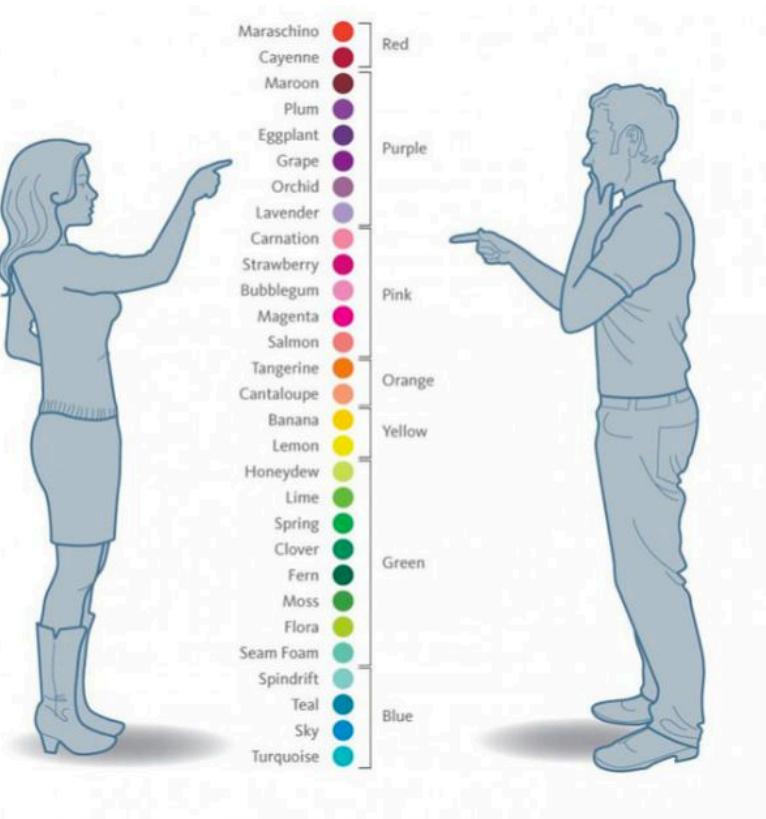


# 4 COLORS

S. Rinzivillo – rinzivillo@isti.cnr.it

# HOW MANY COLOR?

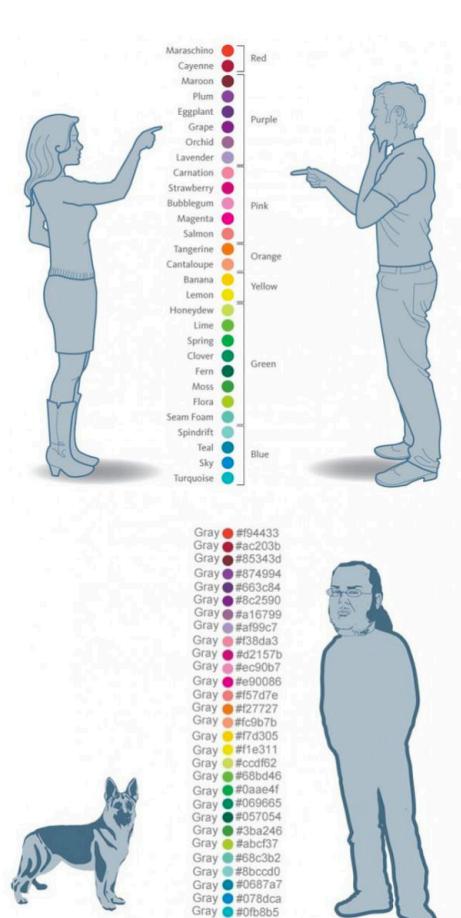
Female



Male



Dog

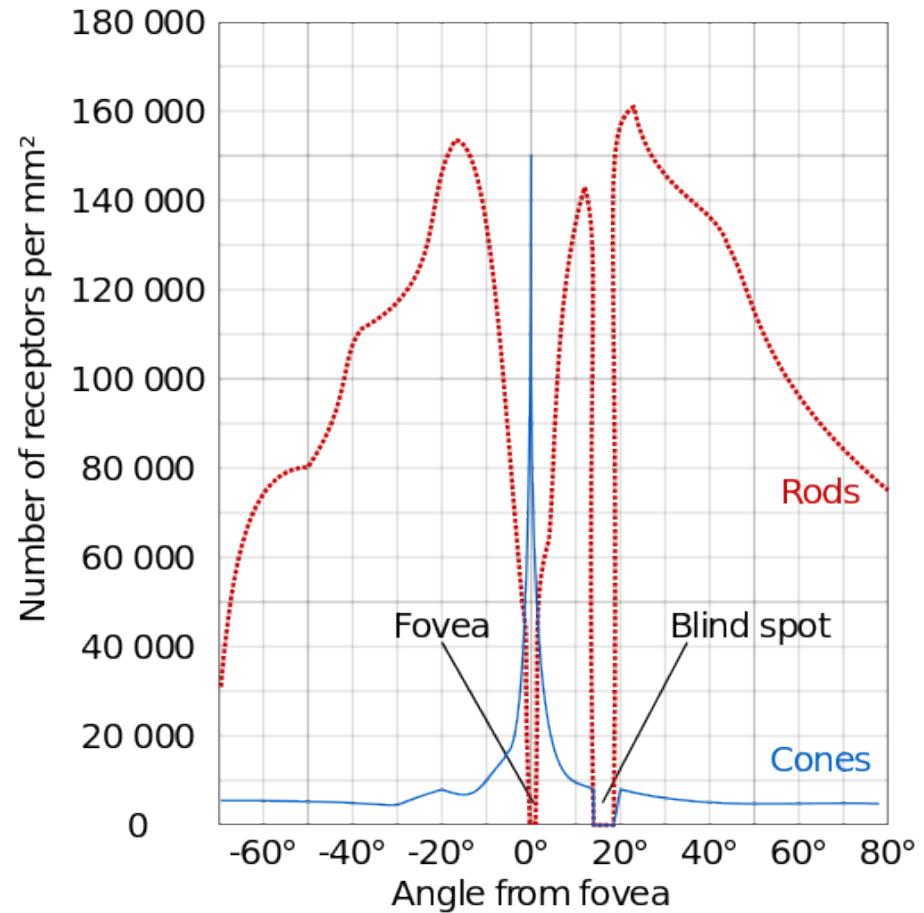


## Programmer



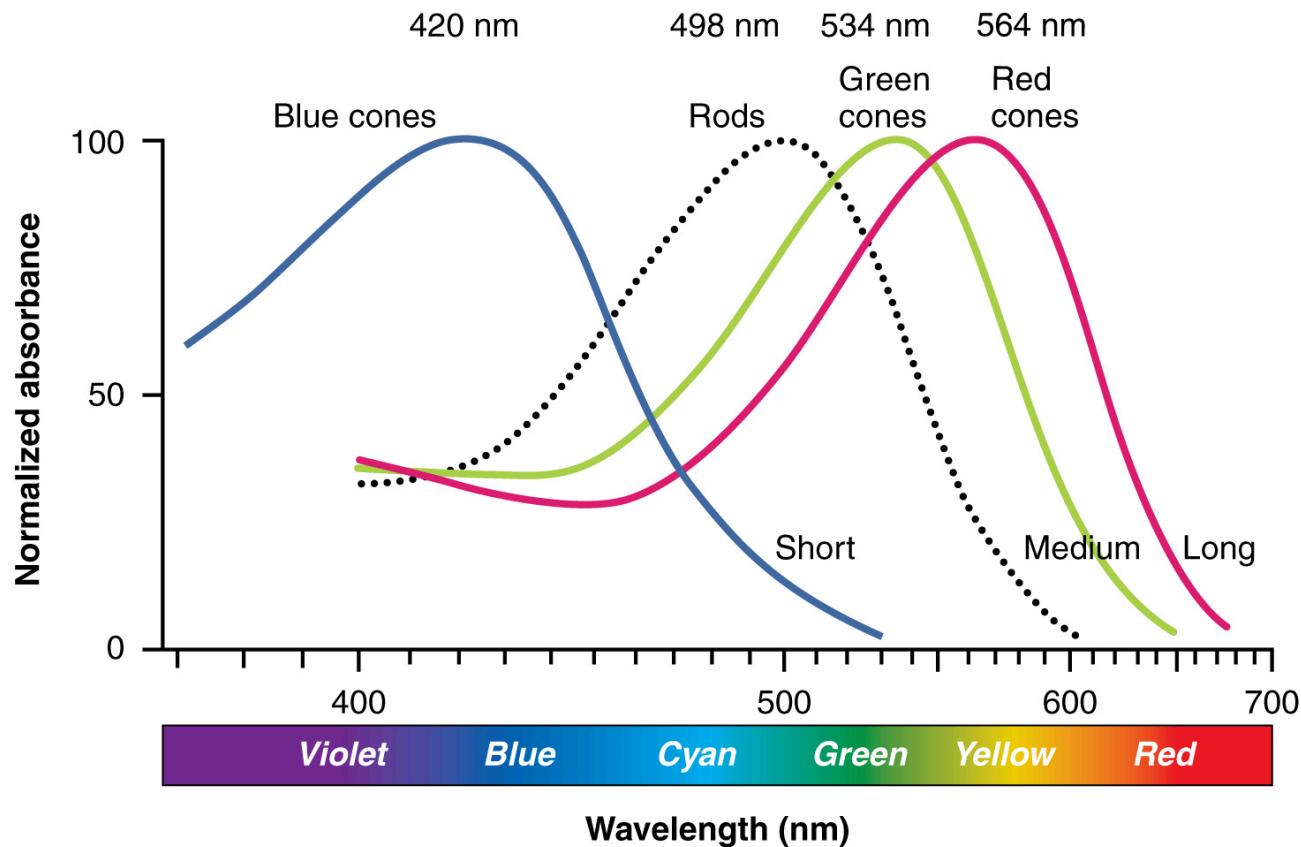
# PHOTO RECEPTOR CELLS

- Two types of light sensitive cells
  - Rod Cells (~120M)
    - Provide low-light vision
    - Peripheral vision
    - Almost no role in color vision
  - Cone cells (~6M)
    - Provide normal vision
    - Three sub-types of cells
      - Sensitivity to different light wavelengths
      - Used for colored vision



"Human photoreceptor distribution" by Cmglee - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:Human\\_photoreceptor\\_distribution.svg#media\\_viewer/File:Human\\_photoreceptor\\_distribution.svg](http://commons.wikimedia.org/wiki/File:Human_photoreceptor_distribution.svg#media_viewer/File:Human_photoreceptor_distribution.svg)

# PHOTO RECEPTOR CELLS



# TEST YOUR COLOR PERCEPTION



# COLOR OF THE YEAR: 2016

## COLOR FORMULA & GUIDES

PANTONE Color of the Year 2016 can be found in the following color systems:

### ROSE QUARTZ

#### FASHION + HOME PANTONE 13-1520TCX

RGB for TCX	sR	sG	sB
	247	202	201

CMYK for TCX	C	M	Y	K
	0	24	15	0

HTML Values for TCX: F7CAC9

#### PANTONE Pastel 9281 C (Closest Match)

9281 C RGB	sR	sG	sB
	242	221	222

CMYK for 9281 C	C	M	Y	K
	0	14	9	0

HTML Values for 9281 C: F2DDDE

 Get Rose Quartz & Serenity and color pairings in [ASE file format for Adobe® Applications](#).

Plastic

PQ-13-1520TCX

### SERENITY

#### FASHION + HOME PANTONE 15-3919TCX

RGB for TCX	sR	sG	sB
	146	168	209

CMYK for TCX	C	M	Y	K
	42	24	3	0

HTML Values for TCX: 92A8D1

#### PLUS Series 7451 C (Closest Match)

Plus Series RGB	sR	sG	sB
	137	171	227

Plus Series CMYK	C	M	Y	K
	46	23	0	0

HTML Values for Plus Series: 89ABE3

 Download Rose Quartz and Serenity wallpaper for your mobile device or desktop.

Plastic

PQ-15-3919TCX



# COLOR OF THE YEAR 2017

COLOR FORMULAS, GUIDES & STANDARDS



— COLOR FORMULA & GUIDES —

PANTONE Color of the Year 2017 can be found in the following color systems:

## GREENERY

FASHION + HOME PANTONE 15-0343 TCX				
RGB for TCX	sR	sG	sB	
	136	176	75	
CMYK for TCX				
	C	M	Y	K
	51	9	88	0
HTML Values for TCX: 88B04B				

PANTONE 376 C (Closest Match)				
PLUS Series RGB	sR	sG	sB	
	132	189	0	
PLUS Series CMYK				
	C	M	Y	K
	54	0	100	0
HTML Values for PLUS Series: 84BD00				

 Get Greenery in ASE file format for Adobe® Applications.

Plastic

PQ-15-0343 TCX

# COLOR OF THE YEAR 2019



[INTRODUZIONE](#) | [STRUMENTI PER DESIGNER](#) | [PALETTE DI COLORI](#) | [ACQUISTA PANTONE LIVING CORAL](#) | [PARTNERS](#)

## Color Formula & Guides

Il Pantone Color of the Year 2019 è disponibile nei seguenti sistemi cromatici:

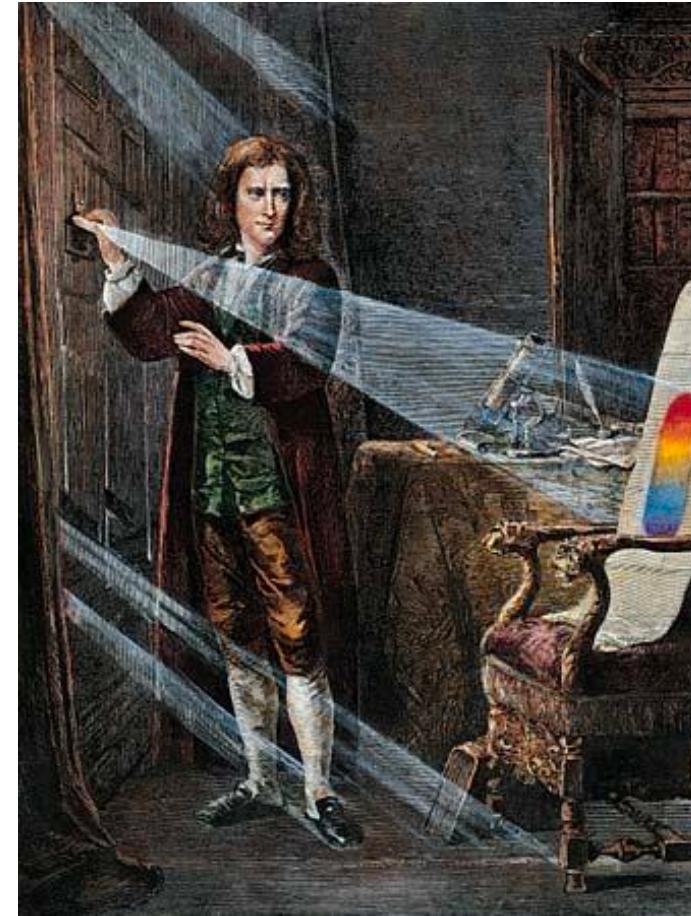
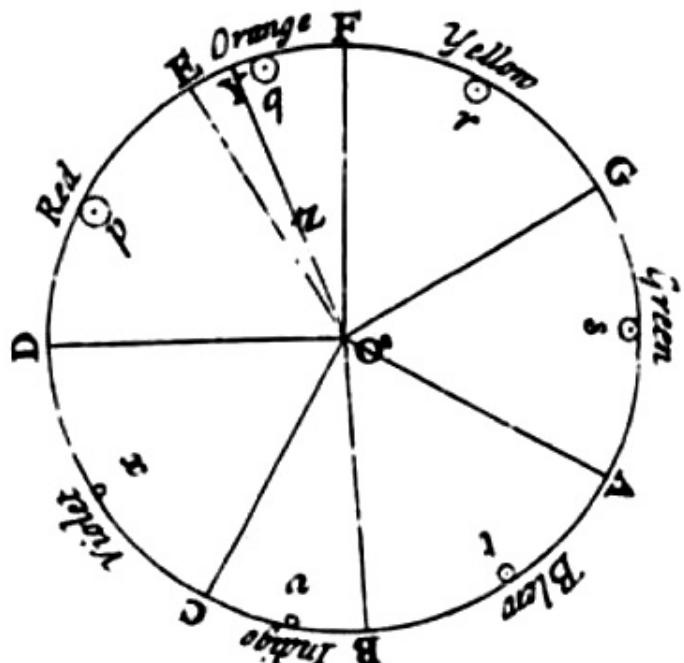
FASHION, HOME + INTERIORS (cotone) PANTONE 16-1546 LIVING CORAL TCX								
Simulazione CMYK per PANTONE 16-1546 TCX*: <table border="1"><tr><td>C</td><td>M</td><td>Y</td><td>K</td></tr><tr><td>0</td><td>65</td><td>54</td><td>0</td></tr></table>	C	M	Y	K	0	65	54	0
C	M	Y	K					
0	65	54	0					
Simulazione sRGB con l'indicatore di luminosità D65 per il PANTONE 16-1546 TCX:  HTML per il PANTONE 16-1546 TCX: <a href="#">FF6F61</a>								
<table border="1"><tr><td>sR</td><td>sG</td><td>sB</td></tr><tr><td>255</td><td>111</td><td>97</td></tr></table>	sR	sG	sB	255	111	97		
sR	sG	sB						
255	111	97						

PLUS SERIES (inchiostro) PANTONE 2345 C								
Simulazione CMYK per PANTONE 2345 C*: <table border="1"><tr><td>C</td><td>M</td><td>Y</td><td>K</td></tr><tr><td>0</td><td>59</td><td>50</td><td>0</td></tr></table>	C	M	Y	K	0	59	50	0
C	M	Y	K					
0	59	50	0					
Simulazione sRGB con l'indicatore di luminosità D65 per il PANTONE 2345 C:  HTML per il PANTONE 2345 C: <a href="#">FF6D70</a>								
<table border="1"><tr><td>sR</td><td>sG</td><td>sB</td></tr><tr><td>255</td><td>109</td><td>112</td></tr></table>	sR	sG	sB	255	109	112		
sR	sG	sB						
255	109	112						

FASHION, HOME + INTERIORS (plastica) PQ-16-1546TCX
FASHION, HOME + INTERIORS (METALLIC SHIMMERS) PANTONE 20-0056 TPM Coralessence
 Procuratevi Living Coral nel formato file ASE per le applicazioni Adobe.

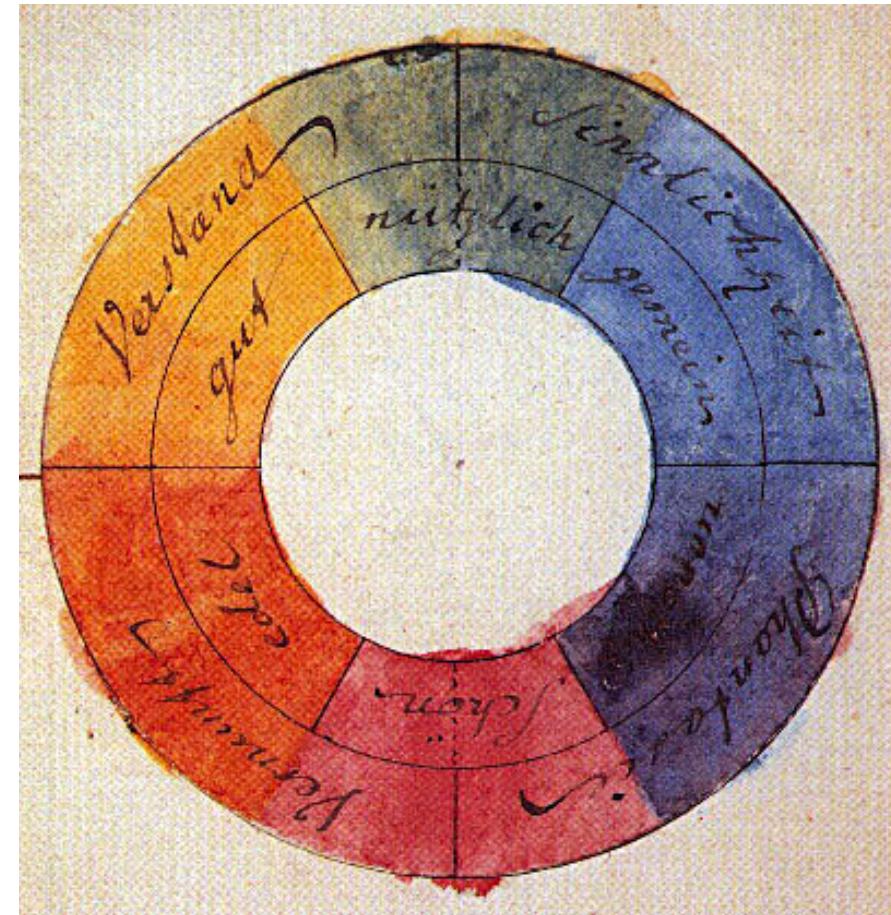
# COLOR MODEL – NEWTON (OPTICKS. 1704)

- White light is a combination of all colors
- Could recombine colors back to white light
- Wrapping basic colors around a circle

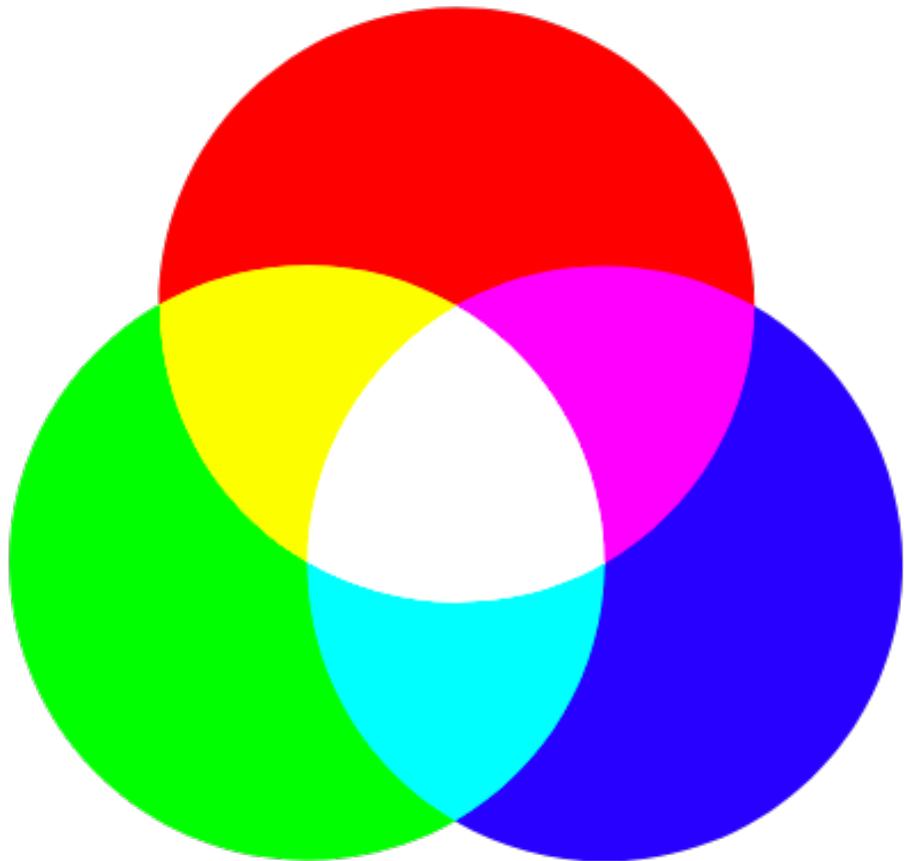


# COLOR MODEL – COLOR CIRCLE (GOETHE, 1810)

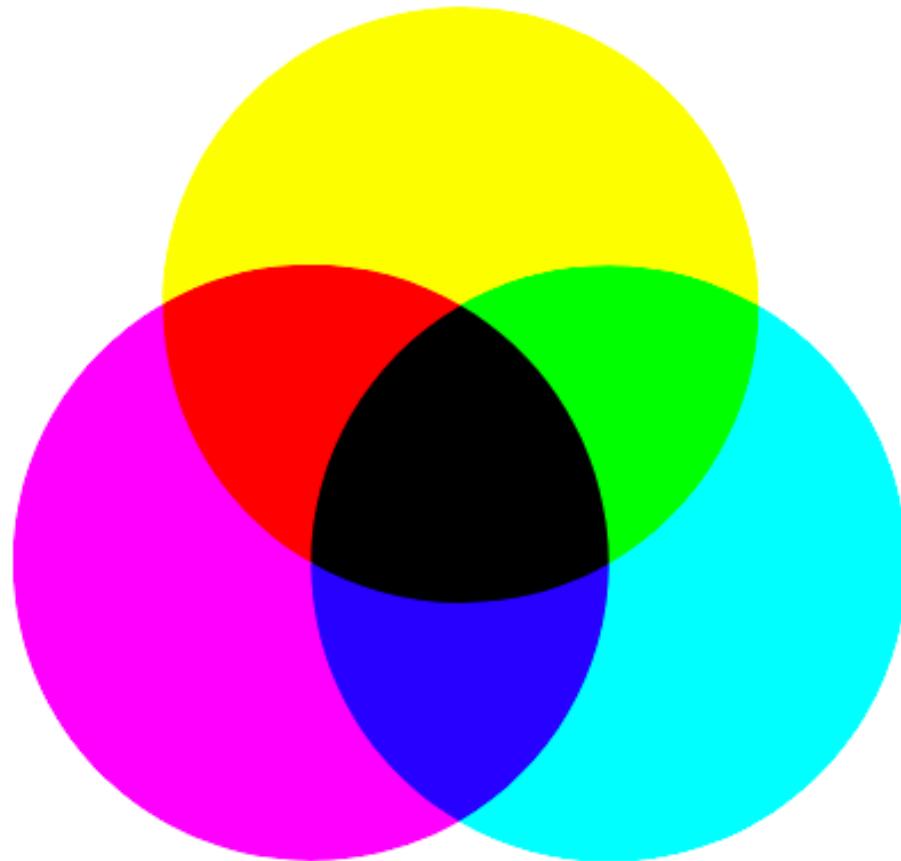
- Measures of eye's response to color
- Three primary colors:
  - Magenta, yellow, blue



# COLOR MODELS – ADDITIVE AND SUBTRACTIVE MODELS

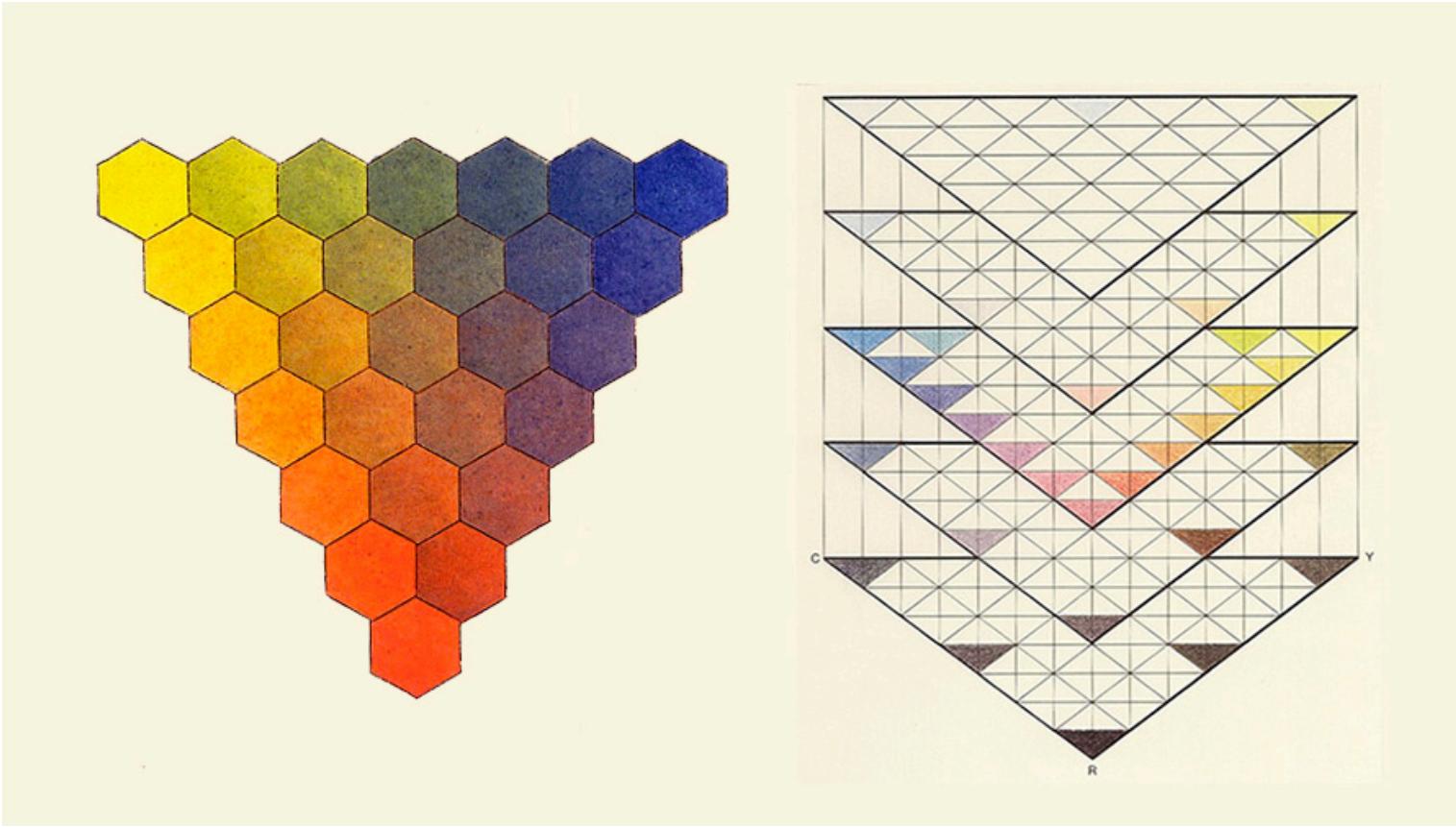


RGB additive model



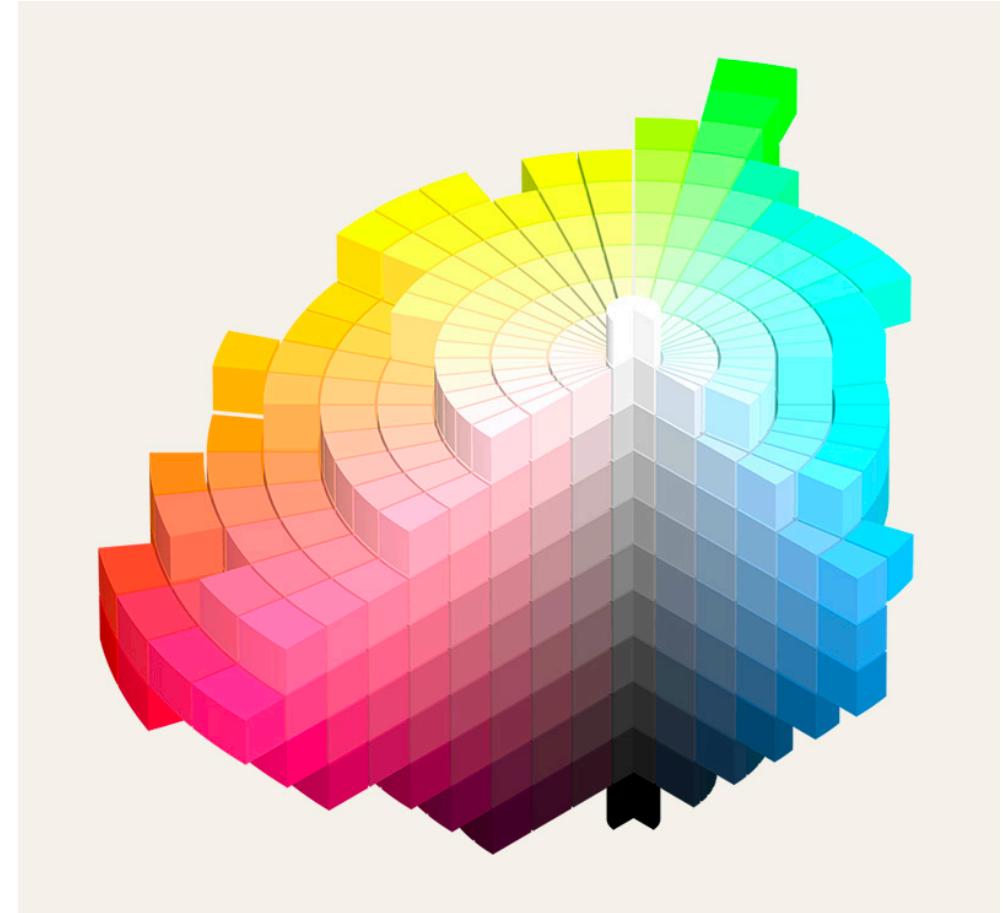
CMY subtractive model

# COLOR MODELS – 3D SPACE MODELS (MAYER, 1775)



# COLOR MODELS – MUNSELL (EARLY 1900'S)

- Introduction of three new dimensions
  - HUE (red, blue, etc)
  - Value (light or dark)
  - Chroma (saturation)
- Irregular shape of solid
  - Low brightness implies fewer visible colors
- Introduction of a mathematical definition of colors (not names)

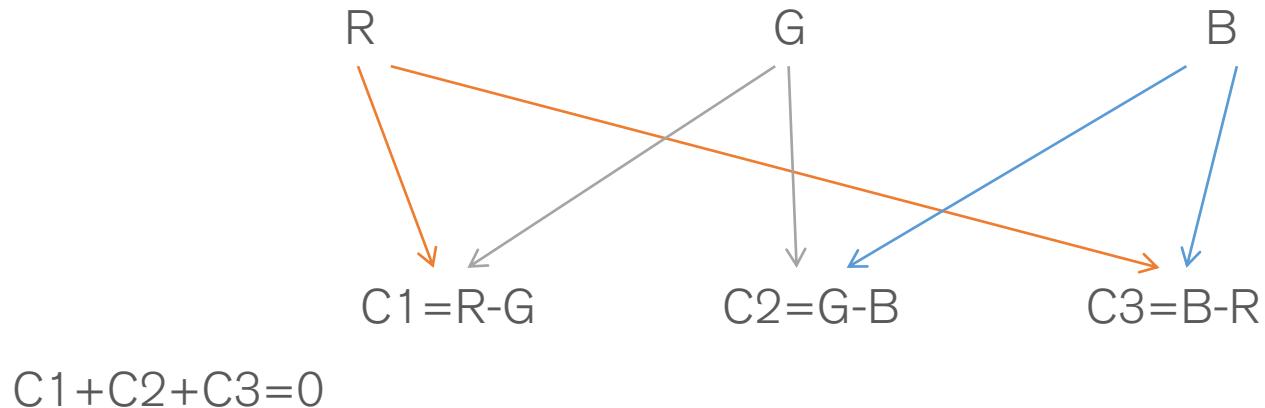


# COLOR MODEL

- Young-Helmotz Theory (19th century)
  - Separate Red, Green, Blue receptors
  - Actually, three receptors type exist
    - Red and Green are located mainly in green-yellow zone
    - Sometimes named as Long, Medium, Short wavelength receptors
  - Eye present different proportions of R,G,B receptors (40:20:1)

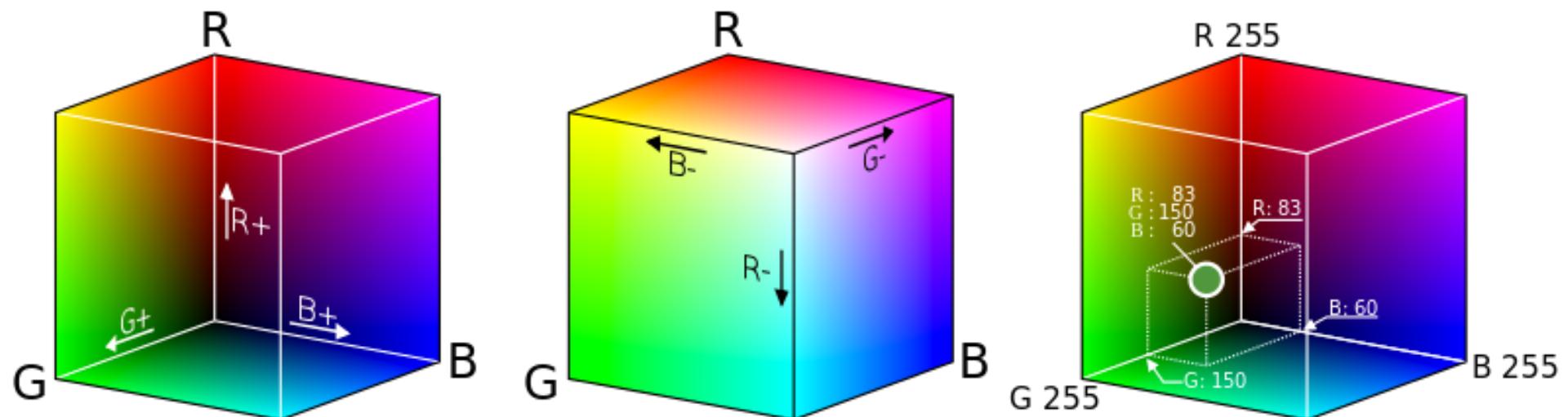
# OPPONENT COLOR THEORY

- Based on estimation of opposite readings
  - red-green comparison
  - blue-yellow comparison
  - dark-light comparison



# RGB COLOR MODEL

- Based on direct specification of three primary colors
- Additive model, each component is summed with the others



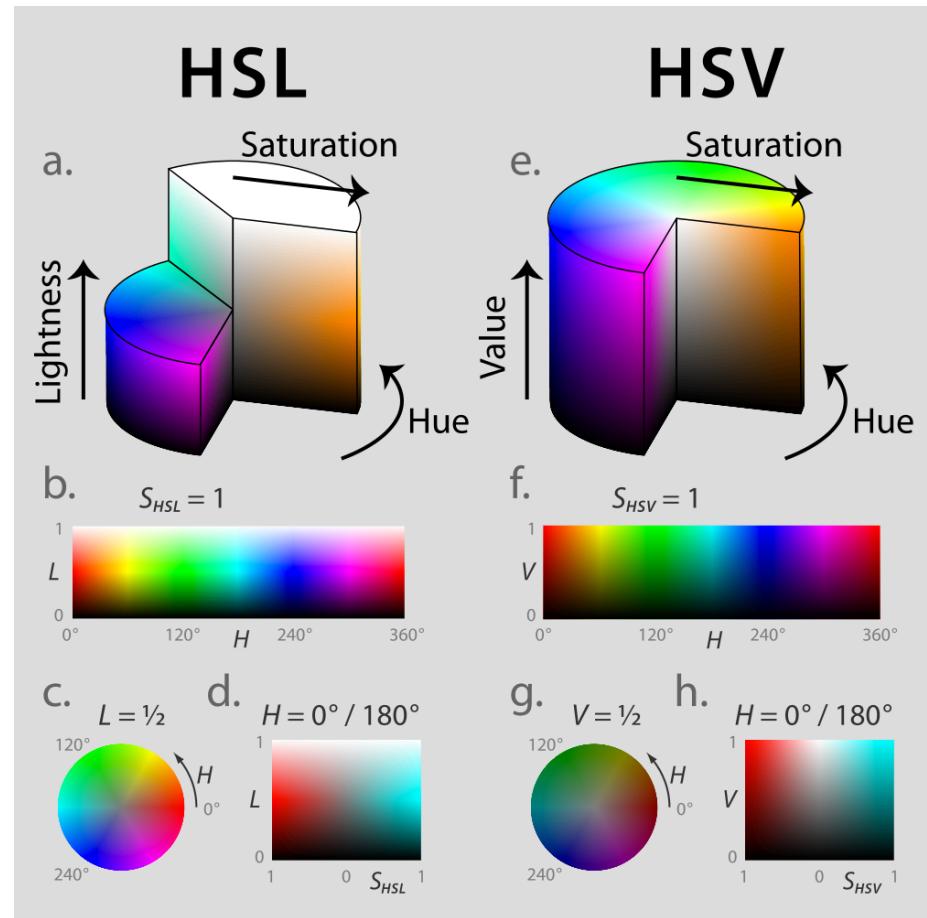
"RGB color cube" by User:Maklaan - Own workbased on:RGB\_farbwuerfel.jpg by Horst Frank. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:RGB\\_color\\_cube.svg#/media/File:RGB\\_color\\_cube.svg](http://commons.wikimedia.org/wiki/File:RGB_color_cube.svg#/media/File:RGB_color_cube.svg)

# RGB COLOR MODEL

- R,G,B values may be expressed in range [0,1]
- Some applications use the range[0,255]
- Usually a hexadecimal notation is used for range [0,ff]
- Not really intuitive: how to define brown?

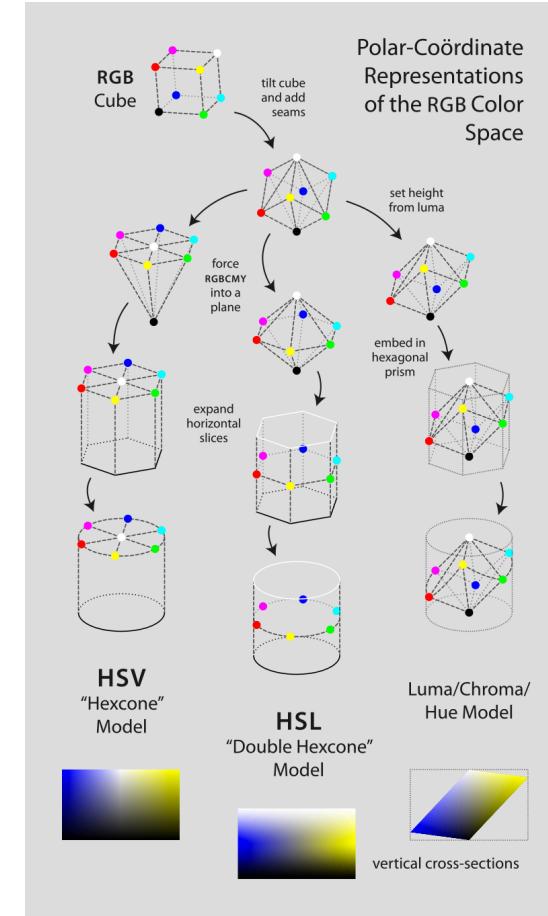
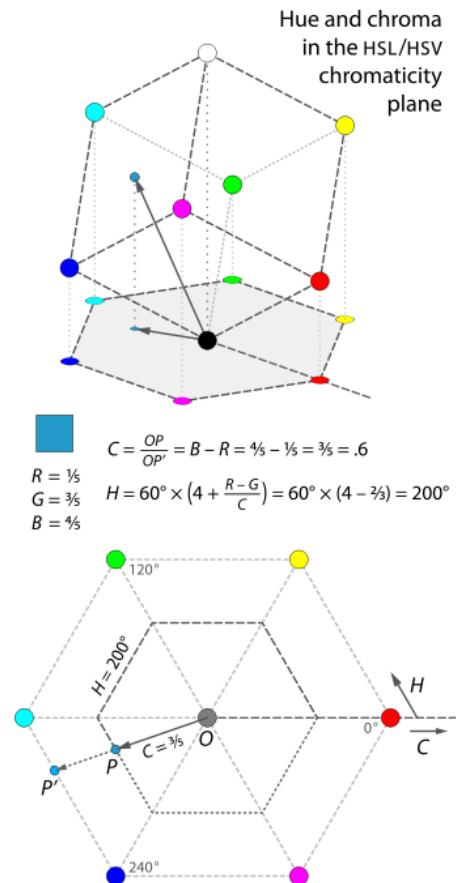
# HSV COLOR MODEL

- Based on the intuitive concepts of
  - Hue
  - Saturation
  - Value (or brightness: 0% implies black; 100% implies pure color)
  - Lightness (or luminosity: 0% implies black; 50% implies pure color; 100% implies white)
- Component values are expressed in ranges  $[0, 1]$  or  $[0, 255]$



"Hsl-hsv models" by Jacob Rus - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:Hsl-hsv\\_models.svg](http://commons.wikimedia.org/wiki/File:Hsl-hsv_models.svg#/media/File:Hsl-hsv_models.svg)

# RGB AND HSV



"HSL-HSV hue and chroma" by Jacob Rus - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:HSL-HSV\\_hue\\_and\\_chroma.svg#/media/File:HSL-HSV\\_hue\\_and\\_chroma.svg](http://commons.wikimedia.org/wiki/File:HSL-HSV_hue_and_chroma.svg#/media/File:HSL-HSV_hue_and_chroma.svg)

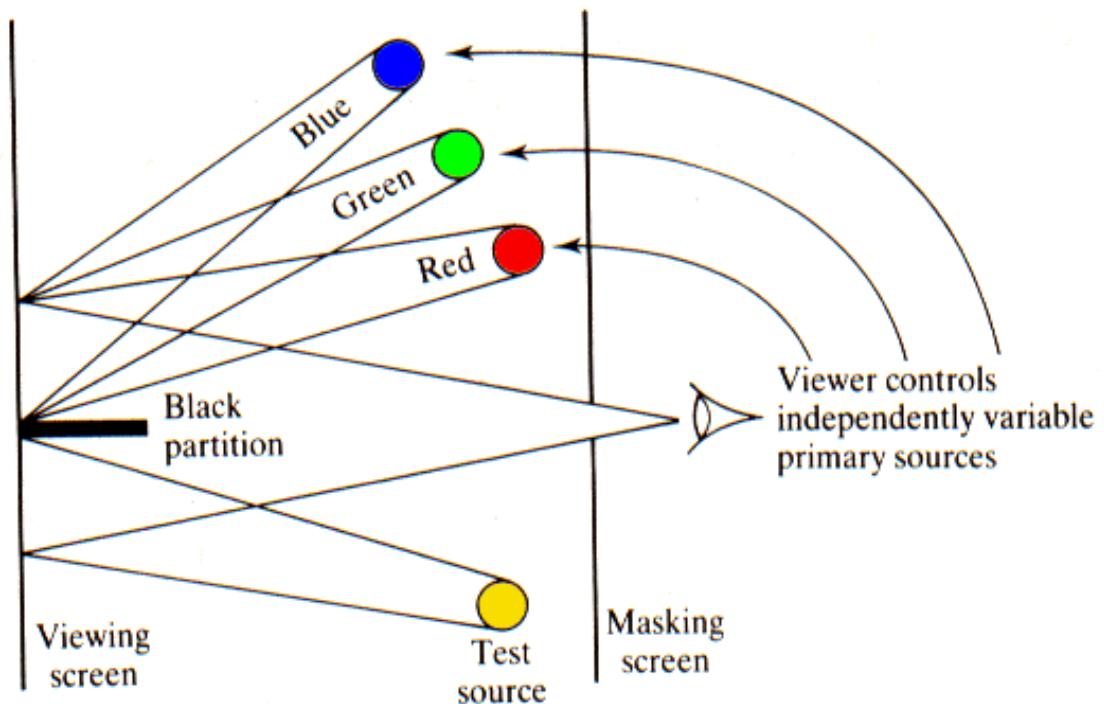
"Hsl-and-hsv" by Jacob Rus - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:Hsl-and-hsv.svg#/media/File:Hsl-and-hsv.svg>

# COLOR SPACES

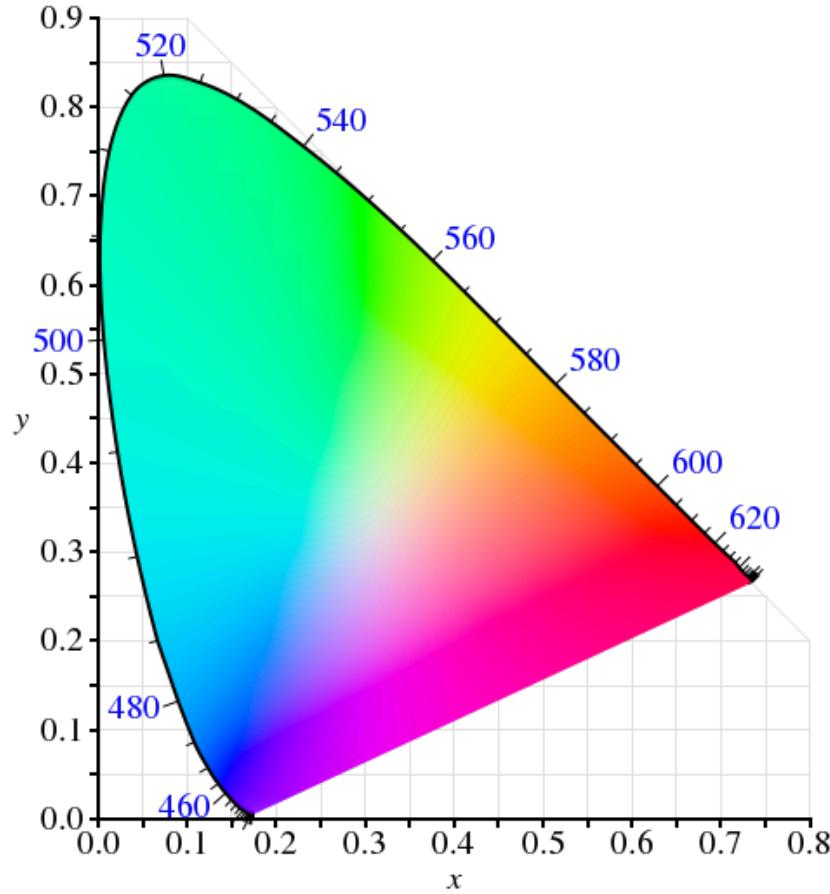
# CIE STANDARD OBSERVER

- CIE: International Commission on Illumination
- Definition of an objective color-mapping function:
  - Standard colorimetric observer
- Experiment
  - An observer is positioned in front of a bipartite screen
  - Observer can manipulate intensities of three primary color beams
  - Task:match the reference color

# STANDARD OBSERVER EXPERIMENT

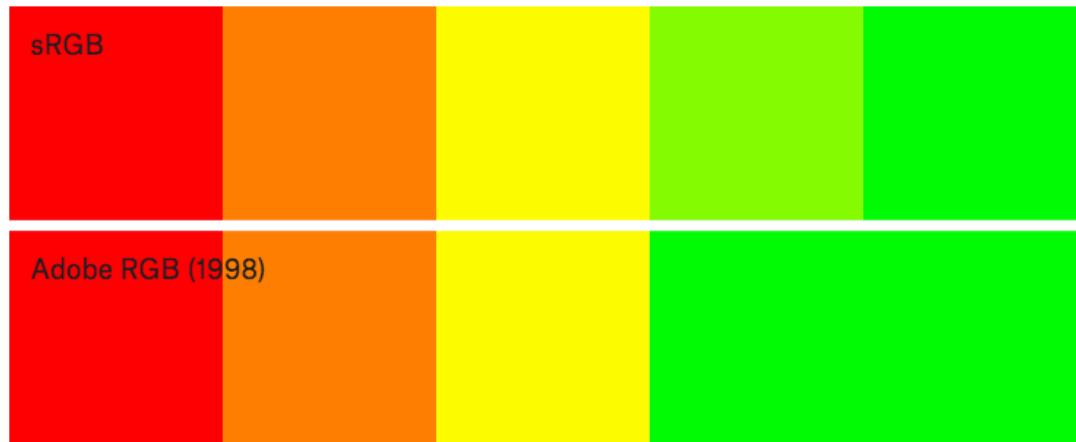
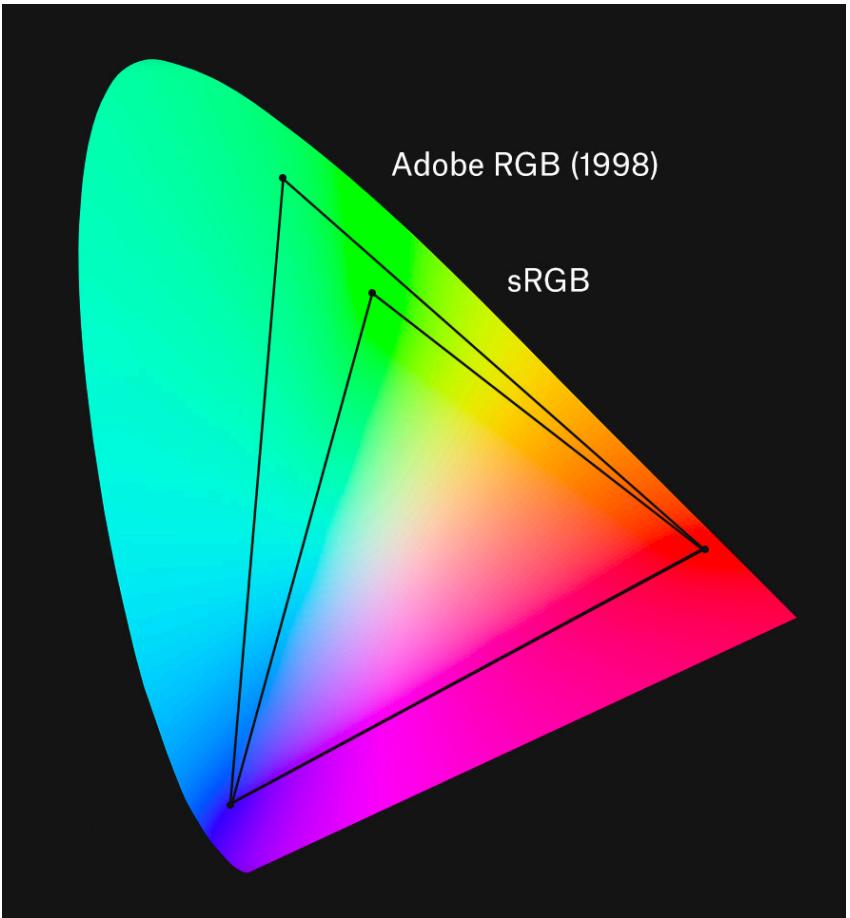


# CHROMATICITY DIAGRAM



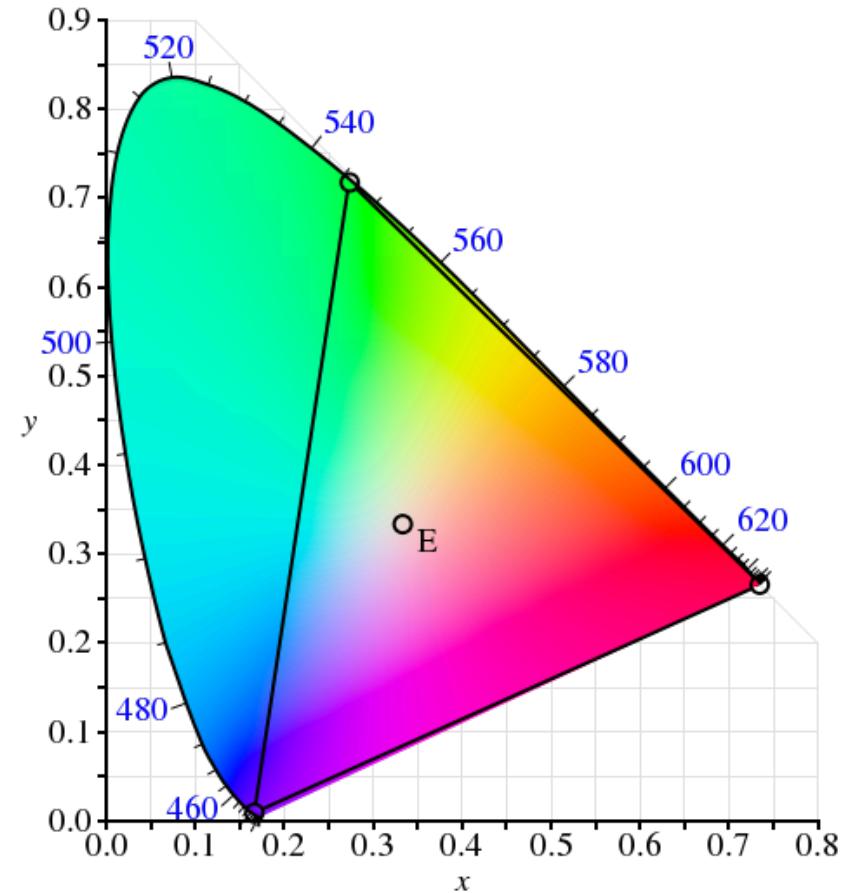
- A mixture of two colors lies on the line connecting the two colors
- Chromaticity Diagram (**gamut**) is convex
- All visible colors are non-negative combination of  $x$ ,  $y$ , and  $z$
- An equal combination of two colors does not lie in the mid-point

# COMPARING COLOR SPACES



# COLOR MIXING

- Given three primary colors, the corresponding triangle cannot cover the whole gamut

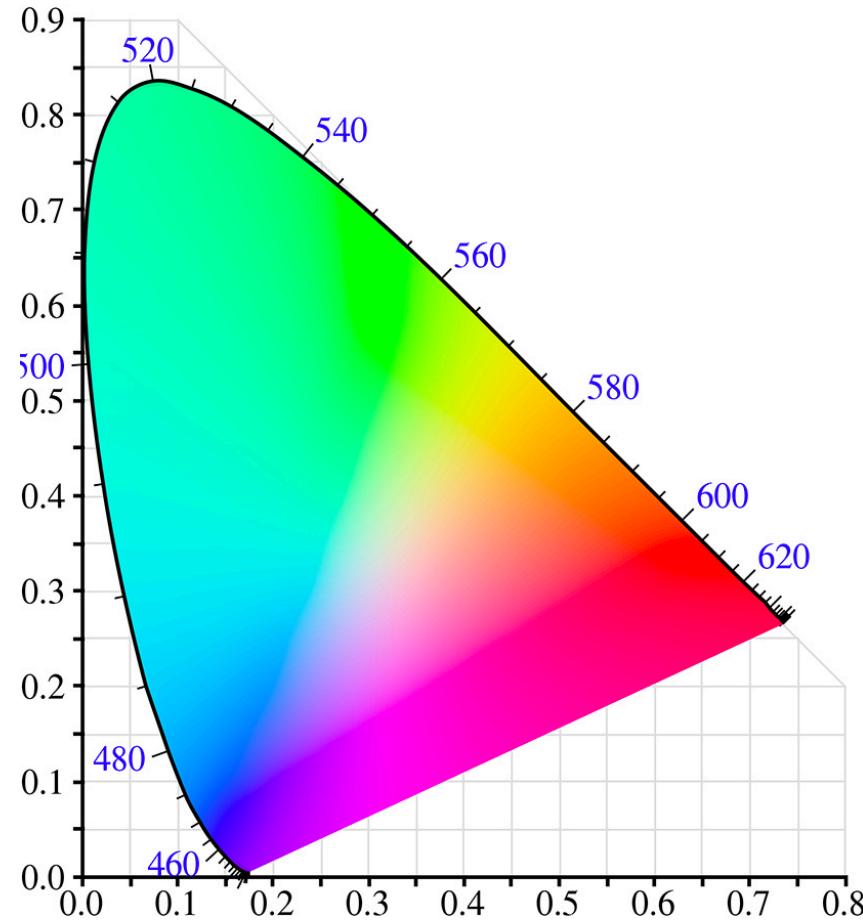


"CIE1931xy CIERGB" by BenRG - Own work, inspired by File:CIExy1931.png. Licensed under Public Domain via Wikimedia Commons - [http://commons.wikimedia.org/wiki/File:CIE1931xy\\_CIERGB.svg#/me](http://commons.wikimedia.org/wiki/File:CIE1931xy_CIERGB.svg#/me)

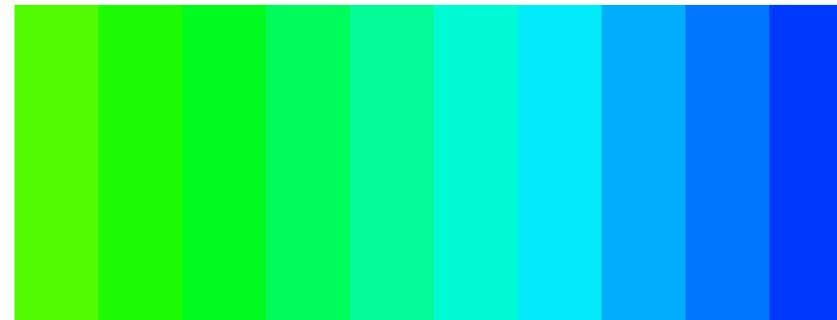
# PALETTE



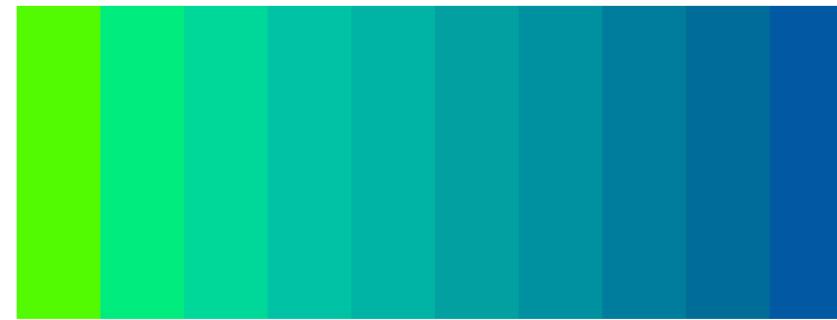
# MAPPING VALUES TO COLOR SCHEMES



sRGB interpolation

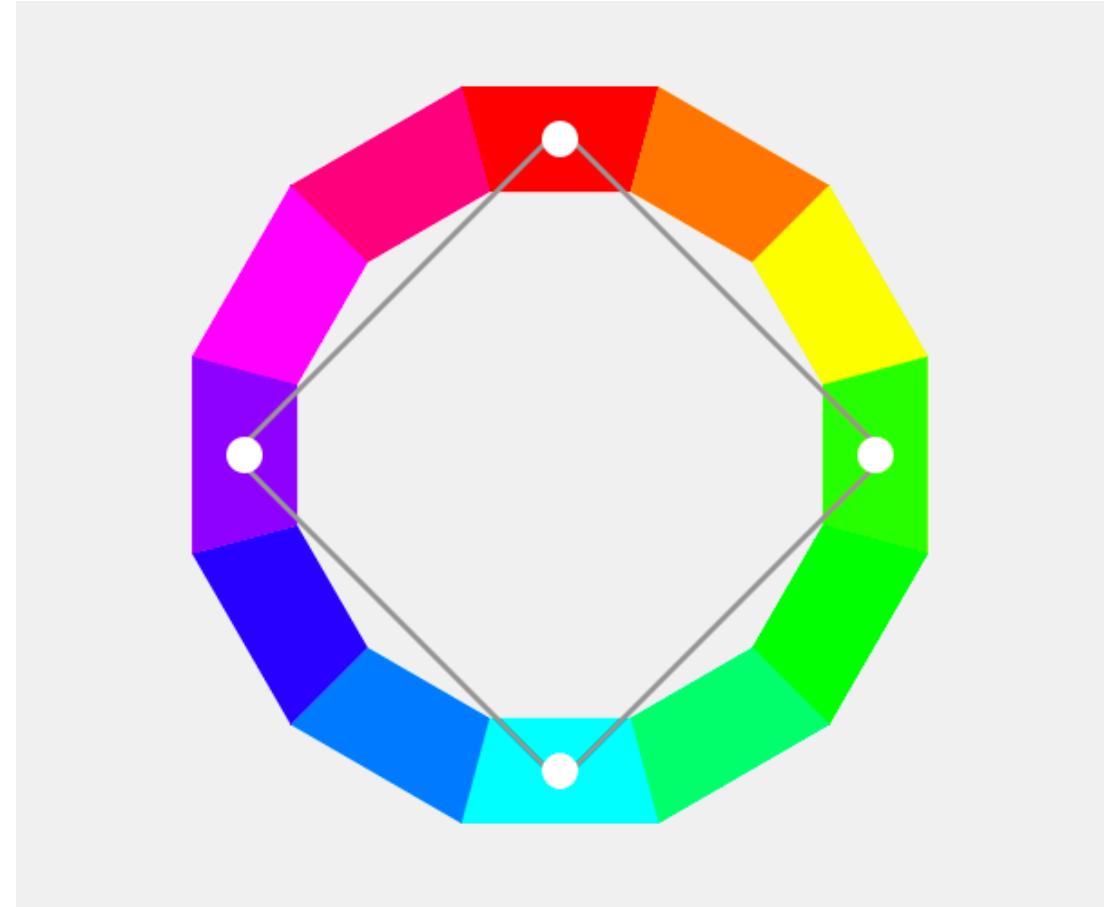
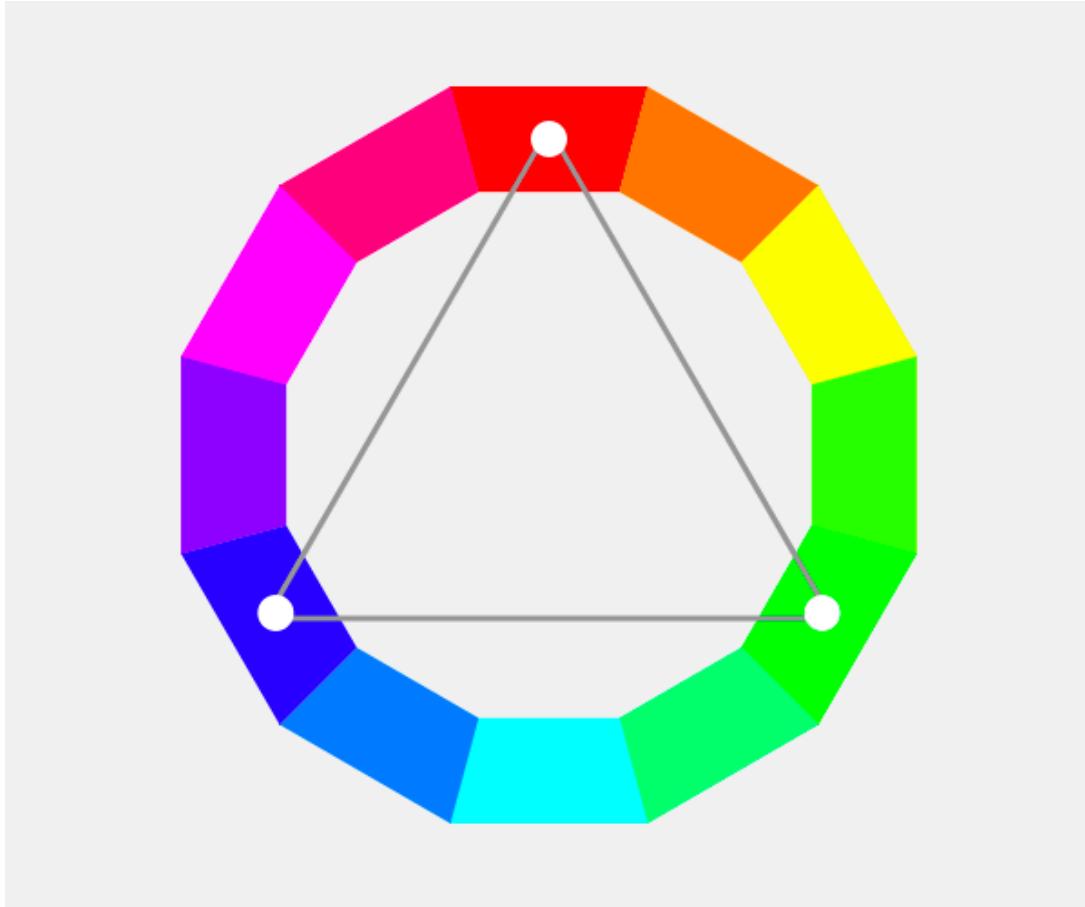


Perceptually uniform color space



HSLuv project provides utilities to colors among different color spaces

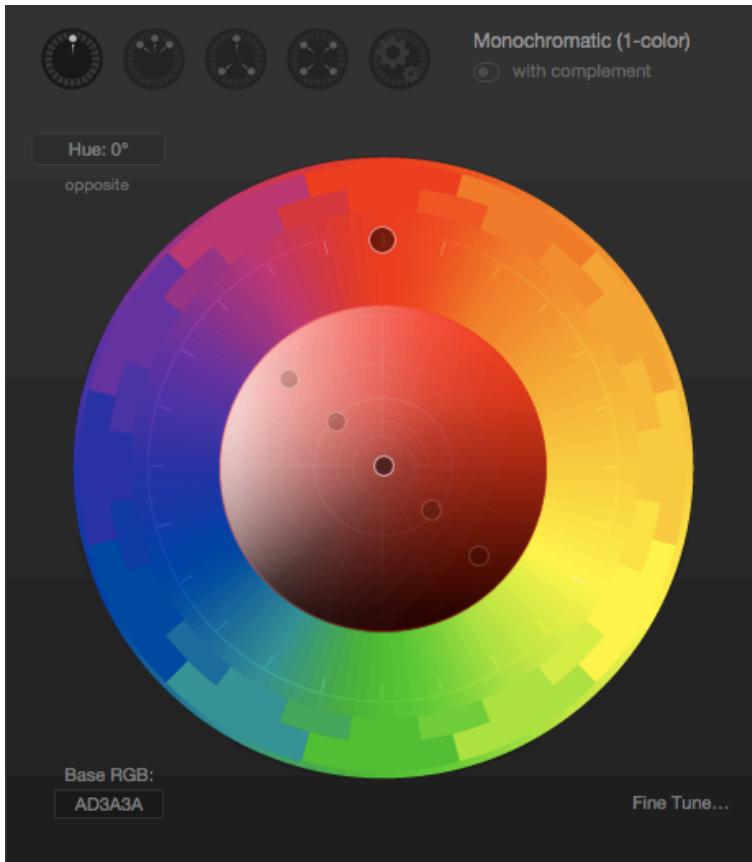
# CATEGORIES OF COLORS



Tetradic colors

# COLOR SCHEMES

Cold colors



Warm colors

# COLOR BLINDNESS



Normal color vision.

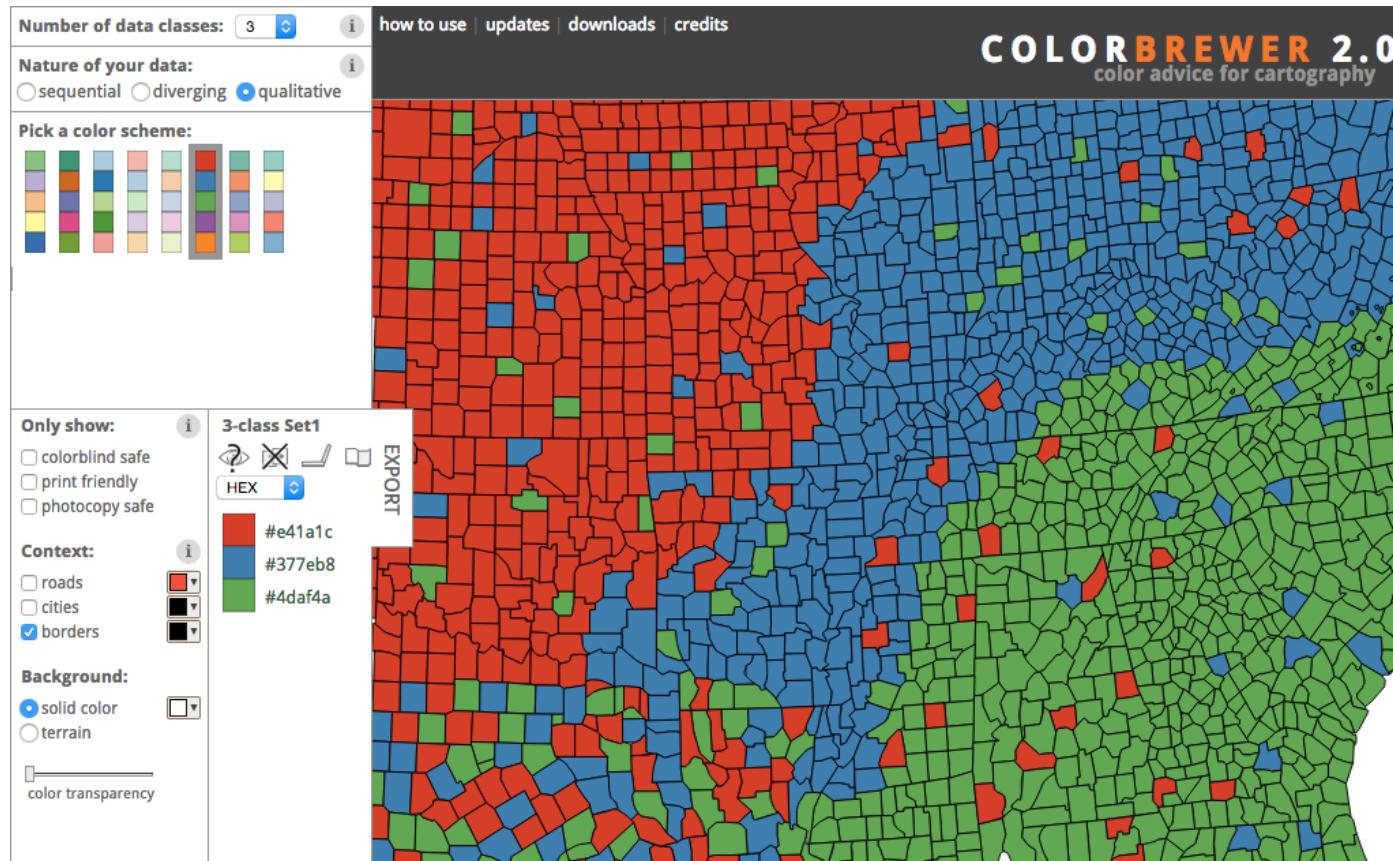


Mild red-green blindness.

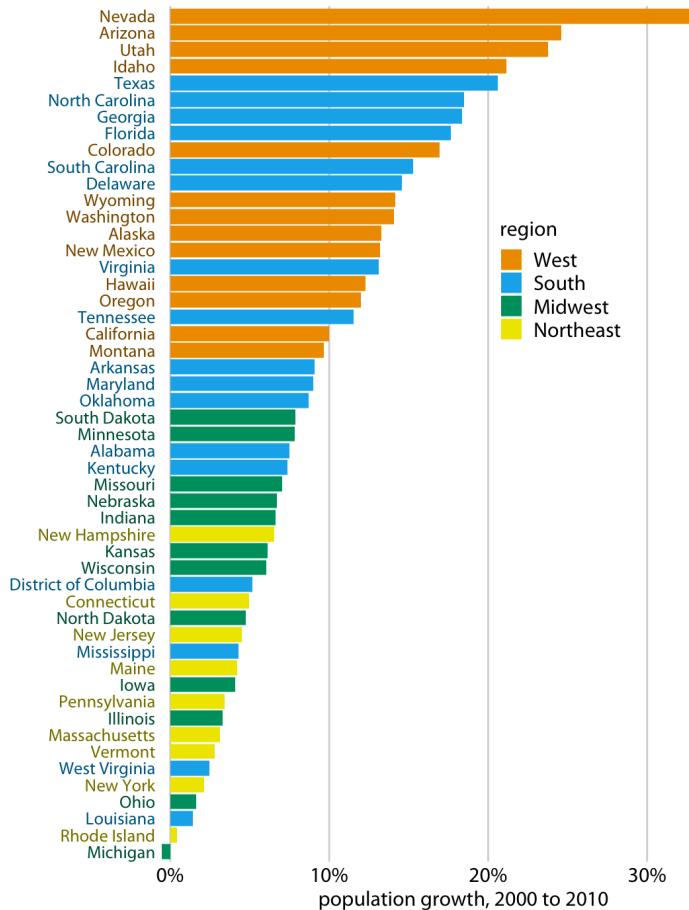


Severe red-green blindness.

# COLOR SCHEMES FOR CARTOGRAPHY



# COLOR SCHEME EXAMPLE (NOMINAL)



Okabe Ito



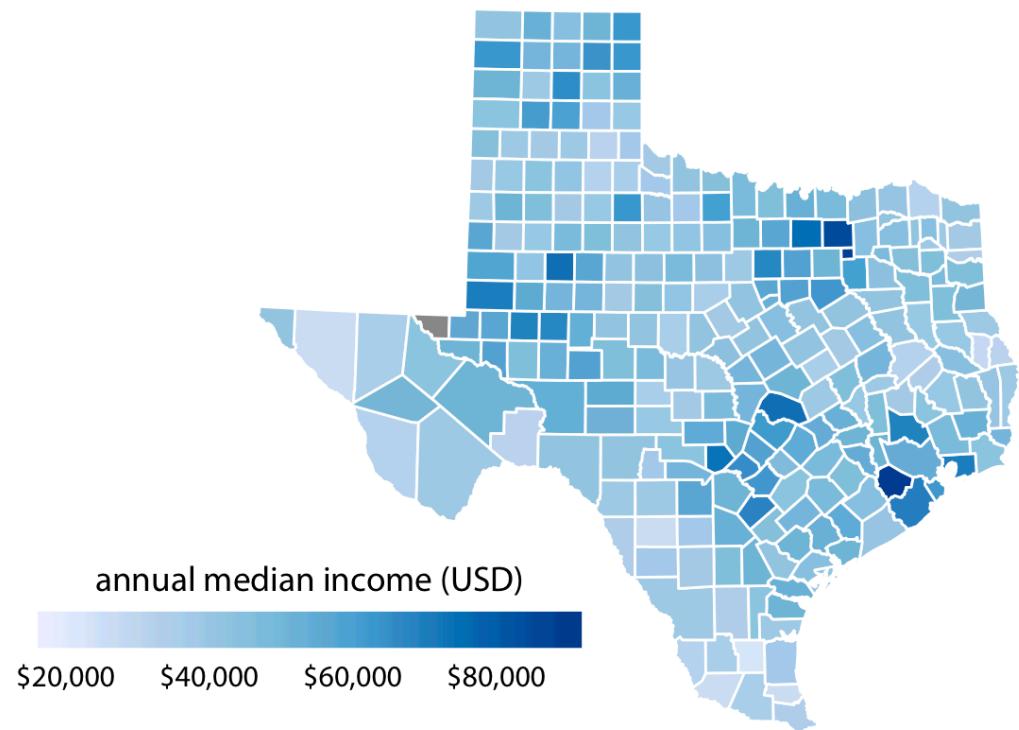
ColorBrewer Dark2



ggplot2 hue



# COLOR SCHEME EXAMPLE (SEQUENTIAL)



ColorBrewer Blues



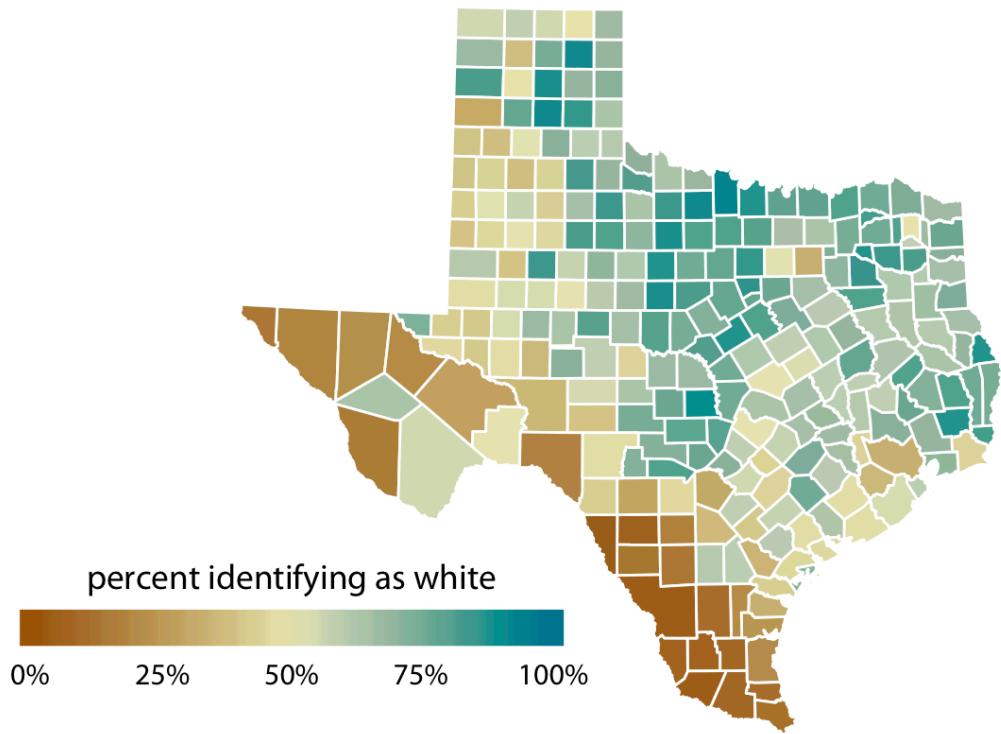
Heat



Viridis



# COLOR SCHEME EXAMPLE (DIVERGENT)



CARTO Earth



ColorBrewer PiYG



Blue-Red



# D3.JS COLOR SCHEMES

 d3.org • d3js.org  
Bring your data to life.  
By  Mike Bostock

Published Aug 16, 2018    4 Forks    Listed in d3-scale-chromatic

**Color Schemes**  
Including Every ColorBrewer Scale  
Click any d3-scale-chromatic scheme below to copy it to the clipboard.

continuous

**Sequential (Single-Hue)**

- Blues
- Greens
- Greys
- Oranges
- Purples
- Reds

**Sequential (Multi-Hue)**

- BuGn



<https://observablehq.com/@d3/color-schemes>

Visual Analytics  
va602aa

# TAKEAWAY MESSAGES

- Different color models and color spaces
- Color palettes to effectively represent scales of values