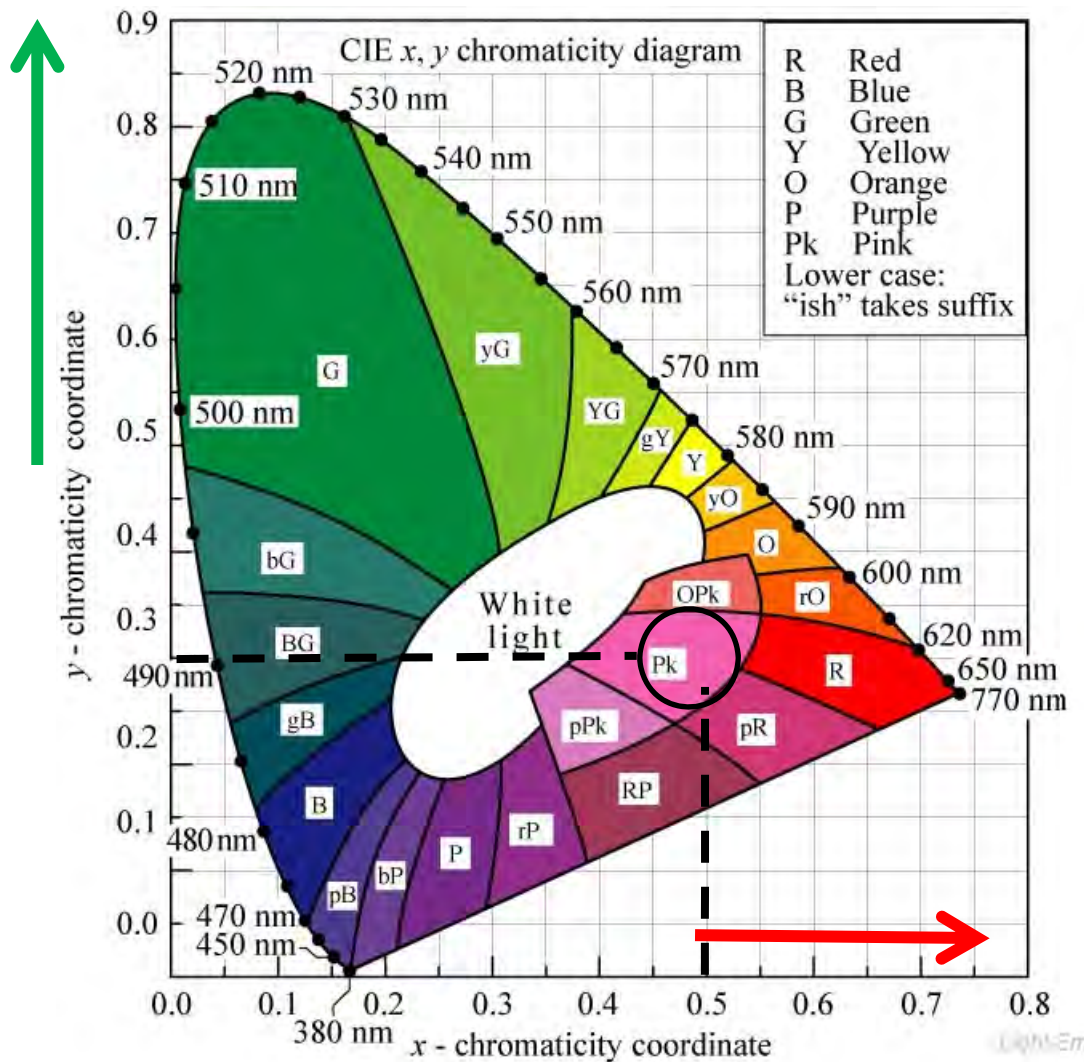


Colors in this  
CIE diagram  
are only  
approximate.

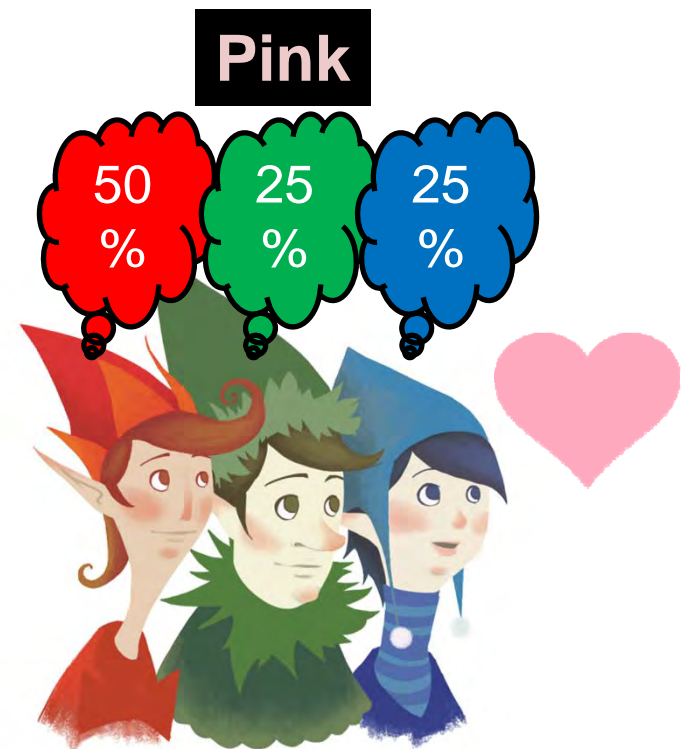




# Color Names

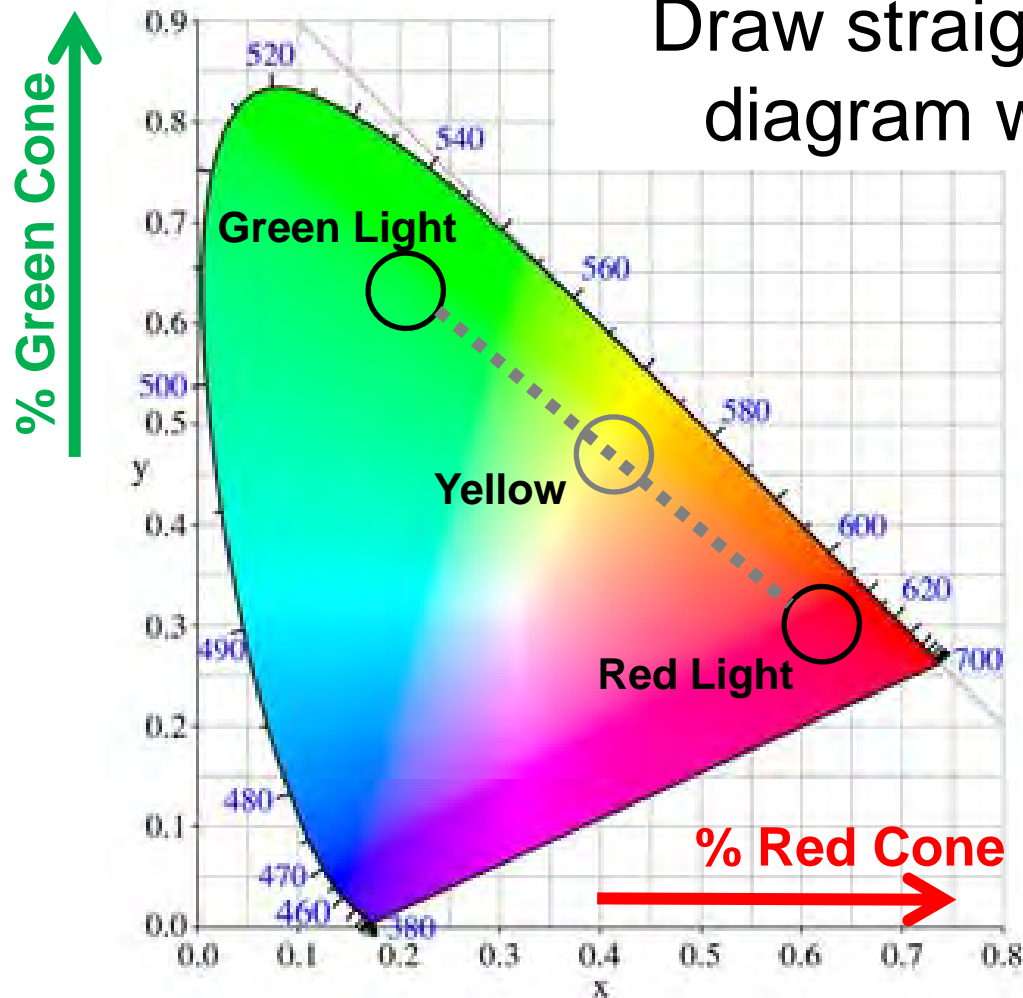


Can assign color names to areas in the CIE diagram.



# Color Addition

Color addition works with lights  
Draw straight lines on the CIE diagram when adding colors



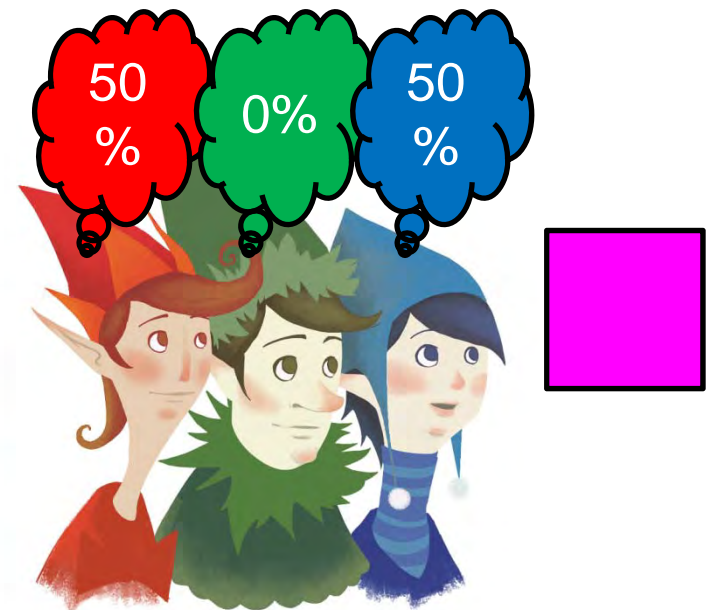
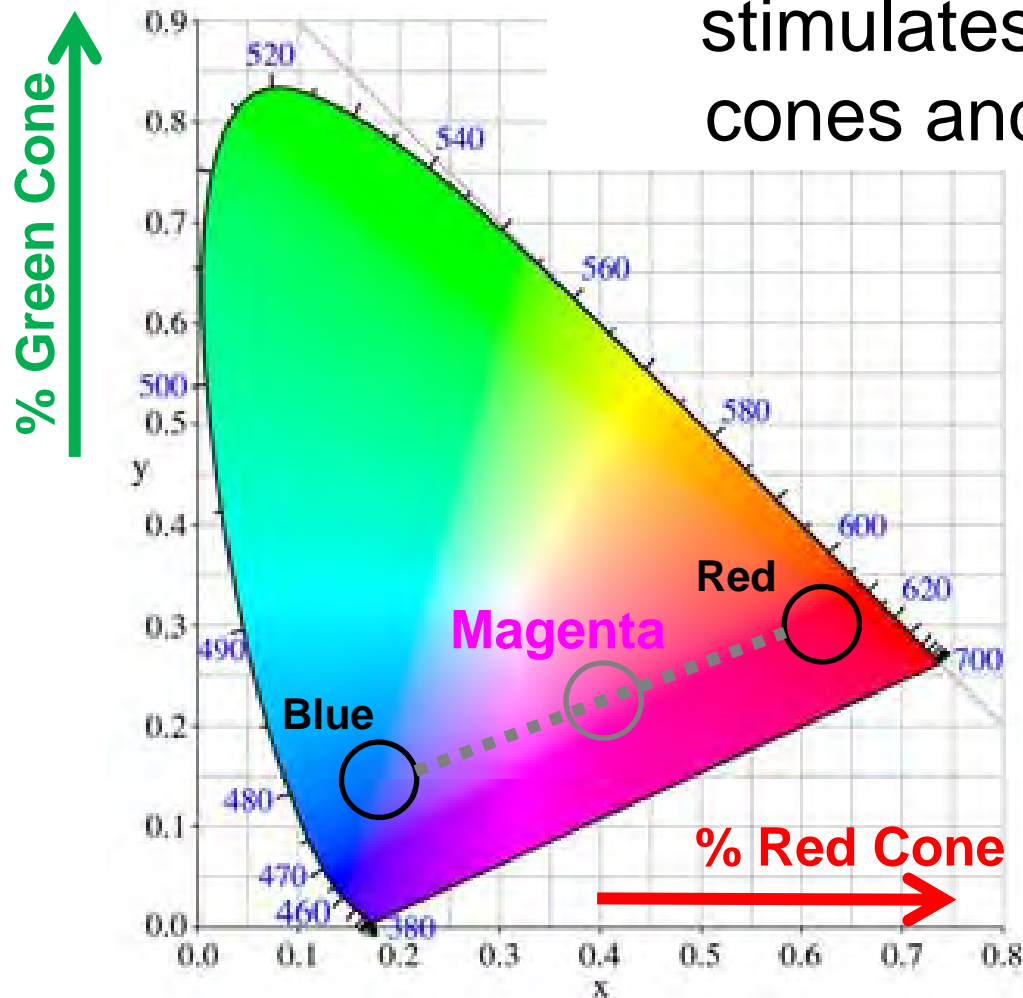
Overlapping red and green lights

# Light Box Demo



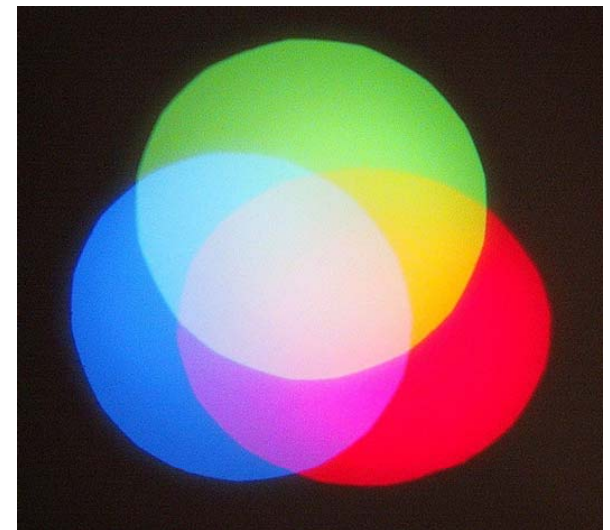
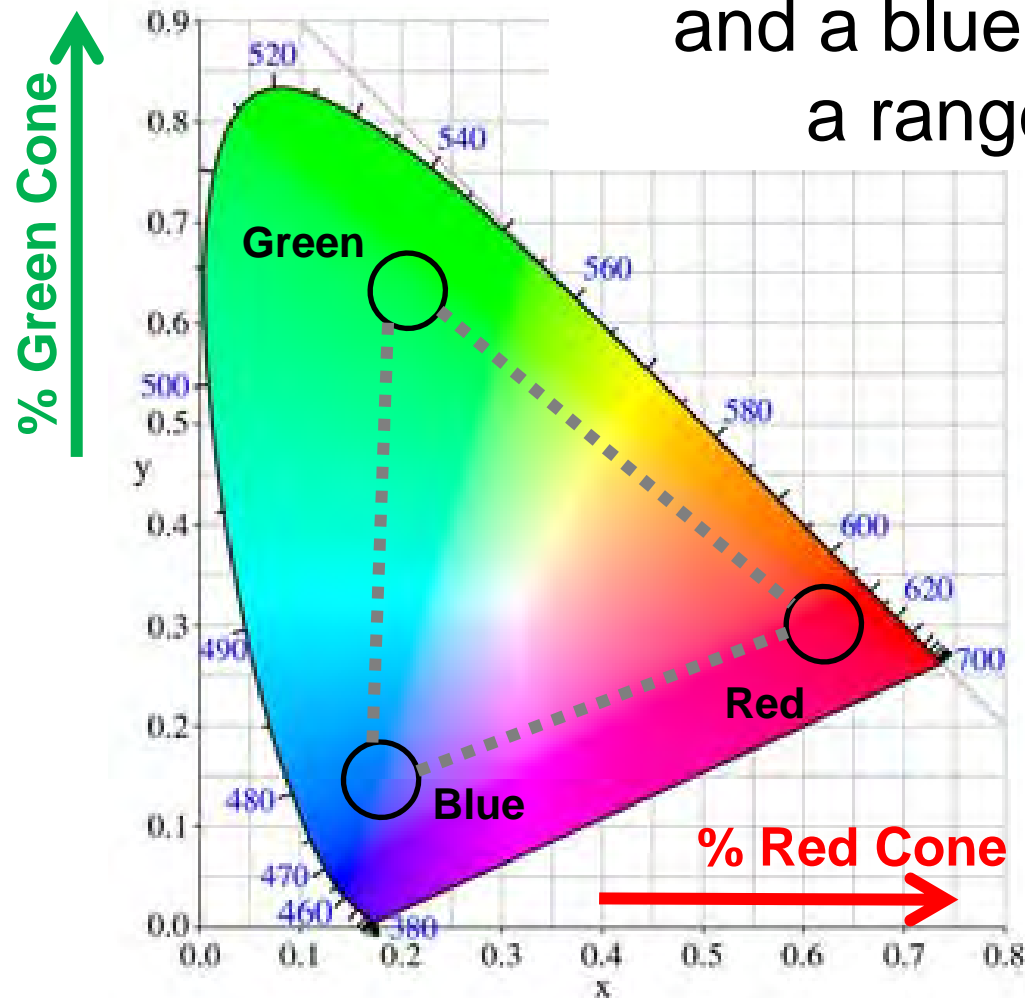
# Color Addition of Blue and Red

Adding red light and blue light stimulates both red and blue cones and we see magenta.



# RGB Color Gamut

Using a red light, a green light, and a blue light we can cover a range (gamut) of colors

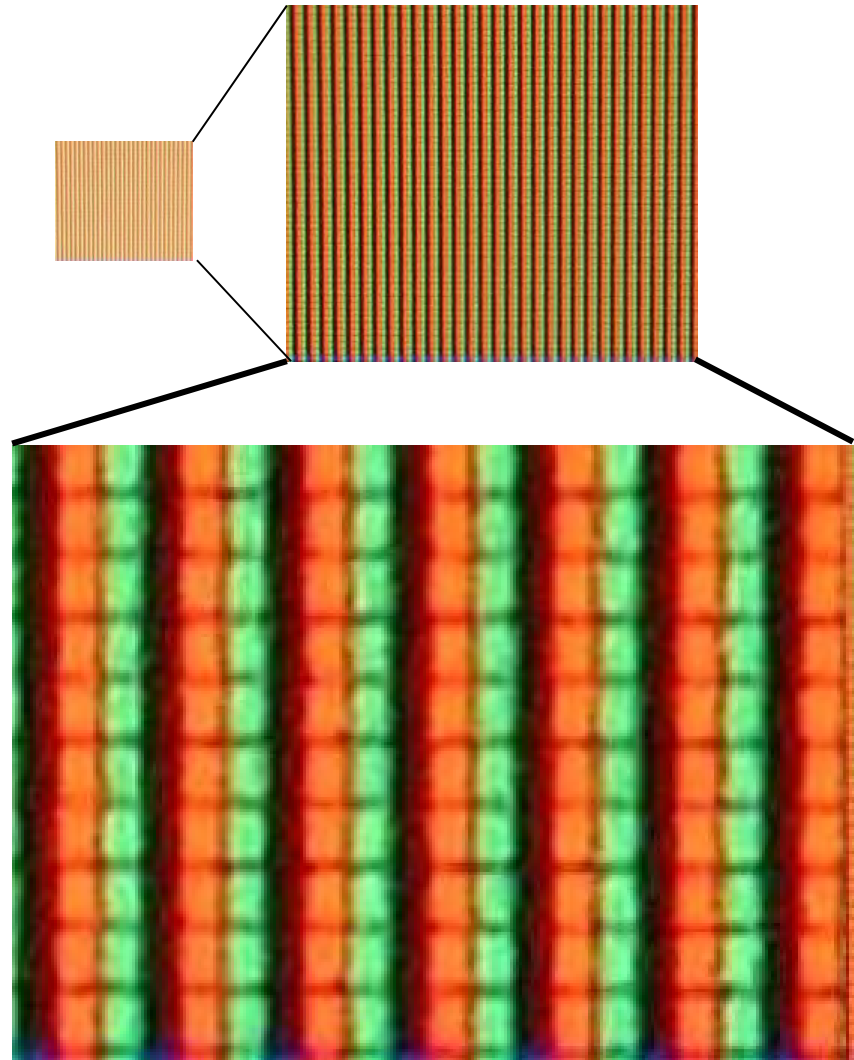




# RGB Display

Color displays typically use red, green and blue sub-pixels of varying intensity to produce a wide gamut of colors.

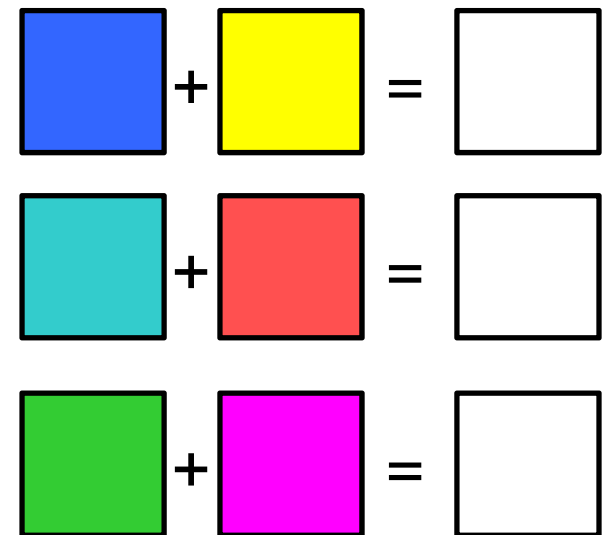
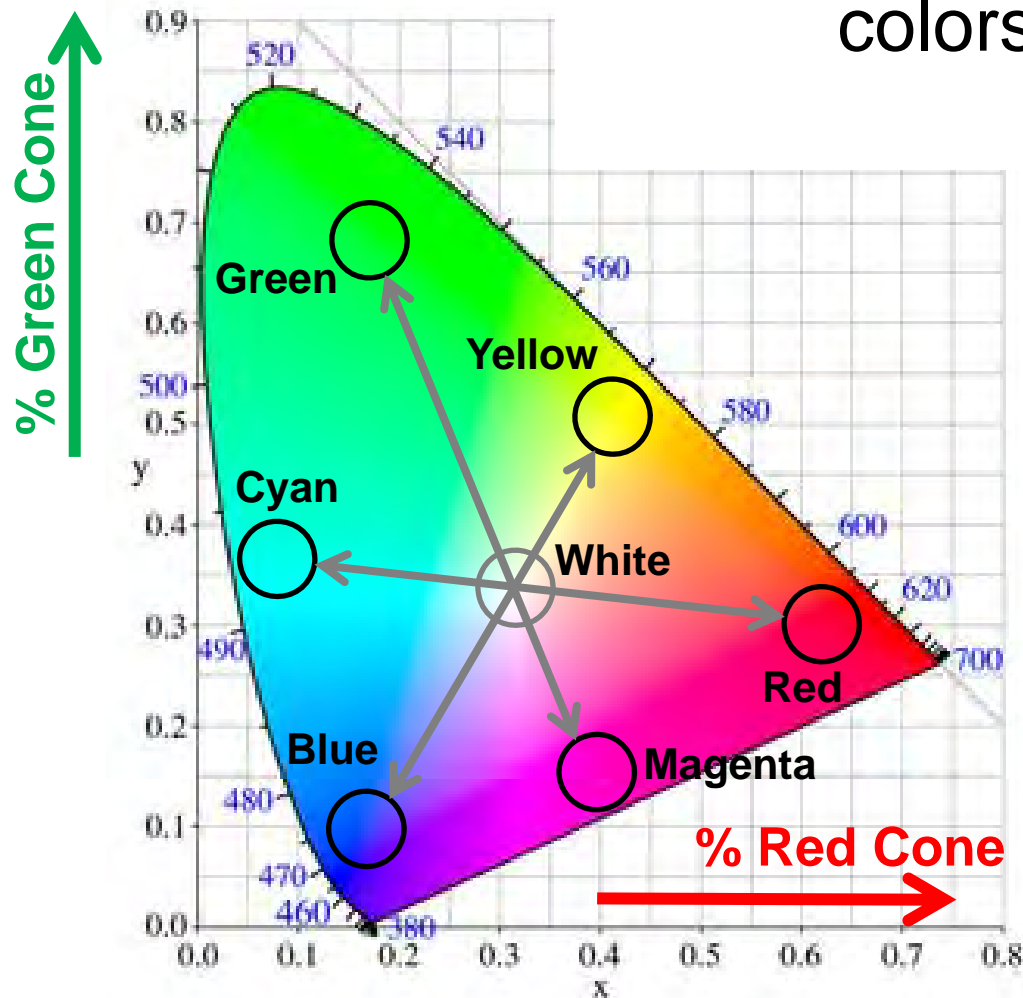
Yellowish-orange made with red and green sub-pixels on an LCD TV.



From Wikipedia

# Additive Color Complements

Color complements are pairs of colors on opposite sides of the white point.



# Anaglyph Glasses

Anaglyph glasses use a color complement pair of filters to create a stereoscopic 3D image.



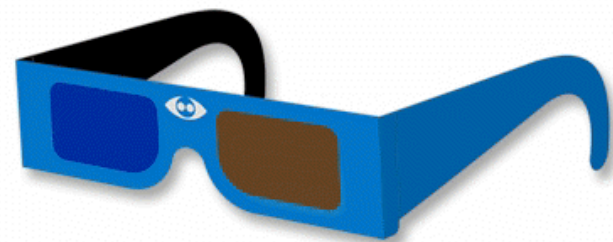
Red/Cyan  
image



Red/Cyan



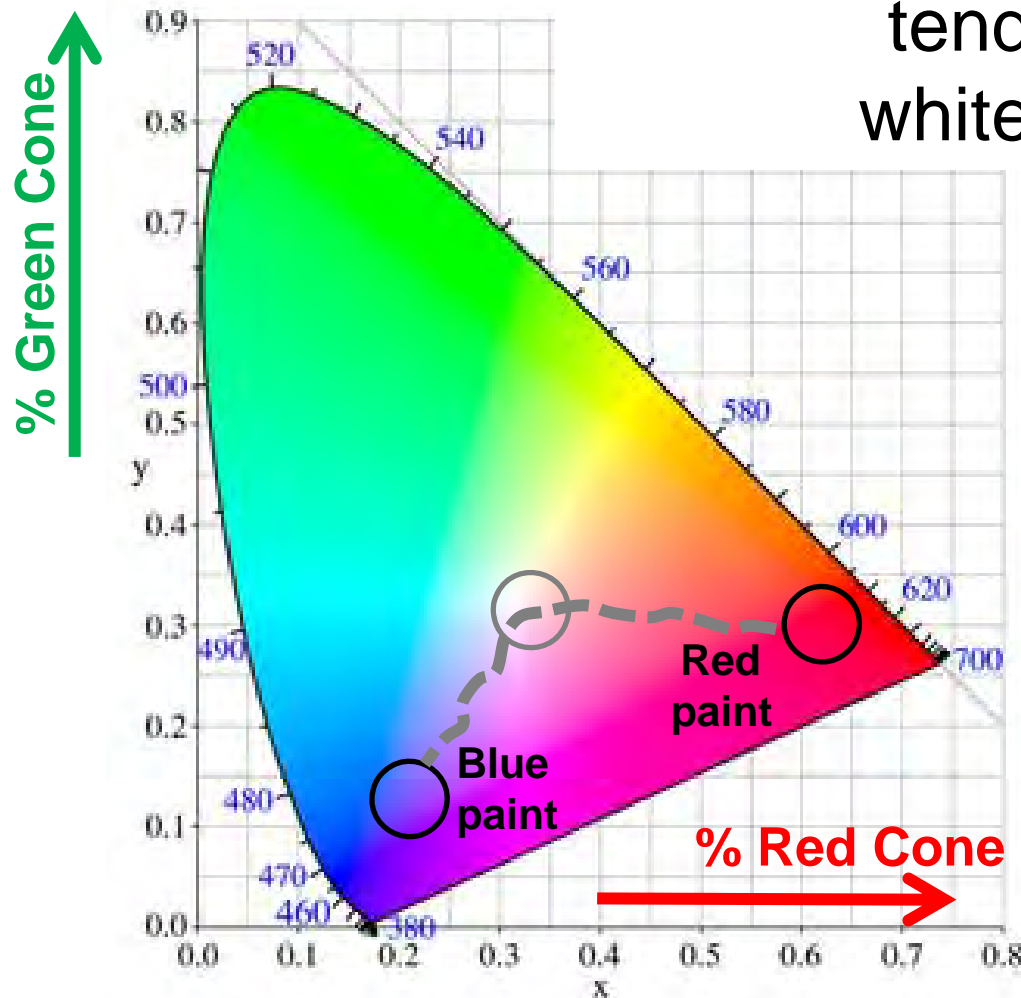
Green/Magenta



Blue/Yellow

# Color Subtraction

Mixtures of red and blue paint tend to fall towards the white/black center point



Mixing pigments is not like adding lights

# Mixing Blue & Red Paint

Mixing paint or ink is different from adding colors together by light.

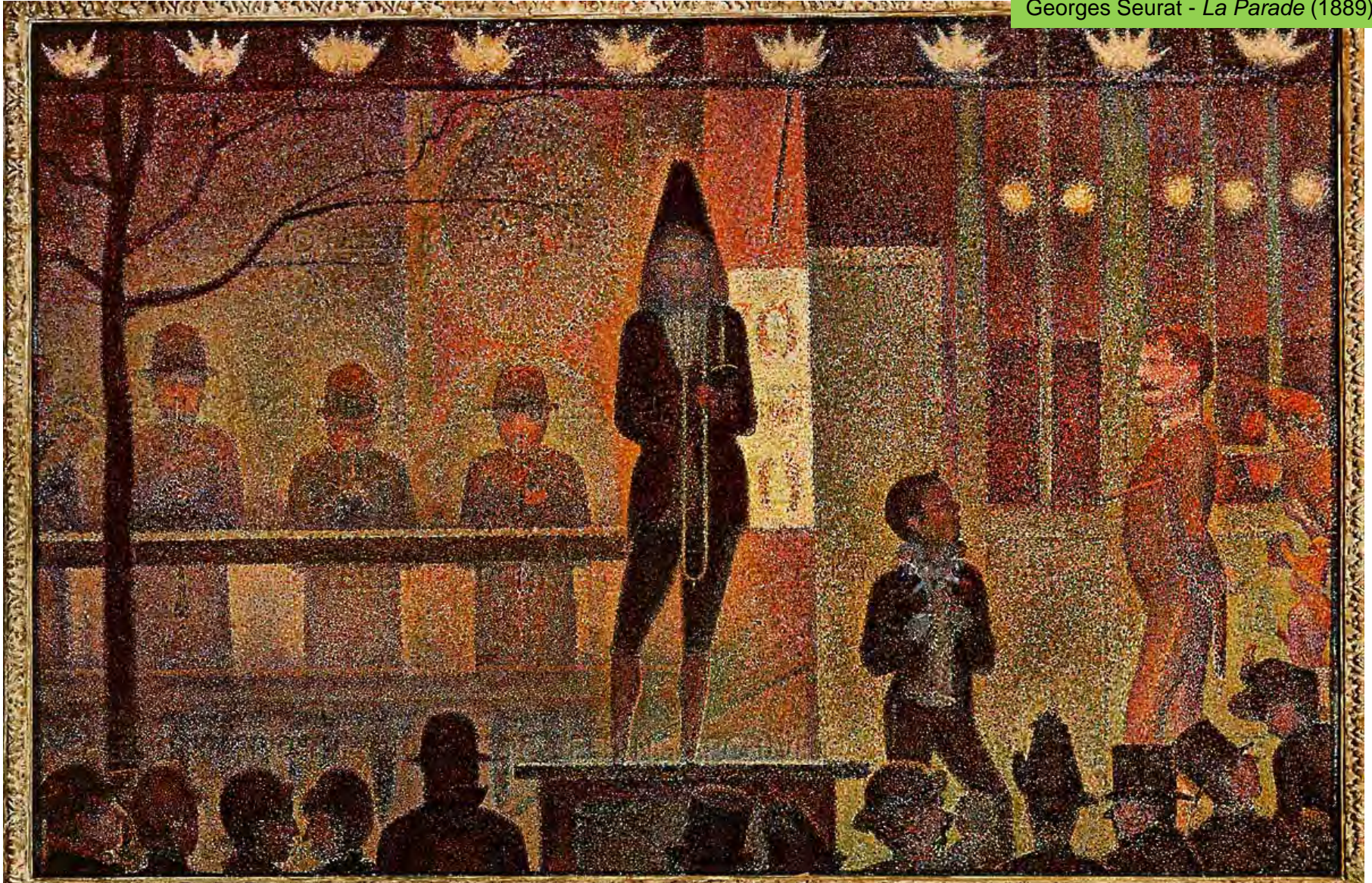


Mix of blue and red paint produces a blackish brown



# Pointillism and Color Mixing

Georges Seurat - *La Parade* (1889)



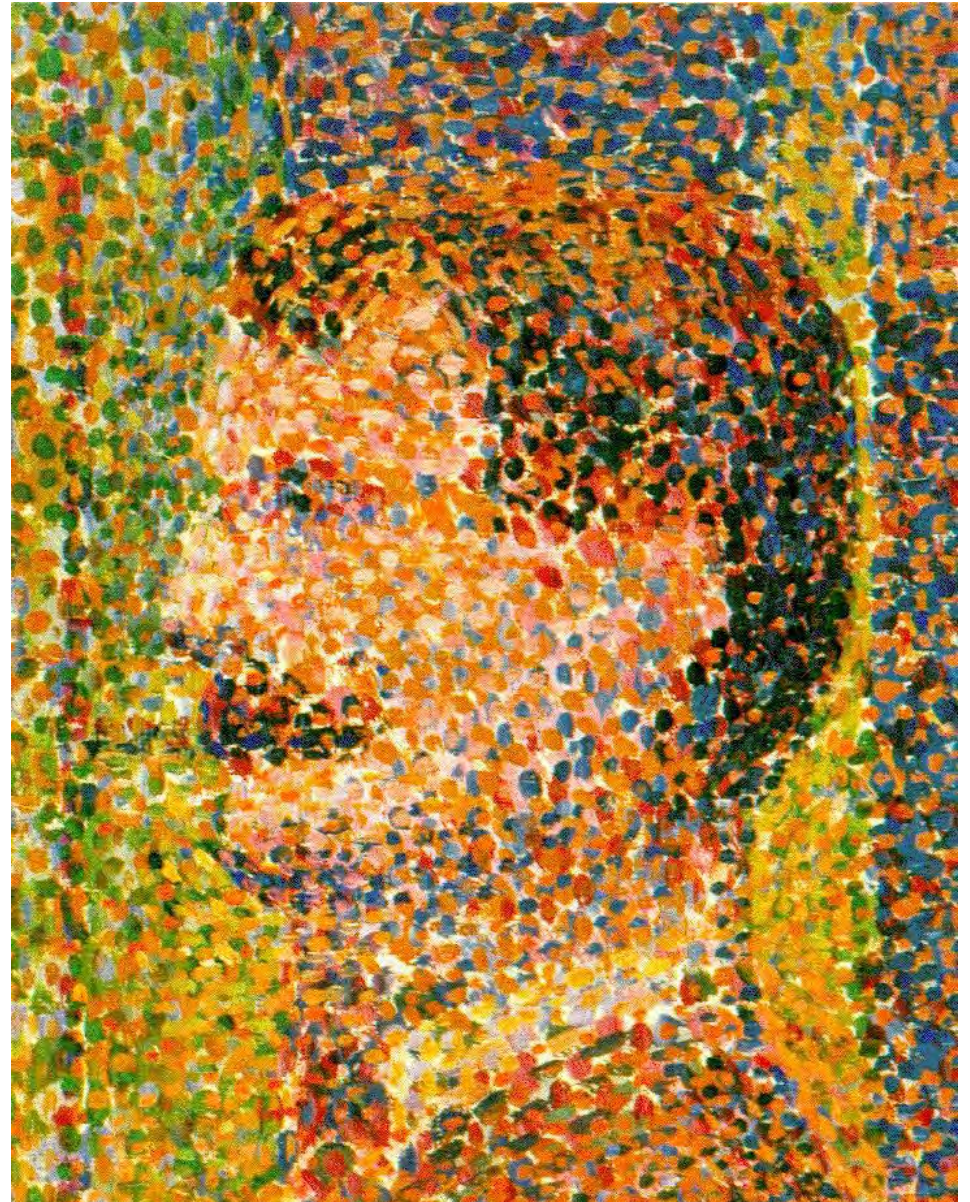


# Pointillism and Color Mixing

Closely spaced dots of color used in Pointillism visually blend together as additive color mixing.

Colors formed this way have greater saturation than what can be achieved by actually mixing the paint.

Detail from *La Parade*,  
Georges Seurat (1889)



# Summary

- The three types of cone cells in the eye's retina send a color signal to the brain.
- The CIE diagram maps the perceived color in terms of tristimulus values ( $x, y$  coordinates).
- The CIE diagram allows us to predict the color resulting from adding colored lights.
- A wide range (gamut) of colors may be reached by adding only red, green, and blue lights.
- Additive color complements are on opposite sides of the white point on the CIE diagram.
- Mixing paint pigments is not additive color.